A Multidimensional Analysis of Inkblot Perception

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Abstract

The Holtzman Inkblot Technique (HIT) was administered in group form to 39 introductory psychology students, and each subject individually rated the similarities of pairs of the HIT inkblots. The similarity judgements were analyzed via a multidimensional scaling (MDS) approach which recovered dimensions of variation among the blots and dimensions of variation in individual use of the configuration of blots in MDS space.

In general, perception of inkblots was well represented in part by a multidimensional model, with 3 or 4 dimensions of variation capturing most of the predictable variance in the blot space and the subject space. Higher dimensions also seem interpretable, and indeed the closest correspondence to the HIT variation was with the second, third, and sixth dimensions. The dimensions of variation typically correspond lowly to HIT variation, however, and are defined primarily by discrimination of physical characteristics of the blots. However, the more objectively physically oriented HIT variables correspond lowly, and more subjective variations were found to relate systematically to the dimensional structures. Differences were also found in dimensional loadings and factor scores between subjects who spoke English versus Chinese as their first language. The MDS analysis was also found effective in identifying a subject whose HIT protocol evidenced clear pathognomic characteristics, and in suggesting a subset of blots maximally capturing perceived variation.

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A Multidimensional Analysis of Inkblot Perception

Projective testing has been the focus of considerable debate within the field of clinical psychology, with questions of usefulness and validity forming a schism between many of the professionals involved. The polarity of current opinions is evidenced by conclusions on the one hand that the massive accumulation of research literature has already invalidated further use of projectives, or alternatively that the literature to date is inconclusive as the research fails to accurately assess projective methods in the way they are used clinically (Goldfried, Stricker, and Weiner, 1971). Part of the concern is attributable to a growing concern over the usefulness of assessment in general, although projective methods have been thought to be declining in popularity more rapidly than objective methods (Shemberg and Keeley, 1970; Thelen and Ewing, 1970).

A recent survey of clinical psychologists, however, has established that both objective and projective assessment remain in substantial use, and are relied upon heavily in clinical settings (Wade and Baker, 1977). Furthermore, although there were considerably fewer administrations of projective tests per week than objective tests, the percentages of time spent in the two types of assessment activities were not significantly different. This continued reliance upon assessment in spite of the lack of clear research support reflects a demonstrated need for the kind of information provided in both types of assessment. The burden, then, appears to remain with researchers in developing or expanding methodological approaches to clarifying the issues of validity and reliability in ways which will either isolate the dependable dimensions of information obtainable from present assessment techniques, or suggest alternative sources for the information needed in the clinical setting.

Within the realm of projective testing much of the past research and debate has focused on the Rorschach Inkblot Test. The dominance of this technique within psychological testing is addressed by the number of investigations alone, numbering over 3,000 to date (Goldfried et al., 1971). Yet with this voluminous literature, the status of reliability and validity have remained obscure. The inconsistency is explained by some proponents in terms of the irrelevance of the employed research strategies and analyses to the application of the test results in practice. At fundamental levels, it has been suggested that the Rorschach is in essence a broad source of information about personality and consequently not subjectable to the typical psychometric criteria for reliability, that the information tapped is multidimensional and too complex for conventional analysis (Goldenberg, 1973), that the Rorschach technique is more a method of observation than of assessment and consequently more coincident with questions of usefulness and productivity than of reliability and validity (Klopfer, Ainsworth, Klopfer, and Holt, 1954), and that the principles of validity and reliability of the Rorschach in clinical and research use have been confused, and investigated with inappropriate statistical techniques (Karon, 1968).

Holtzman, Thorpe, Swartz, and Herron (1961) have argued that many of the characteristics of the Rorschach which have complicated its investigation can be remedied at a practical level. Consisting of two parallel sets of 45 blots each and two practice blots, the Holtzman Inkblot Technique (HIT) was developed with the aim of overcoming several psychometric limitations of the single set of ten Rorschach inkblots. First, the mere increase in the number of blots makes the investigation of the numerous variables scorable from responses more feasible in at least correlational concerns such as reliability. Second, the HIT blots are more varied in characteristics such as color, form, shading, and symmetry. Third, only one response per card is given, and it is followed immediately by a short, standardized inquiry. Fourth, the existance of parallel forms allows implementation of test-retest and individual change investigation. Fifth, 22 variables are scored which include most of the scoring criteria of the several major methods of Rorschach scoring, and norms are provided on a variety of populations for all 22 variables. A final consequence of these changes is that the HIT is suitable to group administration and computer scoring without substantial loss of information.

The changes evidenced in the HIT in the interest of psychometric criteria are considerable. Many sources of variation are obviously attenuated, such as examiner-subject interaction, number of responses per card, and inconsistency across examiners in scoring and procedural style. The critical assertion is that the projective potential of the HIT is preserved, which is necessary if subsequent research is to remain generalizable to projective testing and at some level to the more prevalent Rorschach procedure. Holtzman (1968) in fact argues that the projective quality is preserved, and that the greater number of blots and the richer stimulus properties of the blots more than compensate for the limitations on recoverable information imposed by the more restrictive procedural structure of the HIT.

Although the HIT has been the object of considerable research since its introduction and appears to have become an established assessment technique (Hill, 1972), it does not appear to have substantially replaced the Rorschach as a projective inkblot test of choice (Wade and Baker, 1977). Fehr (1976) suggests that:

> This can be attributed to a combination of the following factors:
>
> 1. The HIT is time consuming to administer.
> 2. The HIT is time consuming to score.
> 3. There are not enough data analyzing the nature of specific HIT variables (p. 485).

The time factor is certainly shared by most projective techniques, although the large number of HIT variables may contribute an extra element of tedium. Although the basic reasoning behind an apparently all inclusive set of variables which cover the range of variables previously scored from inkblot perception is understandable, the large number of variables may be contributing to the third factor as well. With 22 variables to investigate, the slowness of progress in research is not surprising, and this may leave potential users of the HIT with questions about which variables to consider or which patterns to look for, answers to which may be long in coming.

The large numbers of variables also presents more direct problems to research. The psychometric changes in the HIT have resulted in impressive data on inter- and intrarater scoring reliability and test-retest developmental reliability studies, with correlations ranging from .89 to .995 for the former, and .89 to .97 for the latter with highly trained scorers (Holtzman et al., 1961). Nonetheless, the current status of validity research exploring the nature and potential of the HIT variables remains less than clear. This may be attributable to consequences of two of the most typical strategies of investigation. One strategy is to single out one or a few of the HIT variables suspected of relationship to an external criterion of interest, and compare those HIT scores with other behavioral or psychometric measures of the same criterion. The slowness of this route considering all relationships that might exist is obvious, but many of the indices of correlation or prediction to date have also been somewhat low. For example, Sanders (1977) found correlations ranging from .34 to .50 between the Holtzman's Abstract variable and a battery of paper and pencil measures, Fehr (1976) found correlations between the Holtzman's Anxiety and Hostility scores and a group of related objective and behavioral measures ranging from .07 to .43, and Greenberg, Aronow, and Rauchway (1977) found correlations ranging from .20 to .48 in magnitude between two measures of interpersonal distance and the HIT's Human, Barrier, Anxiety and Hostility variables.

A more frequent approach has been to compare measures of an external criterion with each of the 22 variables recovered from each subject (eg., Velez-Diaz, 1976; Greenfield, Alexander, and Sternbach, 1976; Iacino and Cook, 1974), a shotgun approach which appears to minimize effort but at the same time is of questionable statistical soundness. For one or more sets of all pairwise correlations between the HIT variables and an external criterion measure in a given analysis, the tests of significance of the correlations are likely to be highly inflated. In fact, if an overall or experiment-wise probability of Type I error of .05 is desired when each of the 22 variables is correlated with a single criterion measure, the conservative Bonferroni estimate of the alpha level required to conclude significance of a given single correlation would be .002. The stringency of this estimate is an obvious indication of the loss in statistical power to detect non-chance relationships when alpha inflation is guarded against, and failure to account for such inflation is no more satisfactory an approach as it leaves the significance of any obtained results questionable.

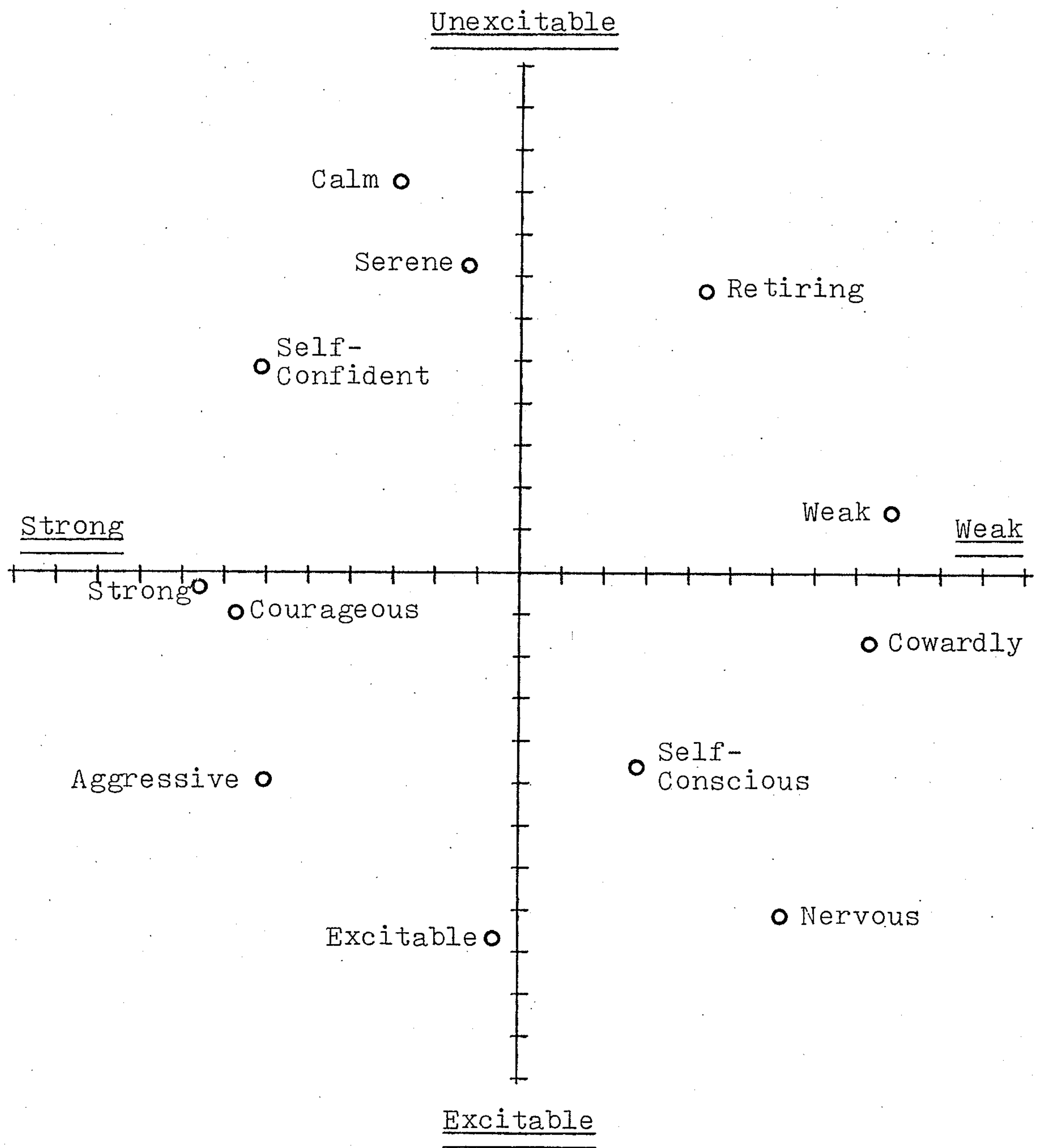
Thus it appears that in spite of the psychometric improvements of the HIT, little advancement is clear regarding empirical evidence of validity or reliable usefulness of projective assessment with inkblots. The improvements contributed by the HIT are noteworthy, and may well be necessary conditions for further advancement in research, but the expected further advancement has not clearly materialized. Problems in the research strategies employed have been cited as possible explanations here and by Gamble (1972), who goes on to conclude that "...many more studies will be needed in all areas before empirical generalizations regarding this instrument's validity can be offered with any confidence" (p. 191). It appears likely that an increase in the sophistication or appropriateness of methodology and analytic techniques must accompany the increase in the numbers of studies if a realistic gain in understanding is to follow. At a specific level, the statistical problems with power and significance and the potential redundancy or irrelevance which could be by-products of the all-inclusive set of HIT variables are concerns which must be met at the level of methodology as well as interpretively. Optimally the new or modified methods of analysis will differ not only toward greater statistical power but in relevance to the special considerations of projective research and the HIT as well. It is in fact the intention of the present investigation to explore the application of a statistical procedure new to projective research which will speak to such needs to methodological advancement.

A new approach. Multidimensional scaling (MDS) is an analytic procedure initially though not exclusively associated with psychophysics, and sporadically employed in most areas of psychological research. It has not received attention in research with inkblot perception, which may be attributable largely to unfamiliarity with the technique, and at least partly to some practical limitations which in some contexts restrict its suitability. Recent developments in both the area of projectives and the MDS methodology, however, have obliviated the restrictive limitations, and it is contended that an application of MDS in projective research is subsequently not only feasible but potentially of crucial benefit. The rationale for this contention can best be presented within the context of an elaboration of the MDS procedure and theory. A detailed summary of the fundamental MDS theory relevant to its present applications is presented in Appendix A, and thus treatment of the theory will be superficial in the present text.

In brief, multidimensional scaling is a method of recovering dimensions of variation among a set of stimulus objects. By considering interpoint proximities--such as similarity, correlation, or physical distance--MDS can determine the number of dimensions needed to approximately reconstruct a multidimensional space formed by the set of interpoint distances from dimensional loadings. The degree of correspondence of interpoint distances in this reconstructed space to the original distances constitutes the "goodness of fit", often referred to as <u>stress</u>. The gain sought is a reduction in the amount of data by constructing a stimulus space with as few dimensions as possible, as little redundancy as possible, and as much accuracy as possible. Perhaps the foremost advantage lies in the unobtrusiveness of the procedure, as all information about the dimensions of variation among a set of objects is recovered simply from judgements or measurement of the similarity or distance between pairs of the objects.

MDS has been employed in psychological research in various areas other than projective tests. A study by Neufeld (1976) serves as a suitable example where, in part, normals and schizophrenics judged the similarity among words in two sets of 12. For a group of "personality" words such as "weak", "courageous", "nervous" and "serene", a MDS analysis recovered two dimensions along which the words were discriminated. The label "Weak-Strong" was attached to one dimension, and "Excitability" to the other. Figure 1 portrays the stimulus words in this 2 dimensional space, and inspection reveals how the Weak-Strong and Excitability characteristics of each word are represented in the two dimensional arrangement. In a similar fashion, dimensional structures were recovered from proximity judgements on a group of "affective" words, and on a set of systematically varying geometric objects. Neufeld went on to explore differences in these perceptual maps among schizophrenic subgroups and normal subjects, which suggests the utility of MDS in exploration of individual perception processes.

Figure 1. A Two Dimensional Structure of Personality Words



MDS and the HIT. The appropriateness of projective stimuli for a MDS analysis is evident at least with regard to recovering information from subjects about the physical characteristics of the blots. Since the stimulus properties of inkblots are quite complex, it seems reasonable to expect that several dimensions would minimally be involved, and thus the dimension to stimuli ratio would preclude an effective analysis of the ten Rorschach blots alone, where no more than two dimensions could be reasonably considered. The 45 blots of the HIT, however, provides considerable latitude in valid dimensionality, to the extent that labelling would more likely be the limiting factor in interpretation.

The total number of proximity measures necessary to complete a half matrix, amounting to 990 comparisons, has until recently been a limiting factor given the tedium of the task of making such a large number of judgements, for both the subject and experimenter. A metric program, INTERSCAL, is now available, however (Cliff, 1977), which recovers comparisons of dissimilarity via an interactive procedure such that substantially fewer judgements are necessary. The actual magnitude of reduction varies across subjects with measurement error and dimensionality, but with 45 stimuli the proportion of all 990 comparisons which would likely be needed should be roughly 25% to 50%. Operating from the assertion that there is considerable redundancy of information when the number of dimensions is much smaller than the number of stimuli, the reduction is accomplished by continually identifying stimulus objects which are outliers on the recovered dimensions, and eliminating new comparisons which can be predicted from the distances to outliers in the known dimensionality (Young and Cliff, 1972).

At a methodological level it seems clear that MDS is a suitable technique for analysis of the HIT, given the interactive program for recovery of data. Returning to earlier issues in the present work, the more important question of relevance must also be dealt with. Contributing to an already massive body of projectives research would not seem justifiable unless the outcome can be expected to address specific needs and concerns of projective assessment. It is to be presently contended that the results of a MDS analysis of the HIT can potentially provide informative and heuristically valuable data in five general areas, which will be discussed in turn.

Description. A minimal expectation of the present endeavor is the provision of a special unobtrusive, multivariate form of descriptive data. From judgements of similarity alone, pilot data suggests that an interpretable order of dimensional structure can account for substantial commonality of variation among stimulus objects as complex as HIT inkblots. Preliminary analyses in 4 dimensions suggested that an even higher dimensionality could continue to substantially improve the goodness of fit. Verification of these assertions alone is a major goal of the present investigation, as it is a necessary precursor to any research or interpretation which might apply MDS in a similar fashion. Recovery of a dimensional structure for a given subject will be followed by identification of the dimensions, with the aid of techniques such as determining correspondence of dimension loadings to externally determined physical or subjective characteristics of the blots.

Individual differences. Special considerations of the domains of individual differences in dimensional structure are possible primarily through the use of INDSCAL, an analysis procedure developed by Carroll and Chang (1970). The individual difference model proscribed will determine the salience of each of the dimensions in an overall configuration for each subject's dimensional configuration. Since the saliences can range from zero to one, the model will consider even unique dimensions, which appear in only one subject's configuration. Recalling that one concern with projectives is that they tap a vast source of general information about personality and consequently are ill suited to psychometric criteria, the quantification and elaborative delineation of dimensions of individual differences possible with INDSCAL holds promise of clarifying how much and what type of consistency can be expected in the framework of inkblot perception. Furthermore, the INDSCAL procedure allows comparisons of dimensional differences in perception attributable to subject variables. For example, sex differences or ratings on psychological scales such as neuroticism could be considered in a fully multivariate framework by comparison of overall differences in group configurations.

Clarification of HIT variables. Several potential outcomes of the MDS would address validation and clarification of the multivariate aspects of the HIT. Given that the dimensional configuration of stimulus variation is obtained unobtrusively from only judgements of dissimilarity, an attempt to conceptually identify the recovered dimensions by their correspondence to the variables derived from the HIT should reveal the extent to which systematic variation which is actually perceived by subjects is tapped by the 22 clinically derived HIT variables.

A lack of correspondence between HIT variables and the recovered configuration may place interpretations of the HIT in a new context. The 22 HIT variables have been factor analyzed, and found to consist reliably of six factors (Holtzman, 1968), accounting for 26%, 17%, 27%, 14% and 9%, respectively, of the variation in a college student sample. Accounting for a cumulative value of 93% of the HIT variance, these factors are essentially dimensions of common variance among the 22 variables. It seems reasonable therefore to expect some correspondence between the loadings on factor scores and loadings on MDS dimensions if indeed the variation classified in the HIT variables substantially represents variation perceived by the subjects. Single HIT variables may also correlate highly with specific MDS dimensions, although it is difficult to predict a priori which if any will do so. Variables or factors which do not correspond to the MDS dimensional structure either represent unique, meaningful variance, or insignificant error variance, or both. To the extent that the MDS configuration accounts for a large amount of the total variation perceived, the lack of correspondence of a factor or variable will more heavily support suspicion of irrelevance. Variables or factors falling into this category will thus be isolated for special consideration, either as candidates for skepticism or for specific examination of validity. A related possibility is that dimensions which do not correspond to HIT variable structures may suggest the development of new variables which would capture such consistent information currently unrecoverable.

Projection versus perception. Many of the HIT variables relate directly to physical properties of the blots--such as symmetry, color or shading--and consequently if physical properties of the blots are considered in the dissimilarity judgements, it would be expected that corresponding dimensions would be recovered from the data which may be identified by high correspondence to one or more HIT variables. Similarly, content oriented responses reflected in the more projective HIT variables such as hostility and anxiety may also be found to correspond with dimensions of configuration. If the distinction is made between reflection of perceived physical blot properties in the responses and the reports of properties such as anxiety which are more projective (as they are not objectively defined by the blot) then dimensional structures recovered from the proximity judgements may consequently discriminate and metrically quantify the elements and extent of actual projection accompanying inkblot perception.

Redundancy of inkblots. Given an accurate representation of dimensional structure from the MDS analysis, blots which are loaded near-identically on all dimensions may be effectively redundant sources of data. Should multiple spacial location of blots occur, redundant blots could be eliminated for the purpose of suggesting an empirically derived short-form of the HIT with minimal loss of information. Given the criticism the HIT has received for its lengthy administration and scoring procedures (Fehr, 1976), a maximally productive shortened form could make the HIT a more attractive and manageable method of assessment.

The above categories of information encompass the major anticipated areas to be addressed by the present analysis, although additional findings are expected to materialize in the multi-stage analysis phase. Moreover, the relevance of the present results will likely extend into considerations for projection theory and assessment as well as providing several foundations for innovative subsequent research.

Method

Subjects. Subjects were 39 volunteers from introductory psychology courses who earned extra credit for their participation. Total participation consisted of up to 4 hours, one hour of which was a group session, three hours being in individual sessions. Subjects having participated in previous investigations with the Experimenter were not allowed to participate, but no other restrictions were imposed. Of the 39 subjects, 29 were female. The average age for all subjects was 19.3.

Procedure. The collection of data was accomplished in two parts--the proximity judgements and the group Holtzman administration. For the first 21 subjects (referred to as the PRE group), the proximity judgement task preceeded the standard group administration, with the order reversed for the remaining subjects (referred to as the POST group). The judgements of proximity were obtained in individual sessions of up to three hours in length, the exact length of the session being determined by the subjects' rate of responding and total number of responses given. The standard group administrations were given in one of three session times, which lasted 70 minutes. The present Experimenter conducted 20 of the individual sessions, with a second Experimenter conducting the remaining 19.

The proximity judgement task. Subjects were introduced to the task by a series of instructions, which are outlined in Appendix B. Following a brief statement that the session's task would be "comparing pictures of inkblots in terms of their similarity", all inkblots were held up one at a time in turn for approximately 3 seconds. As mentioned to the subject, the purpose for the preliminary exposure was to acquaint the subject with the full range of variation among the blots. The order of presentation of blots in the preliminary exposure and for the initial presentation in the proximity judgements to follow was randomized. The random sequence numbers for each blot together with the corresponding HIT identifying numbers are given in Appendix C.

In phrasing similar to instructions given in a standard Holtzman administration, subjects were asked to compare the similarity of the inkblot pairs which would be presented according to "...what they look like, remind you of, or could be", and come up with a number from 1 to 9 which best represents their judgement of the overall dissimilarity, with 9 being the greatest dissimilarity. Pilot data had suggested that emphasis was needed on the use of the dissimilarity scale, and on maintaining attention to the task to maintain reliability. Thus, extra explanation was given to establish that the full scale of 1 to 9 should be used to represent the degrees of difference present, such that a 1 or 9 would represent the extremes among the 45 blots but not require that any pair be <u>completely</u> similar or different. It was further suggested that all points of the scale be utilized as fully as possible. A small sign in front of the subject served as a reminder of the scale direction and range.

Persistance at the task was solicited by request and explanation of its importance, and at least two 3 to 5 minute breaks were taken at equal intervals in the comparison task. Subjects were also made aware that the computer served to reduce the total number of comparisons necessary, and that the final number would be influenced by their accuracy.

The experimenter was seated at an interactive computer terminal located in a research room otherwise containing only office furniture. Subjects were seated in a chair facing the experimenter. The inkblots were arranged in a collapsable file located on a chair between the experimenter and subject. Pairs of inkblots were removed and held vertically on top of the file adjacent to each other. Responses were given verbally and recorded by the experimenter by entering the response into the interactive INTERSCAL program, which stored the information and used it to progressively identify the essential judgements of proximity needed, and some more redundant judgements in proportion to the estimate of dimensional configuration inaccuracy.

The blots were identified in the interactive program by their random identification number, and consequently their order of <u>first</u> appearance was the same for all subjects. The complete sets of judgements for each subject were expected to differ, however, according to the stimuli which are identified as dimensional outliers by the INTERSCAL program. The particular subsequent pairs to be judged were identified and printed out on the terminal typically within one second after the current judgement was relayed. Thus, the total time for one response was approximately 5 seconds longer than just the exposure time required by a subject to formulate a judgement.

The first comparison made was an unrecorded trial judgement comparing the HIT practice blots X and Y. If a 1 or 9 response was given, a final reminder was given that the intention was to use the full dissimilarity scale during the course of the task. Dispersed pseudo-randomly throughout the set of judgements to follow were 25 replicated judgements (roughly 10% of the minimum number of essential proximities) selected and requested by the INTERSCAL program as a reliability check. Large discrepancies caused a message to be printed--which was read to the subject--warning that the judgement differed from a previous comparison and requesting a second try and further effort at consistency.

The standard group administration. The HIT was administered in its traditional form according to the standard procedures for group administration described by Swartz and Holtzman (1963). Official color slide versions of the Holtzman blots were projected onto a screen in the standard order of presentation. The exposure time varied from 120 seconds initially to 75 seconds for all blots beyond number 9 (see Appendix D). Subjects were instructed to use their imagination, and write down the first thing the blot reminded them of (see Appendix E for the complete group administration instructions).

Several of the instructions given are unique to the group form of administration, as outlined by Swartz and Holtzman (1963). Subjects were specifically asked and reminded to include in their responses "...the particular characteristics or qualities of the inkblot which are important in determining the response--i.e., what about the blot made it look that way?" When the first two trial blots were projected on the screen, example "common" responses were given, such as "a bat because of the form", or "a pool of oil, using color and shading". Responding also included circling the part of the blot used in the response on a sketch of the blot in the answer sheets. Further reminders to give as complete answers as possible, to include the important determinants, and to circle the appropriate areas on the answer sheet blots were given in a standard reinforcement schedule (see Appendix F).

Experiment conclusion. At the end the latter session for each subject, a post-experiment questionnaire was completed which dealt with basic demographic data, perceptions of the task, and comments about the information used in the proximity judgements and the experiment in general (see Appendix G). For 21 of the subjects, this was completed at the end of the group administration, and for the remaining subjects it followed the individual session.

After the questionnaire was completed in each case, subjects were debriefed with further information about the experimenter's intents (see Appendix H). It was explained that the blots comprised the Holtzman Inkblot Technique, a general personality test which was commonly used in a manner similar to the group administration. Multidimensional scaling was also briefly discussed, and it was explained that the focus was on connections between the kind of material gotten from the standard administration and the data from the multidimensional analysis of the similarity judgements. Attention was brought to a voluntary follow-up debriefing where the HIT and MDS would be described and related in more detail for those interested.

Results

Collection of proximities. The length of the individual sessions ranged from 110 minutes to a full three hours, with the average time being approximately 2½ hours. The INTERSCAL program required 11 cycles for 25 of the subjects, and from 8 to 10 cycles for the remaining subjects. As shown in Table 1, there was considerable variability among subjects in the number of basis stimuli identified, the number of cycles employed, and the total number of judgements collected. Considering the 990 possible comparisons, the average reduction in distances collected of 50% speaks well for the program's facility in reducing the number of essential distances.

Table 1

Characteristics of the INTERSCAL

Recovery of Distances

Parameter	Minimum Value	Maximum Value	Average Value
Parameters of the Program Operation			
Number of Cycles	8	11	10.36
Number of Basis Stimuli	3	10	8.72
Number of Judgements	241	487	432.36
Parameters of Subject Response			
Judgement Reliability	.150	.927	.666
Average Proximity	5.20	8.70	6.87
Variability of Proximities (Standard Deviation)	0.67	2.63	1.93

Subjects apparently found the blots more dissimilar than similar in general, as the average proximity of 6.87 (see Table 1) was well above the midpoint of the scale. Typically less than the full scale range was relied upon (the score of 1 was given rather infrequently) making the scale effectively 8 points in range for most subjects, with scores beyond 8 points in range occurring less than 5% of the time. Based on the 25 replicated judgements for each subject, reliability ranged from poor to very good (see Table 1), with a median value of 0.672.

The proximity data from the INTERSCAL program was in the form of 45 by 45 symmetrical matrices, with zeros in the diagonals and zeros entered for all missing data. Whereas matrices with missing data were not suitable for entry into metric MDS programs which were intended for later use, the next step of the analysis was a series of procedures aimed at replacing the missing data with estimated distances recovered from a MDS analysis of the available data with a nonmetric MDS program capable of handling large amounts of missing data. The completed matrices would then be suitable to analysis by either metric or nonmetric programs.

Replacement of missing distances. A flexible nonmetric MDS program, KYST (Kruskal, Young and Seery, 1972), was employed to recover an initial dimensional configuration for each subject based on the incomplete distance matrix. To ensure the best estimate of the missing values as derived from the information available in the collected judgements, all configurations were solved for in 6 dimensions, the maximum dimenstionality of the KYST program.

The KYST program provides measures of "stress", which correspond to the goodness of fit of the recovered dimensional solution to the original data values. The stress formula requested in the program options was the variance-like expression:

$$\sqrt{\frac{\sum_{M=1}^{MM}(\mathrm{DIST}(M) - \mathrm{DHAT}(M))^2}{\sum_{M=1}^{MM}(\mathrm{DIST}(M) - d_o)^2}}$$

where M is an index of all interpoint distances, MM equals 990 in this case, DIST(M) is the observed interpoint distance, DHAT(M) is the interpoint distance estimated in the monotonic regression of the program, and d_o is the arithmetic average of the DIST values.

It should be noted that this formula was chosen as it produced fewer difficulties in the process of minimizing stress to arrive at a final configuration. With either formula, the program dealt at some points with extremely small denominators representing the gradient of change, which were effectively considered as divisions by zero in the computer system employed. The stress values in the second formula are somewhat higher than the corresponding values in the alternative formula, which differs only in the use of a zero for the value of d_o in the expression above. The correspondence between the two indices of stress is very close at low stress values, but form 2 becomes progressively conservative at higher values. This distinction should make only negligible differences in the nature of the configuration arrived at by minimizing either stress index, but may be important in interpreting the goodness of fit of dimensional solutions.

The six dimensional solutions for each subject ranged in goodness of fit from stress values of 0.004 to 0.235, with a median value of 0.106. Taken as figurative indices of the amount of unexplained variance in the dimensional solution, the typical stress values were encouraging, with some configurations fitting the observed interpoint distances extremely well. The stress values from the KYST solution were found to be only lowly correlated with the INTERSCAL reliability index ($\underline{r}$ = .199, $\underline{p}$ = .11), suggesting that the accuracy of fit of the dimensional solution was not notably influenced by the consistency in repeated judgements of proximity.

The KYST program also provides the normalized loadings of each stimulus point on each dimension. This information can be directly used to find all estimated interpoint distances in the recovered dimensional space. For any two points--or blots in this case--the distance between them in the six dimensional space equals the square root of the sum of squared differences in loadings on each dimension. In equation form, the interpoint distance in general is equal to

$$\sqrt{\sum_{I=1}^{D}(L_{(I)} - L'_{(I)})^2}$$

where L and L' are the loadings on dimension I for point 1 and point 2 respectively, with the number of dimensions employed equaling D, or 6 in the present case.

A FORTRAN program was composed which recovered the interpoint distances for all originally missing distances using the above formula. However, since the KYST configuration was normalized, the scale of measurement of the recovered distances was different from the original 1 to 9 scale. Usually such standardized distances would be converted to the raw scale by simply multiplying the standard distances by the ratio of the raw scale standard deviation to the standard deviation of the normalized scale. In the present case this procedure is questionable, however, as the variance of all scores in the raw scale is unavailable, and must instead by estimated by the 41% of distances originally present in the raw scale. If the 41% of data present were an unbiased sample of all 990 values, it could be argued that the variance of the present values would be an unbiased estimator of the variance of all 990 values if they were accessible. But again in the present case, the selection of essential distances to be collected was accomplished by the INTERSCAL procedure, which selected the values to be solicited from subjects on the basis of providing the most critical information for locating the points in a dimensional structure. This would not seem to be equivalent to a random sampling procedure. In fact, since most judgements solicited include a stimulus point from the basis set of outliers, it might be expected that the variance of collected judgements overestimates the hypothetical variance for all 990 proximities.

An alternative procedure was developed which replaced missing data with a raw scale value which most accurately represented each subject's corresponding value in the standardized scale. A fortran program was written to replace missing values in the upperhalf matrix in the above manner (to be referred to as "representative replacement"), replace values in the lowerhalf matrix with distances estimated by the "ratio of standard deviations" method (for use in an empirical check on comparability of the two procedures), and provide a listing of all estimated distances and various descriptive information (see Appendix I for the complete program listing).

The representative replacement method involves several phases of analysis which will be described below:

(1) All estimated interpoint distances are calculated on the basis of a configuration of loadings on six dimensions.

(2) For each raw scale value (e.g., 1 through 9), the estimated distances corresponding to each observed, originally solicited distance of that magnitude are averaged. Thus, the first step would be to average all estimated distances corresponding to observations of value 1 in the incomplete data half matrix. The list of most typical estimated distances for each raw scale value are listed in the printed output.

(3) Since some raw scale values are used very rarely by some subjects, it is possible for the values of the typical distances for such infrequently used raw scale values to be out of order. That is, the rank order of the typical distances may not correspond to the 1 to 9 raw scale values. Inspection of the values for several subjects indicated that this was occasionally the case, usually involving the most extreme raw scale values, which were used least frequently. The program therefore checks the rank order of the averaged estimated distances, and substitutes a value of 99.0 for averages which are out of order, which effectively eliminates that value from use in the data replacement process. When the ascending rank is found to be incorrect, the program compares the first averaged distance encountered which is out of order and the immediately preceeding averaged distance. The value which is based on a larger number of observations is then kept, and the other value is assigned a new value of 99.0. In the case of ties in the number of constituting observations, the less extreme value is kept.

(4) Each estimated distance which corresponds to a missing value in the original incomplete distance matrix is then assigned a raw scale value most representative of the subjects' standardized scale. The averaged estimated distance closest to the given estimate to be converted is taken as most representative, and the rank of the closest averaged distance is substituted in the raw scale distance matrix for the corresponding missing value. In the case of ties,

(a) the averaged distance based on the largest number of observations, or secondarily, (b) the less extreme rank is favored.

An empirical check was run on the comparability of the two methods described for replacing missing values. A third method was also compared which simply replaced missing values with the arithmetic average of all reported distances, as it was considered to be a very conservative procedure which would contribute no systematic bias toward the dimensional solution to be recovered. The major criteria of comparison were (a) the comparability of stress values for a nonmetric KYST solution based on the completed matrix to that of the original incomplete matrix, and (b) the correspondence of dimensional loadings. The latter was evaluated by correlating the dimensional loadings of the blots from one solution with the loadings in each other solution, for all 4 distance matrices compared. Six-dimension nonmetric KYST solutions were used for all comparisons, based on the proximity judgements of the first subject only.

As shown in Table 2, the results of the comparison suggest that the mean replacement approach results in very poor fit, and low correspondence to the original dimensional structure. Both the standard deviation ratio and the representative replacement produced high correspondence of loadings to the original configuration. The representative replacement clearly resulted in the closest approximation to to the original goodness of fit, which adds empirical support

Table 2

Comparisons of Missing Data Replacement Methods[a]

Replacement Method	Stress[b]	Correlation with Original Dimension Loadings					
		I	II	III	IV	V	VI
Arithmetic Average	.823	.91	.76	.83	.85	.71	.56
Standard Deviation Ratio	.157	.96	.94	.98	.98	.98	.95
Representative Replacement	.040	.98	.95	.96	.98	.99	.98

[a]Based on the data for Subject 1 only.

[b]The original stess value was 0.058.

to the decision to replace missing data by that method for all subjects.

Total group configuration. The INDSCAL procedure which is to be used to recover individual difference information normally requires only the input of the distance matrices to be compared, and will proceed to arrive at an overall configuration as well as saliences or weights on each dimension for each subject. However, with the present number of stimulus objects, only 8 subjects can be processed at one time within the limitations of the program. Separate runs for groups of 8 or less in the above fashion would result in subject saliences which were independently normalized in subgroups and thus the saliences would not be strictly comparable, nor could they be used to construct a single map of the subject space for all 39 subjects.

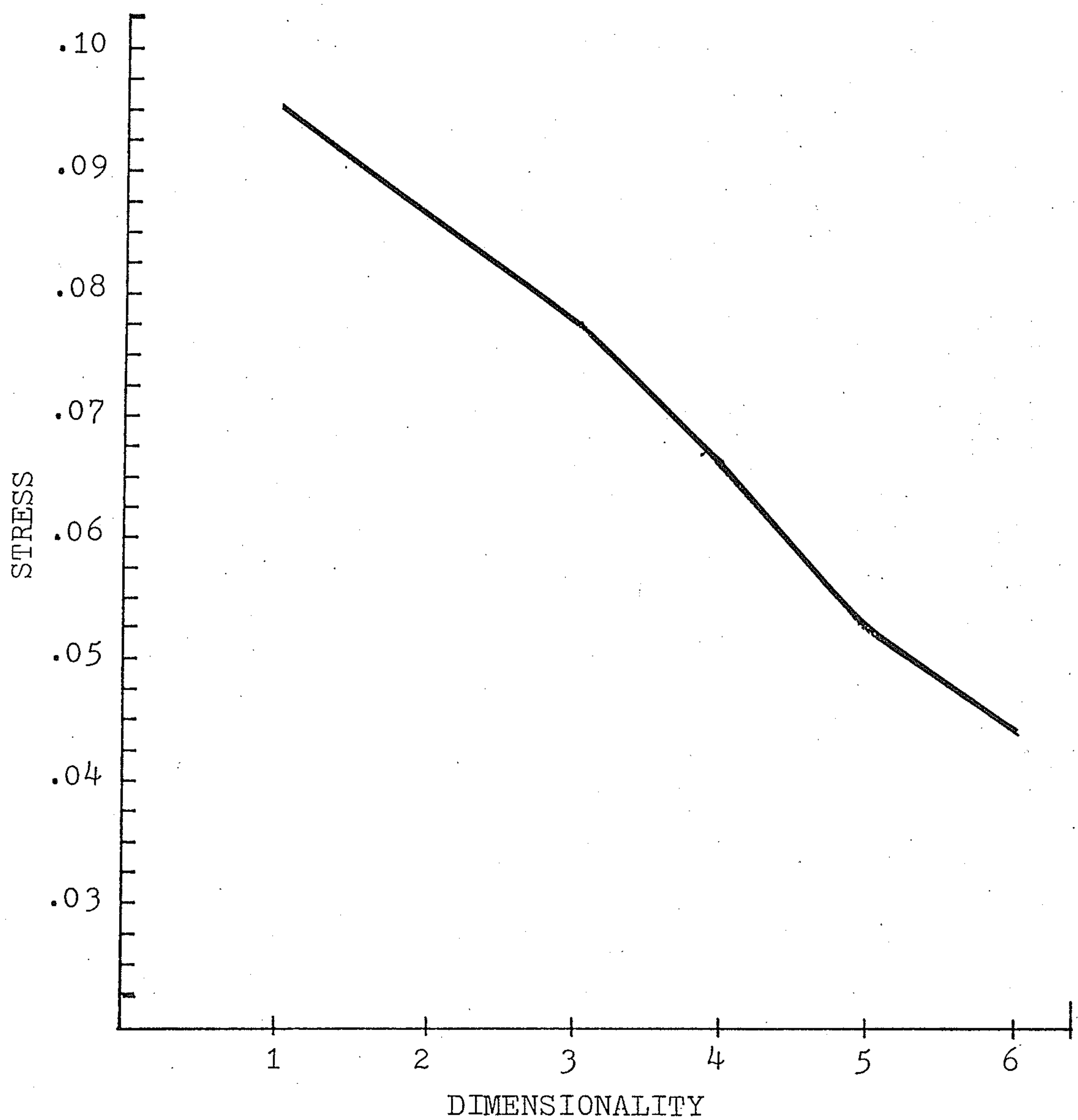
An alternative approach was thus employed, which simply submits a single starting configuration to all INDSCAL runs, from which comparable subject saliences can be solved for. The most suitable starting configuration would therefore, be one derived from a matrix of interpoint distances averaged across all subjects. Each unique entry in the matrix would be the arithmetic average of that entry for all 39 subjects, and thus the proximity data for all subjects would be represented, in equal proportion, in the averaged distance matrix.

The latter approach was employed, and a distance matrix of averaged interpoint distances (referred to as the TOTAL matrix) was constructed with a FORTRAN program. In the next step of obtaining a MDS configuration from the TOTAL matrix, another issue was considered. Up to this point the nonmetric KYST scaling had been used, but INDSCAL on the other hand is based on metric procedures. Given no clear indication of whether a metric or nonmetric solution was called for, both analyses were run in the KYST program for 6 through 1 dimensions.

The solutions derived nonmetrically clearly resulted in superior fit at all dimensionalities. The metric solution at 1 dimension produced a stress of .702, and even at the highest dimensionality of 6 the metric-based stress of .313 exceeded the highest stress (.095 for a 1 dimensional solution) obtained from the nonmetric analysis. For both analyses the intercorrelations between dimensions were all .01 or less. A plot of stress by dimensionality for the nonmetric analysis (see Figure 2) revealed a basically linear decrease in stress through 6 dimensions, with the best fit reaching a stress of .044 in six dimensions. The clear superiority of fit yeilded by nonmetric scaling lead to a decision to use a nonmetric solution as the starting configuration for INDSCAL runs. Since no clear bend in the curve in Figure 2--signifying a point of diminishing gain in higher dimensionality--was evidenced, the highest dimensional solution was used as the starting configuration.

Before subject configurations were submitted to INDSCAL for comparison to the TOTAL configuration, a check was made

Figure 2. Dimensional Reduction in Stress for the Total Group Configuration



for PRE and POST group differences. If, in fact, PRE-POST differences existed such that dimensional solutions derived from PRE or POST group averaged distance matrices differed notably from the TOTAL group configuration, it might be necessary to use separate starting configurations for PRE and POST subject INDSCAL analyses, in spite of the restrictions it would place on generalizability.

PRE-POST configurational differences were assessed by submitting the two PRE and POST averaged distance matrices as two "subjects" in an INDSCAL analysis using the TOTAL group configuration as the starting configuration. Differences in configuration between the two groups would then be evidenced in discrepancies between the two sets of dimension saliences solved for. The normalized saliences produced in such an INDSCAL analysis in 6 dimensions (see Table 3) were quite similar, with no pair of saliences differing by more than 21%. The actual distance between the PRE and POST points in the 6 dimensional space was .069 units in the normalized scale. This interpoint distance compares in magnitude to the heaviest salience as a ratio of 1 : 10, and is roughly half the magnitude of the smallest salience. Thus it appears that the overall configurations for the PRE and POST groups differ little in the scale dealt with. There are some differences at the level of specific dimensions, most notably an apparent trend toward lower dimensionality in the post group. The loading patterns are, however, insufficiently different to warrant separate PRE-POST analysis of individual

Table 3

PRE - POST Configurational Differences

Group	Normalized Dimension Saliences					
	I	II	III	IV	V	VI
PRE	.692	.239	.217	.180	.176	.147
POST	.680	.263	.256	.216	.158	.116

differences, since the small group fluctuations will be evidenced at the individual salience level and thus can be dealt with after comparison to the TOTAL group configuration. The loadings for each blot in the 6 dimensional configuration which will be used as the initial configuration are presented in Table 4.

Since the analysis of individual differences stems directly from solutions derived from the TOTAL group starting configuration, the next phase of investigation is to search for subjective meaning in the TOTAL configuration of blots. The process of labelling dimensions is likely to involve the remaining data collected in the group administration of the HIT, and therefore the characteristics of that data will next be attended to.

The HIT group data. The responses to all 45 blots were scored manually by the present experimenter, for the 20 HIT variables typically scored in group administrations (Swartz and Holtzman, 1963). A random number was assigned to each response booklet to replace all identifying information, and scoring was done in the order of the random numbers, making the scorer blind to any characteristics identifying the protocols at the time of scoring. The scores for each blot on each variable were recorded individually to facilitate later analysis (see Appendix J for random subject I.D.'s).

A second experimenter also rated 4 (10%) of the subject response profiles as an inter-rater reliability check. Reliability was calculated for each variable using the Pearson

Table 4

Blot Loadings on Six Dimensions

HIT Blot	Dimension					
	1	2	3	4	5	6
1	-.493	-.368	.318	.011	.034	-.311
2	-.203	-.619	-.228	.272	-.051	.038
3	-.475	-.154	-.039	-.163	.188	-.308
4	-.102	-.075	-.156	.526	.475	-.113
5	1.954	.038	.006	.004	-.022	.083
6	-.240	.185	-.084	-.046	.087	-.266
7	-.072	-.719	-.134	-.444	-.077	.008
8	-.104	-.132	-.096	.273	.789	-.290
9	-.101	.160	.467	-.089	-.319	.237
10	.092	-.289	-.473	-.162	.130	.549
11	-.439	.321	.508	-.198	.329	-.009
12	-.340	-.277	-.395	.488	-.257	-.148
13	2.074	.272	-.255	.181	.225	-.220
14	-.241	-.069	-.002	-.231	-.278	-.080
15	-.593	.382	.056	.403	.308	.210
16	-.278	.214	-.543	-.790	-.046	-.169
17	-.560	.232	-.229	-.071	.124	-.084
18	-.482	-.267	.242	-.328	.014	.039
19	-.452	-.141	-.452	.343	-.362	.094
20	-.178	.324	-.387	.005	-.623	-.087
21	-.360	.107	-.078	.323	-.103	-.072
22	.063	-.201	.360	-.371	.361	.204

Table 4 Continued

HIT Blot	Dimension					
	1	2	3	4	5	6
23	-.331	.287	.593	.254	-.126	.490
24	1.368	-.367	.291	-.069	-.081	-.191
25	-.623	.309	-.208	.045	-.118	.338
26	-.482	.079	.391	.283	.092	-.286
27	-.529	-.243	-.179	.017	.061	.101
28	-.117	.828	-.490	.215	.199	-.135
29	.108	-.187	.387	-.207	.078	-.264
30	1.667	.178	.508	.325	-.275	.573
31	-.412	.153	.307	.078	-.465	-.146
32	.041	-.517	.022	-.443	-.155	.087
33	2.078	.264	-.160	-.131	-.193	-.258
34	-.505	-.095	-.363	.343	-.170	.289
35	-.678	.356	.263	.303	-.090	-.008
36	-.110	-.065	.571	.109	.453	.106
37	-.152	-.332	.290	-.070	-.284	.061
38	-.027	-.162	.329	-.103	-.137	-.115
39	-.555	.014	-.158	.176	-.570	-.355
40	-.510	.132	.474	-.203	-.083	-.209
41	.072	-.434	-.141	.341	.265	-.027
42	-.271	.802	-.198	-.604	-.006	.096
43	1.702	.052	-.127	.014	.005	-.105
44	-.310	.535	-.174	-.461	.397	.219
45	.104	-.511	-.628	-.150	.277	.436

Product-Moment Coefficient, based on each blot's scores rather than total scores per subject. Thus the reliability coefficient for each variable was based on agreement in 180 observations (45 blots x 4 subjects). The reliability coefficients for all 20 variables are presented in Table 5. Reliabilities varied from .70 for Integration to 1.00 for Rejection, Sex, and Abstract, with a median value of .90.

Since norms are available for HIT total scores, the comparability of the present distribution of scores to standardization populations is feasible. Table 6 compares the present means for each variable to the average scores for college students given in the HIT manual. For each variable, the number of subjects who obtained a total score above the 90th percentile and the number who scored below the 10th percentile are also given.

Table 6 indicates that most scores fell in a range close to that of the standardization group. If the standard error of measurement for the sample is used to assess the extent of deviation of variable means, only the means for FD, C, Sh, I, A, B, PN, and P differ from the standardization means (taken as population parameters) by an extent likely to occur less than 1% of the time by chance. The trend of differences is toward lower scores in the present sample except for FD and A, which were higher. In each of the 8 instances of noteworthy deviation, the number of observations in the 10% upper or lower extremes is shifted from the expected symmetry in the same direction as the

Table 5

Inter-rater Reliability

HIT Variable	Abbreviation	Inter-rater Reliability
Rejection	R	1.00
Location	L	.84
Space	S	*
Form Definiteness	FD	.90
Form Appropriateness	FA	.75
Color	C	.80
Shading	Sh	.82
Movement	M	.94
Pathognomic Verbalization	PV	.71
Integration	I	.70
Human	H	.98
Animal	A	.96
Anatomy	At	.91
Sex	Sx	1.00
Abstract	Ab	1.00
Anxiety	Ax	.85
Hostility	Hs	.95
Barrier	Br	.85
Penetration	Pn	.83
Popular	P	.96

*Not scored by at least one rater.

Table 6

HIT Descriptive Statistics Comparison[a]

HIT Variable	Standardization Mean	Persent Mean	Standard Deviation	No. Below Tenth Percentile	No. Above Nintieth Percentile
R	.88	1.85	2.43	*	12
L	23.68	25.46	11.26	8	3
S	.58	.90	1.25	*	11
FD	80.39	86.95	14.83	0	6
FA	44.04	42.00	4.69	7	4
C	23.80	19.69	8.46	6	2
Sh	17.63	14.28	6.50	7	0
M	42.01	37.74	14.45	6	1
PV	6.26	11.15	15.45	*	7
I	11.08	6.87	4.21	7	0
H	26.00	29.77	9.50	0	8
A	23.00	27.92	6.29	0	10
At	3.28	4.08	2.77	*	11
Sx	.37	.95	1.40	*	19
Ab	1.92	1.74	6.25	*	2
Ax	12.18	11.92	6.43	4	3
Hs	13.06	11.85	5.63	2	2
Br	8.86	6.72	3.55	7	1
Pn	6.16	4.39	2.51	5	0
P	11.03	9.69	2.57	3	2

[a] Comparisons are made to the college student standardization described in Holtzman et al., 1961.

*More than 10% scored zero on this variable in standardization.

deviation of the mean. This would suggest that the distributions of scores were not changed dramatically but simply shifted up or down--an important point given that the major present interest is discriminating relative performance among subjects.

From the demographic data collected it was determined that 13 of the 39 subjects spoke some variation of Chinese and had spoken Chinese as their first language. It was also noted during the HIT scoring that somewhat more extreme ratings seemed to co-occur with apparent difficulty with the English language. Given the above and the extent of deviation of the present sample's HIT variables, separate descriptive statistics were run for the group of Chinese first language subjects (referred to as CH-1ST) and a group of 22 subjects who reported English as the first language (referred to as ENG-1ST). The results (see Table 7) indicated that most of the deviation reflected in total group means was indeed contributed by the CH-1ST group. In the ENG-1ST group, only Integration and Animal remained in the category defined as significantly different, while in the CH-1ST group 6 differences remained in that category, with the FA mean also proving more deviant. With regard to the standardization means taken as comparison points, I and A seem to be the deviations most suggestive of a relevant difference either in the present sample or in scoring, since the ENG-1ST group is the most representative of the standardization population. The differences between the two groups are most suitable for

Table 7

HIT's Broken Down by First Language Spoken

HIT Variable	Standardization Average	English First		Chinese First	
		Mean	Std. Dev.	Mean	Std. Dev.
R	.88	1.50	2.09	2.77	3.00
L	23.68	27.32	12.09	21.92	10.74
S	.58	.96	1.01	.62	1.33
FD	80.39	86.73	15.72	86.92	13.07
FA	44.04	42.91	5.32	40.08*	3.69
C	23.80	22.00	8.92	15.23*	6.15
Sh	17.63	15.18	6.05	11.69*	5.99
M	42.01	37.59	14.48	39.23	15.65
PV	6.26	12.41	19.51	10.23	8.74
I	11.08	7.18*	4.51	6.39*	3.23
H	26.00	29.67	9.25	30.00	10.33
A	23.00	27.32*	4.75	28.15	7.27
At	3.28	4.36	2.40	3.93	3.52
Sx	.37	1.27	1.70	.54	.78
Ab	1.92	2.18	8.05	1.23	2.89
Ax	12.18	13.18	7.67	10.54	4.24
Hs	13.06	12.82	5.71	10.62	6.04
Br	8.86	8.00	3.41	4.39*	2.82
Pn	6.16	5.27	2.31	2.69*	1.70
P	11.03	9.55	2.79	9.69	2.43

*Difference is likely to occur less than once in 100 times by chance.

multivariate analyses, but the present ratio of variables to subjects (1 : 1.75) would lead to serious question of the consequential capitolization on chance. Alternatively, first language differences will be further explored at a later point with the use of a more manageable number of factor composite scores as well as in analysis of MDS configuration differences.

In the formation of factor composites, the present number of subjects and variables again prohibited a reasonable factor analysis of the present data. In order to attempt a reduction in the number of variables in contention, 6 factor composite scores were thus derived using weights provided from the standardization groups, as given in Holtzman et al, 1961.

Arriving at a dimensionality. Several criteria were considered in the decision of what dimensionality to deal with and interpret. Foremost were two major concerns: (a) the number of dimensions meaningfully interpretable, and (b) the importance of each dimension to explanations of subject differences. The latter concern was first dealt with by solving for subject salience weights on each dimension in the INDSCAL program. The first 32 subjects were run in groups of 8, and the last 7 comprised the final group. The weights for each subject on all 6 dimensions are provided in Table 8, as well as the correlation of fit for each subject--the INDSCAL inverse analog to KYST's stress.

Table 8

Subject Dimension Saliences

Subject	Corr. of Fit	Subject Dimension Loadings					
		1	2	3	4	5	6
1	.472	.303*	.081	.197*	.268*	.074	.086
2	.510	.401*	.259*	.119	.080	.096	.048
3	.554	.478*	.189*	.109	.030	.106	.137
4	.508	.360*	.158*	.229*	.135	.099	.151*
5	.638	.510*	.247*	.177*	.102	.181*	.091
6	.621	.464*	.282*	.206*	.162*	.103	.106
7	.536	.389*	.227*	.147	.205*	.130	.057
8	.253	.143	.070	.082	.071	.135	.093
9	.398	.331*	.092	.082	.132	.114	.051
10	.428	.204*	.127	.172*	.218*	.183*	.121
11	.598	.535*	.101	.157*	.126	.101	.102
12	.483	.292*	.164*	.220*	.155*	.203*	.082
13	.556	.414*	.179*	.181*	.152*	.158*	.156*
14	.587	.513*	.199*	.131	.134	.062	.057
15	.401	.342*	.107	.056	.085	.078	.127
16	.446	.362*	.199*	.069	.089	.102	.068
17	.323	.140	.136	.113	.114	.170*	.110
18	.471	.354*	.063	.238*	.084	.122	.119
19	.621	.451*	.192*	.205*	.285	.105	.108

*Loadings greater than .150 are starred.

Table 8 Continued

Subject	Corr. of Fit	Subject Dimension Loadings					
		1	2	3	4	5	6
20	.561	.410*	.174*	.212*	.183*	.110	.161*
21	.366	.202*	.241*	.051	.110	.121	.076
22	.574	.338*	.203*	.282*	.239*	.158*	.112
23	.479	.297*	.193*	.173*	.193*	.133	.138
24	.463	.314*	.260*	.088	.133	.074	.129
25	.386	.297*	.138	.101	.112	.082	.111
26	.604	.457*	.259*	.240*	.144	.066	.081
27	.438	.291*	.147*	.100	.210*	.162*	.075
28	.550	.502*	.105	.115	.112	.072	.093
29	.451	.218*	.253*	.196*	.180*	.119	.079
30	.481	.357*	.170*	.086	.108	.233*	.045
31	.494	.321*	.146	.203*	.155*	.207*	.107
32	.536	.304*	.224*	.308*	.171*	.109	.093
33	.643	.543*	.222*	.215*	.088	.079	.096
34	.513	.408*	.085	.214*	.187*	.070	.069
35	.518	.343*	.313*	.156*	.105	.099	.087
36	.381	.216*	.192*	.164*	.099	.110	.113
37	.562	.442*	.200*	.167*	.178*	.121	.081
38	.534	.460*	.163*	.129	.080	.102	.114
39	.535	.468*	.086	.196*	.096	.073	.083

*Loadings greater than .150 are starred.

According to the heavier saliences which are starred in Table 8 , there is a steady decline in reliance upon higher dimensions. Dimension 1 is loaded heavily for almost all subjects, and the bulk of heavy loading are accounted for by the first 3 or 4 dimensions. Interestingly, the two subjects (8 and 17) who depart most from this trend also have the lowest correlations of fit. The cutoff of .150 is essentially arbitrary, corresponding to 9% of the average variance explained by the configuration per subject, and roughly 50% of the average variance per subject per dimension. Considering this criterion of loadings which contribute at least half as much as the typical dimensional loading, 3 to 4 dimensions seems to be the area of diminishing gain in higher order. However, 28% of the subjects load .150 or more on at least one dimension beyond the fourth, and 49% use at least one dimension beyond the third by these standards. Since the cutoffs are subjective in nature, it is difficult to make a clear decision about the highest dimensional necessary to maintain the critical information.

The total variance explained is also broken down in Table 9 according to dimensions. Dimension 1 again proves to be dramatically dominant, accounting for 56% of all explained variance. The point of diminishing gain from higher dimensionality seems to clearly fall at either 3 or 4 dimensions. With four dimensions, the comfortable figure

Table 9

Subjects' Usage of Dimensions

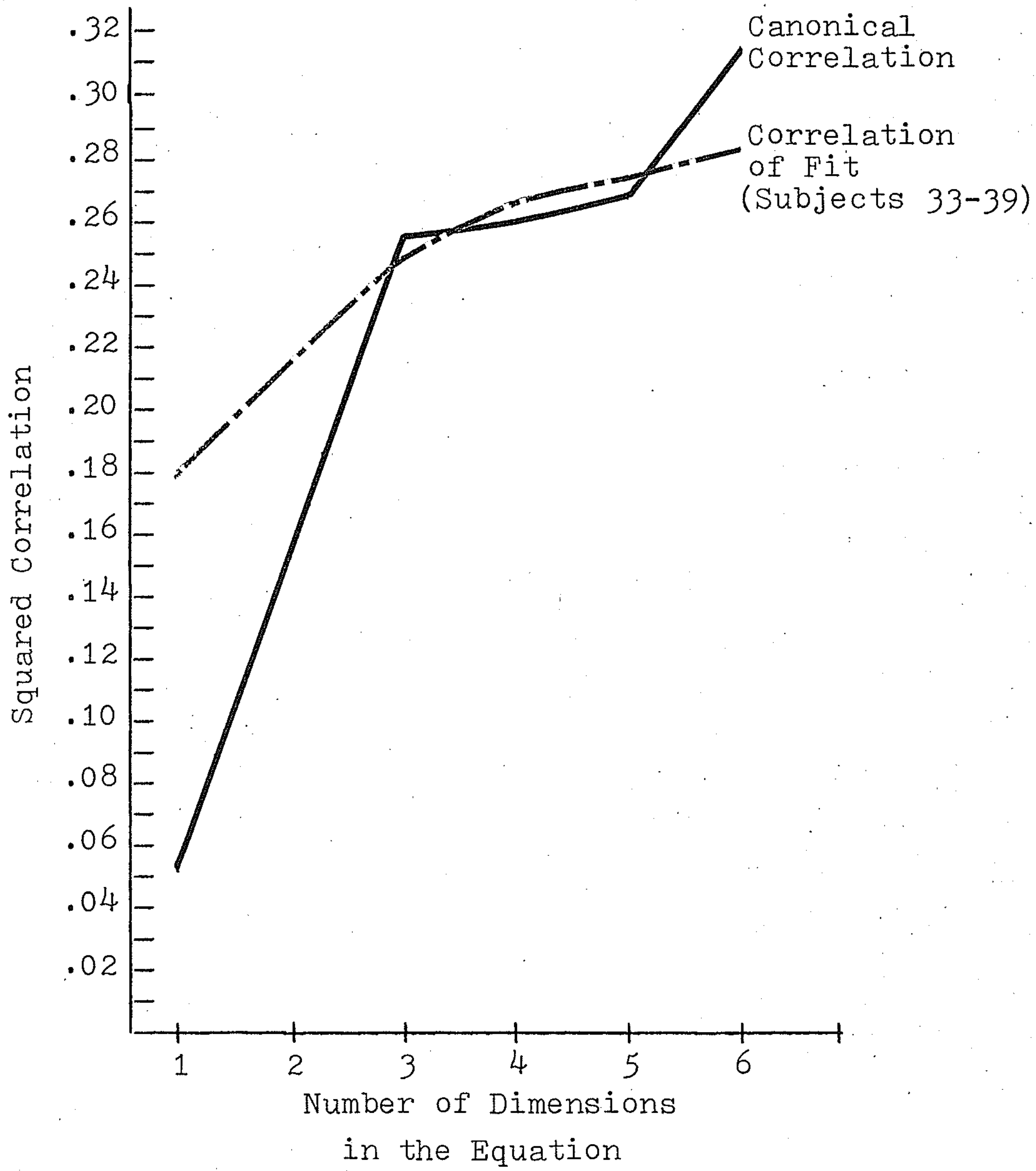
Criterion	Dimension 1	2	3	4	5	6
Subject Saliences Exceeding .150						
Subjects With "Exceeding" Saliences	37	26	23	16	9	3
Percentage of all 39	95%	67%	59%	41%	23%	8%
Subject Salience Variance						
Total Variance of Saliences	5.580	1.359	1.119	.898	.617	.405
Percentage of all Explained Variance	56%	14%	11%	9%	6%	4%
Cumulative Percentage	56%	70%	81%	90%	96%	100%

of 90% of explained variance is accounted for, although the gain from 3 to 4 dimensions is only 9%.

A third criterion is the correlation of fit, which more directly assesses the ratio of predicted to <u>residual</u> (unpredicted) variance. Since the cost of running all subjects through complete 1 through 6 dimensional solutions is prohibitive, a subgroup--the last 7--of the subjects were chosen to run through all six dimensionalities. A plot of dimensionality against the overall squared correlation of fit for the 7 subjects is shown in Figure 3. The same figure also depicts a plot of the squared canonical correlation between the six Holtzman factor scores and the dimensional loadings on 1 through 6 dimensions for all subjects. The plot of the 7-subject squared correlation shows noticable changes in slope at only 3 and 4 dimensions, with a slightly larger change in slope at 4 dimensions. The squared canonical correlation shows a change to nearly zero slope at 3 dimensions, and then an upswing in predictability with the addition of the 6th dimension.

It seems that the internal criteria of subject loading patterns, proportions of variance accounted for per dimension, and the reduction of goodness of fit in lower dimensions all point to 3 or 4 dimensions as a point of diminishing gain, but none of the three clearly distinguish between 3 or 4. On the basic of these criteria alone, it might be safest to err liberally and interpret 4 dimensions. The canonical correlation between factor scores and dimension loadings,

Figure 3. Dimensional Correlation of Fit and Canonical Correlation to Holtzman Factor Scores



however, suggests that the fourth dimension provides little information about the blots which pertains to their more traditional use. Since the correspondence of MDS information to more traditional HIT information is a central guideline to the present study, dimension importance measured by this external criterion is especially relevant.

A compromise was pursued which speaks to both parsimony and maximum recovery of information. The three dimensional structure was adopted for purposes of primary interpretation and graphical representation. The higher dimensions will be dealt with at a later point by analyses of distinguishing characteristics of subjects who load heavily on each, to determine if information valuable in a more clinically qualitative sense is contributed by dimensions beyond the third.

Interpretation of the 3 dimensional blot space. A nonmetric solution for the 3 dimensional configuration was desired as it was proven more suitable than a metrically derived starting configuration in earlier comparisons. Unlike the metric approach which employs a principal component extraction procedure the nonmetric KYST program can provide loadings in a 3 dimensional solution which differ from the first 3 dimensions recovered in a higher dimensional solution. The KYST program also rotates the solution, which compounds differences in loadings. Therefore a new 3 dimensional solution was derived nonmetrically, and used as a starting configuration in 3 dimensional INDSCAL runs for all subjects.

The loadings for each blot on the 3 dimensions are presented in Table 10, and the subject saliences are presented in Table 11. The stress value of 0.078 is not meaningfully higher than the stress in 6 dimensions, which was 0.048. The comparability of the two 3 dimensional solutions is further, and more directly assessed by comparing the loadings of the blots on each respective pair of dimensions. Visual inspection reveals noticable differences in loadings from the two solutions, especially for blots loading heavily. Table 12 lists the blots which fall at the extremes of each of the dimensions in both the 6 and 3 dimensional solution, which reveals only minor differences between the two 3 dimensional configurations. Dimensions 2 and 3 have switched polarity and order, and this higher variance accounted for by the former 3rd dimension is reflected in the per cent of total predictable variance of subject saliences for each of the three new dimensions (55%, 13%, and 11%, respectively, based on the variability predicted in 6 dimensions). Since essentially the same three dimensions seem to be represented in both solutions, interpretation should not be qualitatively different in proceeding to use the 3 dimensional solution's configuration.

The 3 dimensional blot space is represented graphically in Figure 4. The blots are clearly separated most extremely along dimension 1, with a few of the blots at the positive extreme being distinguished from the rest and loaded very little on either of the other dimensions. These positive

Table 10

Blot Loadings on Three Dimensions

Blot	Dimension 1	Dimension 2	Dimension 3	Blot	Dimension 1	Dimension 2	Dimension 3
1	-.446	-.148	.220	24	1.877	-.030	.014
2	-.373	.206	.324	25	-.682	-.009	-.061
3	-.327	-.024	.076	26	-.470	-.272	-.011
4	-.099	.147	-.145	27	-.483	.126	.094
5	2.424	-.002	.021	28	-.478	.167	-.605
6	-.426	-.043	-.047	29	.030	-.129	.036
7	-.219	.095	.455	30	2.228	-.513	.082
8	.040	.139	-.214	31	-.556	-.146	-.008
9	-.189	-.284	-.096	32	-.109	-.043	.369
10	-.110	.445	.153	33	2.647	.106	-.125
11	-.351	-.346	-.103	34	-.699	.093	.116
12	-.510	.276	.168	35	-.587	-.252	-.136
13	2.658	.232	-.052	36	-.245	-.415	.185
14	-.345	.063	.037	37	-.276	-.091	.258
15	-.659	-.297	-.060	38	-.184	-.146	.107
16	-.301	.547	-.280	39	-.661	.246	-.053
17	-.484	.067	-.182	40	-.324	-.216	-.073
18	-.387	-.125	.105	41	-.177	.211	.223
19	-.628	.237	.119	42	-.404	-.043	-.617
20	-.582	.227	-.251	43	2.267	.101	-.058
21	-.493	.073	-.029	44	-.307	-.018	-.391
22	-.010	-.087	.144	45	-.178	.511	-.305
23	-.433	-.636	-.014				

Table 11

Subject Saliences in Three Dimensions

Subject	Dimension 1	Dimension 2	Dimension 3	Subject	Dimension 1	Dimension 2	Dimension 3
1	.297	.093	.147	21	.194	.030	.145
2	.367	.303	.089	22	.330	.244	.213
3	.463	.169	.105	23	.306	.202	.187
4	.356	.119	.205	24	.309	.102	.102
5	.515	.239	.181	25	.282	.079	.117
6	.457	.256	.204	26	.466	.244	.218
7	.389	.216	.133	27	.290	.068	.132
8	.138	.073	.064	28	.509	.120	.083
9	.323	.071	.094	29	.212	.185	.191
10	.201	.136	.124	30	.363	.074	.163
11	.552	.148	.094	31	.312	.152	.161
12	.285	.234	.185	32	.295	.323	.174
13	.406	.206	.144	33	.533	.197	.240
14	.520	.131	.176	34	.422	.062	.170
15	.359	.076	.102	35	.345	.295	.151
16	.361	.061	.187	36	.196	.171	.217
17	.143	.115	.097	37	.445	.223	.174
18	.362	.248	.049	38	.458	.177	.094
19	.435	.212	.304	39	.476	.096	.171
20	.403	.214	.139				

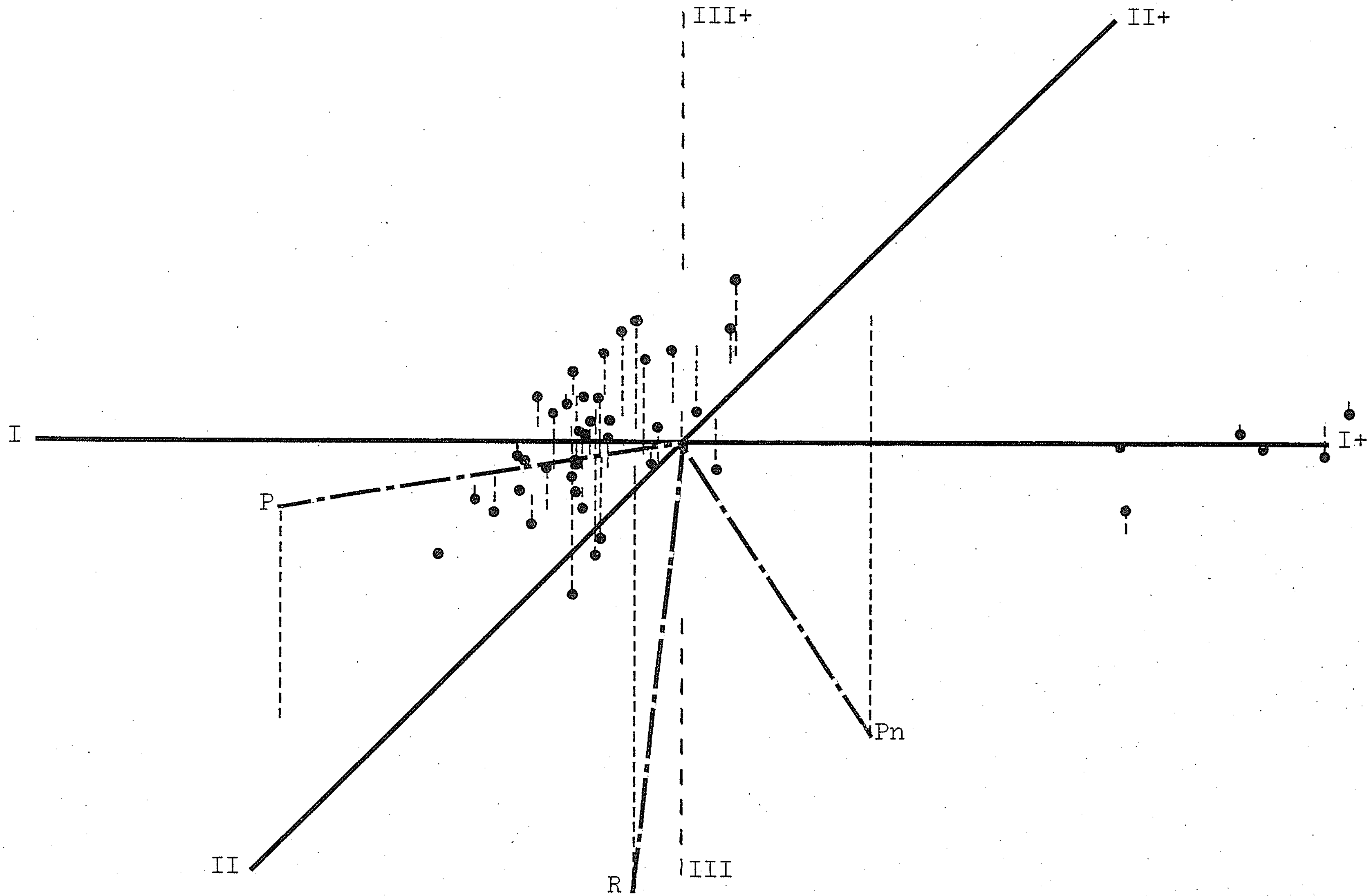
Table 12

Blot Configuration Outliers

Dimension	Positive Outliers[a]		Negative Outliers[a]	
	Blot Number	Maximum Loading	Blot Number	Maximum Loading
	Six Dimensional Solution			
1	33, 13, 5	2.078	35, 25, 15	-.678
2	28, 42	.828	7, 2	-.719
3	23, 36	.593	45, 16, 28	-.628
4	4, 12, 15	.526	16, 42	-.790
5	8	.789	20, 39, 31	-.623
6	30, 10, 23	.573	39, 1, 3	-.355
	Three Dimensional Solution			
1	13, 33, 5	2.658	25, 34, 39	-.682
2	16, 45, 10	.547	23, 30, 36	-.636
3	7, 32, 2	.455	42, 28	-.617

[a]The heaviest loaded blots are given in descending order, unless fewer than three are clearly the outliers.

Figure 4. The 3 Dimensional Blot Space



outliers for dimension 1 (see Table 12) are blots which are visually characterized as speckled, hazy, or fuzzy in appearance. Such blots often are perceived globally as dust, dirty snow, etc. Although the rest of the blots are not as well discriminated along the first dimension, the most negative outliers do seem to be distinguished by solid coloration and sharp contrast, giving an appearance of clarity and distinction. It appears that dimension 1 then represents an inverse, achromatic scale of clarity or contrast. Since the purity or solidity of colored areas seems to be an obvious element in the negative outliers, the term "contrast/clarity" will be favored as the label for the first dimension.

Dimension 2 seems to be a function of visual density. Blots loaded positively are dark, opaque and solid, whereas negatively loaded blots are spacious, spread out, and of translucent or vague hues, with typically large areas of white space and smaller unconnected areas of color. Two somewhat distinct traits are suggested--visual density in terms of concentration of color in a global or averaged sense, or density in terms of the number of colored areas which are present and separated from each other. The two interpretations are clearly related in that they both speak to density and concentration versus spatiousness and openness incorporated within the perimeter of the blot material.

To attempt to clarify the interpretation, several of the Holtzman variables were run as properties in the PROFIT program. Properties were expressed in terms of (a) scores on each HIT variable (b) for each blot (c) averaged across all subjects. Shading, Location, Space, and Popular were selected as variables which would most likely relate to the present interpretations. The PROFIT program provides direction cosines, which are interpretively similar to correlations with each dimension, and serve as loadings to define a vector in the stimulus space. Also provided is an index (Rho) of the maximum, multiple correlation between a property and all dimensions, which serves to qualify the interpretation suggested by simply the degree of alignment of a property vector to a dimension axis. The direction cosines and Rho coefficients for Sh, L, S, P, and the other Holtzman properties are presented in Table 13. Given the strain of capitalizing on chance with the 20 multiple correlations necessary to consider all Holtzman variables as PROFIT properties, caution was taken to rely upon selected variables mainly for confirmation of tentative interpretations suggested by visual inspection of outliers or other means. The Rho indication of the proportion of predictable variance was also used to conservatively qualify interpretations. For possible value in future references but not for exhaustive use presently, all 20 Holtzman properties are presented in Table 13.

The PROFIT results relevant to dimension 2 show that Shading and Location are poor overall predictors in the multidimensional space, making their correspondence to dimensional loadings of questionable merit. Space evidences

Table 13

HIT Variables as Blot Space Properties

HIT Variable	Rho Correlation	Direction Cosines		
		I	II	III
R	.358	-.044	-.062	-.997
L	.142	-.234	-.904	.358
S	.056	-.043	.423	-.905
FD	.226	-.149	.218	.965
FA	.313	-.175	-.574	.800
C	.280	.023	.653	-.757
Sh	.146	-.094	-.197	-.976
M	.303	-.163	.462	.872
PV	.184	.314	.824	.472
I	.321	-.206	-.050	.977
H	.300	-.624	-.437	.649
A	.269	.434	.305	.848
At	.102	-.625	-.602	-.498
Sx	.125	.014	.228	.974
Ab	.221	-.109	.533	-.839
Ax	.271	.096	.391	-.916
Hs	.133	-.025	.712	.701
Br	.142	.072	-.280	-.957
Pn	.498	.125	.402	-.907
P	.391	-.246	-.844	.476

the lowest Rho value, and a moderate positive loading on dimension 2. Popular is a moderately good multidimensional predictor, and loads highly negatively and highest of the three dimensions on dimension 2. P and Pn have been depicted as vectors in Figure 4. The interpretation of dimension 2's subjective meaning favored by property fitting would seem to emphasize the presence or absence of distinguishable parts within the global blot perimeter, with the presence of Penetration less likely in the multi-element blots, but only as a more indirect consequence. Popular is apparently the most salient property because of the greater number of Popular responses corresponding to smaller, distinct blot areas than whole or vague areas. It is difficult to exactly clarify which sense of "density" described above best fits as the dimension 2 label, and it may be that all variations speculated are sufficiently redundant to make a distinction impossible. The presence of distinguishable sub-elements of a blot is apparently necessary in the positively loaded, spacious outliers, but the term density may connote a more simplistic meaning. Therefore the term "percept multiplicity" will be adopted as the working label for dimension 2, as defined by the characteristics discussed.

Dimension 3 reflects a somewhat subtle differentiation which seems to involve chromatic color. Blots which are dominated by bright colors load positively, while blots composed of pastels in small amounts or no chroma at all load in the negative direction. Support for this interpretation was sought by fitting Color, Anxiety, and Hostility as PROFIT properties. Anxiety and Hostility were included because the bright red colors commonly used in the blots would be likely to suggest more responses of blood, which are always scored for Ax and Hs. As shown in Table 13, neither C, Ax, or HS attained Rho values of a comfortably moderate level. A post hoc scan of the property fits reported in Table 13 showed that the two properties with the highest Rho values (R and Pn) load very heavily on dimension 3, negatively in both cases. Both R and Pn are represented as property vectors in Figure 4.

If an inverse scale of color dominance is in fact represented, the decreased likelihood of rejection give fewer associations to colored blots is straightforward and coincident with the negative direction cosine of the Rejection vector. Since Penetration refers to passing beyond or through a body wall, it too would seem to be scored more likely on chromatic blots where internal organs, bruises, etc., would be suggested in part by the dominant chromas. Rejection also loads negatively, heavily, and almost exclusively on dimension 3, which may speak to connections between color responses, emotionality, and threat. Dimension 3 may incorporate more beyond objective blot characteristics than 1 or 2, judging from the properties most coincident. At present, however, the label "color subordinance" (as the inverse of color dominance) seems strongly supported as the dimensions interpretive label.

Interpretation of the 3 dimensional subject space. The subject saliences on each dimension, derived from the INDSCAL analysis of individual differences, have been presented (see Table 11) and discussed in other contexts already. The saliences can also be used to construct a subject space of the same number of dimensions as solved for, in which the differentiation along axes represents dimensions of individual differences in the MDS configuration. Such a subject space was constructed from the INDSCAL 3 dimensional saliences, and is portrayed graphically in Figure 5. The parameters of dimension usage have already been discussed, and present concentration will therefore be on interpretation of the subject space dimensions.

Unlike the blot space, properties of the subject space need not be separately expressed at the level of each unique blot to be suitable for PROFIT analysis. Instead, properties now deal with individual subjects as the unit of analysis, which makes the range of suitable properties considerably broader. To represent the contribution of HIT variables to the PROFIT analysis most efficiently, the 6 HIT factor composite scores for each subject were run as properties. The results (see Table 14) showed that two of the factors were at least moderately well predictable overall, and they are represented graphically as vectors in Figure 5.

Factors 5 and 6 correlate moderately well with the dimensional structure, loading strongest and in opposite directions on dimension 2. Factors 5 and 6 are unstable in

Figure 5. The 3 Dimensional Subject Space

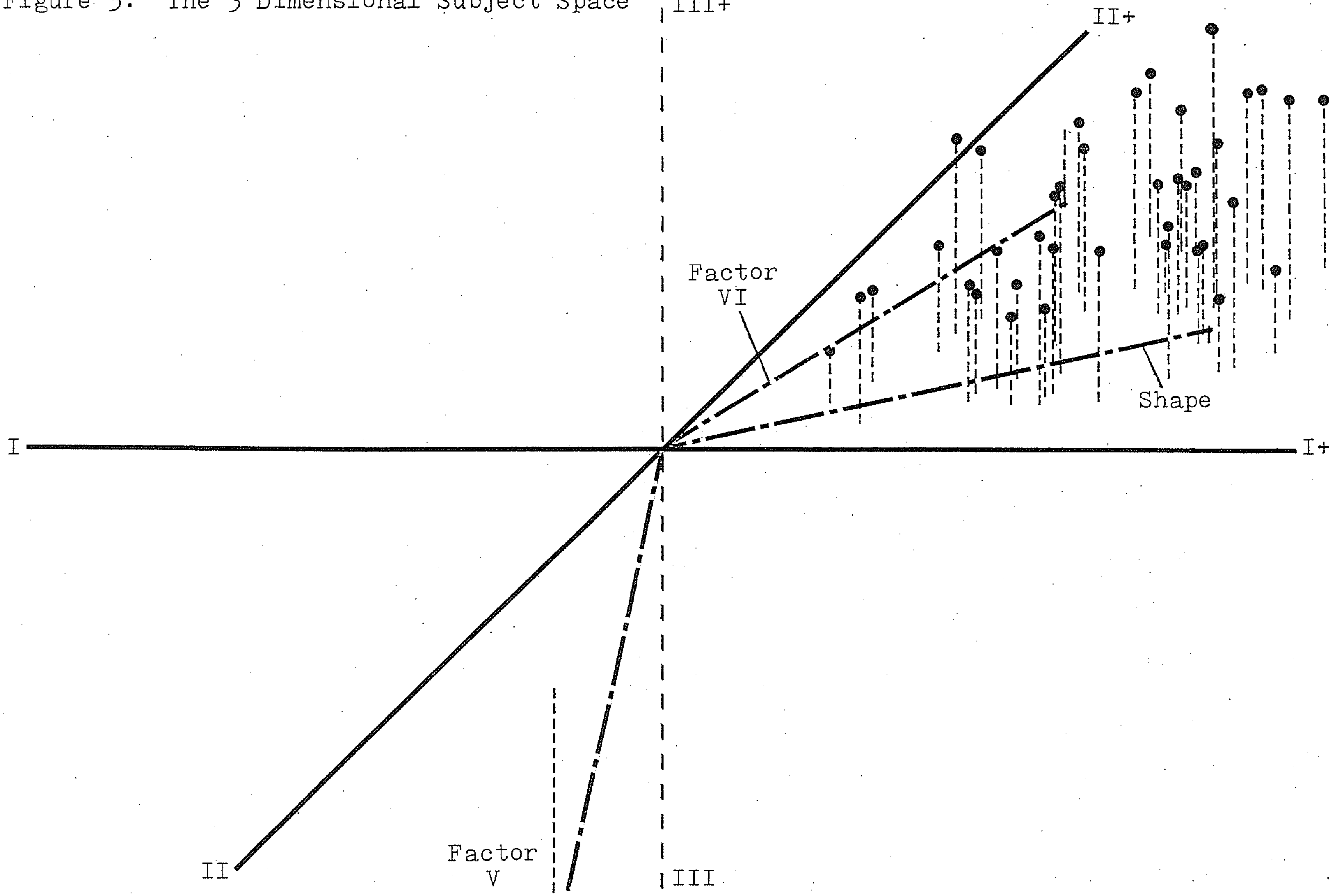


Table 14

Holtzman Factors as Properties

Criterion	Factor I	Factor II	Factor III	Factor IV	Factor V	Factor VI
Based on a 3 Dimensional Solution						
Rho Correlation	.061	.166	.240	.231	.350	.345
Direction Cosine I	-.137	.549	-.381	-.201	.272	.183
Direction Cosine II	-.092	-.470	.187	-.856	-.719	.970
Direction Cosine III	-.986	.692	-.906	.476	-.629	-.158
Based on a 6 Dimensional Solution						
Rho Correlation	.406	.284	.406	.388	.534	.383
Direction Cosine IV	-.297	-.259	-.359	.564	.312	-.381
Direction Cosine V	-.284	.444	-.438	.322	-.212	.514
Direction Cosine VI	-.068	.641	.290	-.638	.125	.580

some populations, but most often take the form of a scale of either strong inhibition or inability to perceive concepts in the blots for factor 5, and a scale of mild pathology and bodily preoccupation for factor 6 (Holtzman, 1968). The PROFIT direction cosines for these two factors on dimension 2 suggest that a contrast of factor 6 minus factor 5 is most relevant. Subjects using dimension 2 heavily tend to score high on factor 6 and low on factor 5, and those who use dimension 2 less heavily would evidence a smaller discrepancy between scores on factors 5 and 6. Judging from the factor descriptions above, a contrast of the two does make interpretive sense. The positive bodily preoccupation of factor 6 involves responses in the Penetration, Sex, and Anatomy categories to a large extent. These responses would seem to require openness, indifference, or some effective self-disclosure to appear in large numbers, and if so, would likely correspond to low scores on the inhibition scale of factor 5. Interpretively then, the contrast of factors 5 and 6 suggests that the use of dimension 2 differentiates subjects along a scale from (a) unwillingness to report or (b) inability to perceive concepts in the blots--especially intimate or personal concepts--at the low end of the scale, to a greater openness or frankness in those subjects at the higher points of the scale.

Dimension 1, though dominant in proportion of variance in the configuration, and dimension 3 do not load heavily or distinctly on any of the Holtzman factor score properties.

Since the factor scores correspond well to dimension 2 the redundant and less efficient approach of using all 20 HIT variables as properties was not pursued for the subject space. Instead, simple correlations between those dimensions' subject saliences and the 20 HIT variables were used to search further for the psychological utility. For dimension 1, the resulting correlations ranged from .014 to .345, but none exceeded the significance level of .01 which was considered minimal for such a large number of correlations. The only correlation approaching that level was for Abstract ($\underline{r}$ = .345, $\underline{p}$ = .016), which simply implies that higher reliance on inclarity of the blots leads to greater distance between the strict blot material and the perceived concept. For dimension 3, correlations with the HIT variables ranged from -.003 to -.293 in magnitude, with a median magnitude of .065. The strongest correlation was with Penetration ($\underline{r}$ = -.293, $\underline{p}$ = .035). Since Penetration often involves deterioration of or passage through a body wall, this may simply reflect a higher occurrence of bodily oriented responses in blots colored in reds or fleshtones.

The post-experiment questionnaire (see Appendix G) also proved to be a valuable source of information for interpreting the dimensional structure. Subjects were asked to describe the kinds of information they used in making the similarity judgements, and the most frequently reported determinants were coded and tabulated. Five categories of responses were used substantially (by at least 7 of the 39 subjects), and were processed as properties in a PROFIT analysis. The results (see Table 15) evidence a heavy loading on Shape for dimension 1, which tends to confirm the objectivity of physical differentiation of blots along that dimension. Dimension 2 received no definitive loadings, but dimension 3 is nearly collinear with three of the vectors. The corresponding Rho coefficients are rather low, however, and the determinants are somewhat sketchy in meaning. At best, the direction cosines suggest that a physical, internal arrangement of blot material constitutes the criterion of differentiation, which lends neither strong support nor criticism to the previous label of color subordinance.

As a final consideration of the psychological interpretability of the three dimensional subject space, some of the descriptive data collected considered potentially relevant was processed as properties in a PROFIT analysis (see Table 16). The Rho correlations were all relatively low, but some trends can be noted. Heavy users of dimension 1 tended to be more reliable in their judgements, and there was a tendency for subjects of higher birth order to report perceptions of less multiplicity. Perceptions dominated by chromatic color were more likely to co-occur with older subjects, males, subjects with lower grade point averages, and subjects who made the similarity judgements before participating in the group administration.

Again, all of the descriptive property fits were characterized by low or moderately low multiple correlations, and

Table 15

Subjects' Reported Use of Determinants

Criterion	Color	Shape	Outline	Pattern	Thoughts or Feelings
Based on a 3 Dimensional Solution					
Rho Correlation	.133	.334	.317	.232	.270
Direction Cosine I	.747	.947	.005	.211	.089
Direction Cosine II	.529	.320	-.381	.205	-.131
Direction Cosine III	.403	.033	-.925	.956	-.987
Based on a 6 Dimensional Solution					
Rho Correlation	.347	.530	.385	.488	.542
Direction Cosine IV	.427	.569	.414	-.120	-.795
Direction Cosine V	-.670	-.752	.126	.508	.297
Direction Cosine VI	-.580	-.203	.405	.644	.415

Table 16

Descriptive Variables as Properties

Criterion	Age	Sex	Academic Performance (4 pt. scale)	Birth Order	Experiment Order (PRE...PST)	INTERSCAL Relia-bility	KYST 6-D Stress
Based on a 3 Dimensional Solution							
Rho Correlation	.357	.207	.151	.358	.277	.269	.227
Direction Cosine I	.286	.163	-.090	.199	-.116	.902	.535
Direction Cosine II	-.097	.397	.097	-.979	-.124	-.432	.521
Direction Cosine III	-.953	-.903	.953	-.053	.986	.021	-.666
Rho Correlation	.352	.423	.190	.319	.346	.481	.459
Direction Cosine IV	.273	-.436	.202	-.198	-.202	.401	-.914
Direction Cosine V	.101	.028	.648	.112	-.160	.136	.102
Direction Cosine VI	.289	.874	-.478	-.292	-.826	.560	.326

thus cannot be considered conclusive even as tendencies. They are at best suggestive that several personality correlates underlie individual differences in the MDS structure. The Holtzman factor scores much more directly imply psychological meaning for dimension 2, although dimension 1 remains largely explained only by physical characteristics of the blots.

Beyond the third dimension. Approximately one-fifth of the variance explainable in a six-dimensional solution is accounted for by the fourth through sixth dimensions. Although not addressed in the previous interpretive discussion, these latter three dimensions were further studied for possible psychological value. The emphasis, then, was on the interpretive value of individual differences moreso than subjective meaning of the blot dimensions.

The subject reported determinants (see Table 15) again proved to be a valuable source of information for analysis of the higher dimensions. The results indicated that subjects who employed dimension 4 little reported using spontaneous feelings or impressions in judging the responses (see Table 15). Presumably, subjects who employed dimension 4 heavily were more systematic in some sense. Inspection of the outliers (see Table 12) reveals that positive outliers are entirely chromatic, and negative outliers are at least partially of a chromatic coloring, but suggests no clear affective dimension. Similarly, the property fits of the Holtzman factor scores (see Table 14) show no predominant loadings on dimension 4.

Finally, the selected descriptive properties presented in Table 16 were processed, and only KYST stress was found to load heavily and primarily on dimension 4. Concerns for the Rho value are more stringent with 6 dimensions as predictors, but the value of .459 for KYST stress seems tolerable. Subjects who use dimension 4 heavily then are typically associated with configurations of poorer fit, and infrequently report use of spontaneous feelings or impressions in making judgements. This remains a somewhat elusive interpretation of dimension 4, as there is little correspondence to other Holtzman or demographic information, nor is there a clear convergence of information toward a subjective label. One interesting implication is that greater spontaneity and affective reaction to the blots results in configurations of better fit. This is also evidenced by a positive correlation between KYST stress and the spontaneous feeling variable ($\underline{r}$ = .273, $\underline{p}$ = .047). Interestingly, this is not collaborated by a positive correlation between spontaneous feelings and INTERSCAL reliability ($\underline{r}$ = -.185, $\underline{p}$ = .130).

Dimension 5 is apparently not characterized by the use of color or shape, judging from subjects' reported determinants (see Table 15). Inspection of the outliers (see Table 12) suggests only that negative loaders are typically separable into 2 distinct halves, whereas positive loaders are more unitary, with no space or boundaries separating the blots bilaterally. This characteristic was not collaborated by a subsequent correlation between Location and dimension 5 saliences, however (r = -.014, p = .467). The Holtzman factor properties (see Table 14) revealed no predominant loadings on dimension 4, nor were there any decisive patterns among the descriptive properties in Table 16. In summary, dimension 5 may reflect a unitary versus bilateral characteristic of the blots, but this is not collaborated by other variables investigated, nor are there interpretable correlates of individual differences with the present information.

For dimension 6, it was initially noted that the three subjects whose saliences exceeded .150 reported using the "pattern" of the blots in making comparisons, as compared to 7 of all 39 subjects who mentioned pattern as a determinant. Pattern, as a property, was moderately well predicted in the six dimensional configuration, and did load heaviest on dimension 6 (see Table 15). Examination of the outliers (see Table 12) shows a roughly similar cup-like or semicircular arrangement of blot material among negative outliers, and only the absence of this characteristic in common among positive outliers. The only strong loadings among the Holtzman factor properties are on factors correlating low with the dimensional structure (see Table 14), making speculations questionable at best. The descriptive properties (see Table 16) do reveal a higher usage of dimension 6 for males and for subjects making the comparisons prior to the group administration, but no information of further interpretive aid. Given the container-like appearance of negative outliers, Penetration and Barrier were investigated as properties in the subject space for possible relevance. Barrier was found to load least on dimension 6, but Penetration did load predominantly on dimension 6, with a direction cosine of .826 (versus -.512 as the next largest value) and a Rho value of .534. Reconsideration of the negative outliers revealed that the container-like arrangements of blot material always included markings which might represent a passage or opening at the base area. It may then be this sort of characteristic that is either most salient to the dimension or most sensitive to identification as a property.

The relevance of Penetration is further collaborated by re-examination of the canonical correlations of the subject saliences to the Holtzman factor scores reported earlier. Recalling Figure 3, there was a gain in correlation in going from 5 to 6 dimensions which exceeded the amount expected from changes at lower dimensions. In the canonical correlation with six dimensions, Holtzman factors 3 and 6 loaded heaviest and positively among the criterion set, and the loading for dimension 6 among the predictor set was positive and exceeded only by a negative loading on dimension 3. Although the first canonical correlation was not significant ($\underline{r}$ = .559, $\underline{X}^2_{(36)}$ = .929), factors 3 and 6 are the only Holtzman factors which were found to load heavily on Penetration in standardization samples (Holtzman, 1968). A trait tapped by the Penetration variable does therefore seem to be tapped by dimension 6 of the MDS configuration as well.

First language differences. Differences were noted earlier (see Table 7) between subjects reporting English as their first-learned language and those who reported Chinese as their first language on the HIT variables. These differences and differences in the MDS structures were further addressed multivariately, in two-group discriminant analyses. The SPSS (Nie, Hull, Jenkins, Steinbrenner, and Bent, 1975) discriminant analysis program was employed, with an F-for-inclusion and an F-to-remove of 1.000, a tolerance level of .001, and stepwise entry to minimize Wilks' Lambda.

Beginning with the subject saliences on 6 dimensions as the 6 predictors, the discriminant function failed to attain significance ($X^2_{(4)} = 8.638$, $p = .071$). However, for the 6 Holtzman factor scores as predictors, a discriminant function including factors 2, 3, and 6 was found to be significant ($X^2_{(3)} = 12.701$, $p = .005$). Factor 6 entered first, factor 3 second, and factor 2 third, with F's to enter, F's to remove from the final equation, standardized loadings, and percentage of correct group classifications based on the three predictor equation, as described in Table 17. The overall percentage of correct classification was 74.29%.

On the basis of the standardized loadings on the discriminant function and the F-to-remove criterion, factor 2 is clearly the largest contributor to discrimination in the final prediction equation, and factor 3 the smallest. The group centroid for the ENG-1ST group was -.436, and for the CH-1ST group, .739. Taken with the negative standardized

Table 17.

First-Language Differences

Criterion	Dimension/Factor 1	2	3	4	5	6
6 Dimensional Saliences as Predictors						
Standardized Loadings	*	.464	.478	-.580	-.485	*
Order of Entry	*	4	3	2	1	*
F to Enter	*	2.03	2.71	2.39	1.95	*
F to Remove	*	2.03	2.10	3.16	2.26	*
Significance of Change[a]	*	.096	.070	.106	.163	*
6 Holtzman Factors as Predictors						
Standardized Loadings	*	-.823	-.167	*	*	-.375
Order of Entry	*	3	2	*	*	1
F to Enter	*	8.98	2.48	*	*	2.54
F to Remove	*	8.98	0.37	*	*	2.01
Significance of Change[a]	*	.001	.097	*	*	.111

*Not applicable.

[a]Based on the change in Rao's V.

loadings, this reflects a lower score on the composite of the three factors for the CH-1ST group, contributed to most by differences on factor 2 and least by factor 3. Judging from Holtzman's (1968) description of the factors, this would imply greater sensitivity to the spectrum of blot determinants and more fantastical, body oriented responses among ENG-1ST subjects, perhaps similar or related to a dimension of minor pathology.

Generation of a short-form HIT. A shortened version of the HIT was generated for evaluation by selecting blots to maximally represent the variation perceived by subjects. The most extremely loaded blots on a given dimension were taken to represent the points of maximum perceived variation along that dimension. To partially account for differences in the amount each dimension explains of the total predictable variance, the number of extreme, outlying blots per dimension to be selected were kept in proportion to the number of subjects with saliences on that dimension in excess of .150. In the case of multiple selection, the dimension of higher order was assigned the outlier and the closest alternative was assigned to the lower dimension. To keep the shortened form more comparable to Herron's (1963) short form, the total number of blots was limited to 30. Thus the number of outliers selected for dimensions 1 through 6 were 10, 7, 6, 4, 2, and 1, respectively. The blots selected are identified in Appendix K.

The means and standard deviations for the 20 HIT variables are presented for the full and short forms in Table 18, as well as the correlation between short and full form scores for each variable. The equivalent correlations between full and short form scores for Herron's shortened version development are not available, but the differences between means for his short form and predicted scores are presented in Table 18 as well as the standard deviation for the short form.

The results show high agreement between the present long and short forms, with a median correlation of .9415. Only the differences between observed and predicted mean values are given in Herron's report, which prohibits correlational comparison. It can be seen in Table 18 that for 15 of the 20 variables, the variability of present short form scores was higher than the full form, which speaks to a correspondence between maximizing MDS dimensional variance and subsequent maximization of HIT variance. As a rough comparison, it was noted that the mean differences were smaller for the Herron study for 11 of the 20 variables. However, consideration must be given to the fact that (a) the Herron mean difference is based on an actual versus predicted difference, and (b) that the variability of variables in the present case exceeds the variability of corresponding Herron variables in all but one case. Within the present sample, no short-form variable differed from the full-form equivalent by an amount exceeding the corresponding

Table 18

A comparison of Short Form HIT's

HIT Variable	Full Form		Short Form		Mean Difference	Full/ Short Corre- lation	Herron Study[a]	
	Mean	Standard Deviation	Mean	Standard Deviation			Mean Difference	Standard Deviation
R 1	1.846	2.434	2.154	2.833	.308	.954	.33	1.94
L 2	25.462	11.257	24.436	11.646	1.026	.976	.49	8.61
S 3	.897	1.252	.974	1.614	.077	.923	.44	1.27
FD 4	86.949	14.843	83.641	16.898	3.308	.958	1.89	9.68
FA 5	42.000	4.685	40.487	5.150	1.513	.935	.42	3.85
C 6	19.692	8.458	21.744	8.416	2.052	.953	1.68	7.25
Sh 7	14.282	6.501	14.846	6.858	.564	.954	1.22	3.76
M 8	37.744	14.447	35.256	14.400	2.488	.953	2.28	9.73
PV 9	11.154	15.447	11.256	16.006	.102	.989	1.90	3.63
I 10	6.872	4.206	6.231	3.957	.641	.916	.62	2.79
H 11	29.769	9.499	27.026	10.330	2.743	.948	.96	6.73
A 12	27.923	6.293	29.179	6.996	1.256	.923	1.91	4.64
At 13	4.077	2.766	4.359	3.082	.282	.883	.11	1.89

Table 18 Continued

HIT Variable	Full Form		Short Form		Mean Difference	Full/ Short Corre- lation	Herron Study[a]	
	Mean	Standard Deviation	Mean	Standard Deviation			Mean Difference	Standard Deviation
Sx 14	.949	1.395	1.000	1.257	.051	.826	.13	.56
Ab 15	1.744	6.248	1.949	6.585	.205	.994	.24	.70
Ax 16	11.923	6.429	12.026	6.683	.103	.938	.54	4.46
Hs 17	11.846	5.631	10.795	5.202	1.051	.907	.15	3.96
Br 18	6.718	3.554	7.538	4.179	.820	.881	1.21	2.36
Pn 19	4.385	2.509	4.692	3.010	.307	.898	.14	1.81
P 20	9.692	2.567	7.590	2.980	2.102	.854	.88	2.27

[a]Based on actual and predicted scores for a shortened HIT presented by Herron (1963).

full form standard deviation. The average difference was .176 standard deviation units for the present form, and .211 standard deviation units for the Herron form.

A case study. A striking coincidence was noted during the processing of data, which forms the basis of this section. In the subject space configuration, one subject could be identified whose coordinates were noticably more deviant than the typical subject. In the scoring of the Holtzman administrations, again one subject's protocol was markedly more deviant than typical. Suspicions were verified when the reassignment of the correct identification data revealed that the same subject was the one singled out in both cases. For this subject (referred to as subject 8) the deviance of the HIT protocol was toward pathology, and thus an opportunity was presented to explore HIT-MDS parallels not only at a more sensitive individual level, but with a subject whose protocol was likely more representative of a clinical population.

The HIT protocol was characterized foremost by a PV score of 91 (see Table 19), which falls at the 99th percentile of college student norms. Other noteworthy scores include FA, Sh, I, H, At, Ax, Hs, and M. A rough characterization of subject 8 on the basis of the HIT would suggest decapacitating pathology, likely of a psychotic nature. The high PV, Factor 3, and low FA evidence a pervasive autistic logic which has little connection to external reality. Objective and sometimes conventional concepts are perceived in the blot,

Table 19

Holtzman Scores for Subject 8

Variable	Score	Percentile[a]	Variable	Score	Percentile[a]
R	1	*	H	52	99
L	19	43	A	20	41
S	4	*	At	6	90
FD	77	43	Sx	4	*
FA	34	1	Ab	38	*
C	37	91	Ax	32	98
Sh	7	9	Hs	27	96
M	61	89	Br	6	33
PV	91	99	Pn	8	77
I	5	17	P	10	43
Factor 1	2.58	*	Factor 4	-3.17	*
Factor 2	2.87	*	Factor 5	1.33	*
Factor 3	12.70	*	Factor 6	-2.51	*

[a]Based on the HIT college student norms.

*Not Available.

but the subject cannot maintain an adequate self boundary, making illogical connections and extrapolations from the percept. The FD, Ab, and H scores suggest that intellectual functioning has an average or above potential, and the autistic system is presented in a pseudo-intellectual style with perhaps a concentration on universal, human, and/or sexual identity. Clearly, subject 8 is not well adjusted to the system, and Hs and Ax suggest that the current turmoils may be very close to the surface and restrained little. He is likely in a highly emotional predisposition, preoccupied by needs for affectional contact and assurance.

It would seem likely that this 18 year old male either has been or soon will be under psychiatric treatment. He indicated that he had previously been administered an inkblot test, which suggests the prior. He rated the comparison task very enjoyable, easy, and interesting, and from observation seemed to maintain attention to the task, with occasional affective reactions such as rapidly drawing back into the chair at first sight of some blots.

In the MDS task, his INTERSCAL reliability was moderately high ($\underline{r}$ = .597). The KYST stress of .142 and INDSCAL correlation of fit suggested a poorer than average fit in 6 dimensions to the total group starting configuration, but a roughly average fit for a uniquely solved configuration. The decrease in stress for 1 through 6 dimensions was virtually linear, suggesting that the stress may have continued to improve in higher dimensionalities. With regard to deviation from the total configuration, subject 8 was the only subject who had no INDSCAL saliences in excess of .150. This reflects not only the lower correlation of fit, but also a tendency toward more uniform use of the 6 dimensions. Only dimensions 1 and 5 were noticably favored.

Given that the uniqueness of subject 8's dimensional structure rather than intrinsicly poor fit (recalling the superiority of his KYST stress to the INDSCAL correlation of fit) may explain the poor correspondence to the total group configuration, a separate INDSCAL analysis was performed. The total group configuration was treated like a "typical" subject, and its distance matrix was submitted with subject 8's distance matrix for a 2-subject INDSCAL analysis. The major advantage of the approach is that the solutions would not be constrained by a rigid starting configuration, both derived configurations being free to vary, and thus neither MDS structure would be favored in the analysis.

The results showed that a final configuration was reached which evidenced an overall correlation of fit of .786, with only 38% of the variability unexplained by the MDS structure. To this final configuration the "typical" subject correlated .766 and subject 8 correlated .806, confirming the premise of comparable goodness of fit for subject 8's deviant dimensional structure. The two "subjects" were clearly discriminated by the dimension saliences on all dimensions. Subject 8 loaded near zero (.051) on dimension 1 and quite uniformly from .264 to .350 on the remaining dimensions, with dimension 3 loaded heaviest. The "typical" subject loaded predominantly (.708) on dimension 1, moderately (.174) on dimension 2, and .093 or less on the remaining dimensions. It appears that only the first dimension is defined primarily by the total group, and at least the last four are principally derived from subject 8. It is thus understandable that extracting only variance in subject 8's configuration that is in common with the total group configuration would have done little justice to the accuracy of the former's solution. With the exception of the first and possibly the second dimension, it is likely that the INDSCAL final configuration would bear more resemblance to subject 8's structure than to that of the total group.

There seems to be substantial evidence that MDS individual differences are sensitive to clinically relevant personality factors. Subject 8 makes little use of dimension 1, which is presumably the contrast/clarity dimension which dominated differentiation among normal subjects. Subject 8's differentiations are likely along more subjective or autistic dimensions and less bound by physical characteristics of the blots. The latter premise was further investigated by a separate consideration of HIT variables as PROFIT properties for subject 8's blot space. Only a few of the variables evidenced satisfactory Rho correlations (greater than .50 for only R, I, and A) and the direction cosines rarely loaded definitively (greater than .80 only for S negatively on dimension 3 and L negatively on dimension 6). Given no combinations of good predictability and definitive orientation, the PROFIT results are not reported in detail. It was noted that PV, the most pathological aspect of the HIT protocol, loaded as did L, negatively on dimension 6 with a direction cosine of -.722 and a Rho value of .377. For L and I the direction cosines for dimension 6 were -.920 and .786, respectively, with Rho values of .346 and .500, respectively. A contrast of pathognomic integration of blot materials versus objective integration does then seem to be reflected in dimension 6. The remaining dimensions may be more reflective of autistic systemmatic differentiations, but were not pursued further within the present constraints on data and time.

Discussion

Inkblots, perception, and the HIT. A wide variety of data has been presented which attests to (a) a systematic multidimension structure in the perception of inkblots, and (b) a relatively low degree of overt correspondence between that multidimensional structure and the information tapped by the HIT variables. Clearly, a substantial amount of variation perceived in inkblots fits a structure consistent across individuals but relatively distinct from traditional HIT variables.

The stress of the total group configuration solved for nonmetrically was very good, indicating that the proximity information represented in the averaged distance matrix was reducable to a multidimensional model with little loss of information. The INDSCAL correlations of fit for individuals were generally lower than suggested by the analogous KYST stress values. The latter indicated highly accurate representation of the stimulus space for most subjects, while the correlations of fit suggested that typically 25% of the stimulus variability was accounted for by the multidimensional structure.

The two goodness of fit indices are not strictly comparable, and thus a discrepancy may not exist. A possibility, however, is that the constraint placed on the data by requiring a rigidly fixed initial configuration for the INDSCAL analyses was partly responsible for poorer individual fit. Certainly in the analysis of subject 8, low INDSCAL correlation of fit was found to reflect primarily the uniqueness of the individual configuration. With subject 8's configuration processed separately with the total group represented only as a "typical" subject, the correlations of fit were more impressive. There may be advantages to recovering individual saliences in this manner, but the procedure assigns disproportionate weight to the individual subject and thus the comparability of saliences produced in such runs is uncertain. Alternatively, it may be that too many individual differences are compromised in an averaged configuration for 39 subjects. Analysis in smaller subgroups where initial configurations were unnecessary may have been advisable, even at the expense of comparability of subject spaces.

In general, subjects relied on strictly physical characteristics of the blots in the similarity judgement task. Even for subjects who had previously listened to and presented more subjective, projective descriptions of the blots in the group session, the task of systematically comparing the blots elicited reliance on more objective characteristics. The nature of the task may have even constituted a bias in this respect. Faced with making consistent, quantitative distinctions among complex stimuli, subjects may have chosen more obvious blot properties to incorporate in their judgements. Given that reliability on repeated judgements correlated very little with the fit of the data to the MDS configuration, it may have been advantageous to solicit more subjectivity in the judgements at the expense of traditional reliability. This was even further suggested by a positive relationship found in investigating dimension 4 between reliance on spontaneous feelings and configurational fit. The independence of configurational accuracy and conventional reliability with regard to reliance on subjective criteria might be further pursued to address the relevance of conventional reliability to projective assessment. Configurational consistency independent of judgement reliability could add a new dimension to perceptual constancy.

The typically low correspondence of HIT data to the MDS structure not only was disappointing, but made the task of interpreting the dimensions difficult. The dominant dimension 1, which accounted for about half of all predicted MDS variance and very little of the variance in common with the HIT, was the clearest case where the suitability of the attached label seems unquestionable. All of the hazy, blurred blots were sharply distinguished from the rest of the blots by most subjects, and their low loadings on all other dimensions may question the utility of including all of them in acquiring non-redundant information.

Of the 6 dimensions, 2, 3 and 6 evidenced property fits with HIT variables which contributed substantially to interpretations, but in each case the overall Rho correlations were only marginally comfortable. In most cases, the differentiation along dimensions was characterized primarily by variation in the physical properties of the blots. This does suggest that some personality characteristics tapped by the Holtzman variables are closely tied to systematic variations in the blots themselves. In the development of the HIT, blots were selected for their "pull" for certain kinds of responses, and individual differences in responsiveness to such characteristics may indeed be represented in the current subject space arrangement.

The connections present between the MDS structures and the HIT source of data thus seem to operate indirectly through a third medium--the pattern of differentiation of blots along physical dimensions. If so, the elusiveness of the interrelationships and perhaps even the low overall correlations are more understandable. Subjects made no blatant judgements about the blots based on how threatened they felt--which would have been helpful in recovering a dimension of "susceptability to threat", for example--but blots which loaded negatively on the color dominance scale were in fact more frequently rejected. Thus Rejection, and perhaps threat is demonstrated to be partially a function of the blots' solidity and lack of chromas.

In some cases the correspondence between dimensions and HIT variables are essentially coincidental, such as a greater occurrence of Popular responses in blots higher in multiplicity of intra-blot elements. Rejection on the other hand is a more psychologically meaningful demonstration of a subtle MDS-HIT relationship. Decisive loadings by well predicted properties were rare, however, and tedious to pursue. Even the factor scores, which are the most straightforward reductions in the HIT redundancy, load definitively with only dimension 2. Dimension 2 does then seem to be the clearest correlate of a psychological dimension, demonstrating that subjects making heavier use of the complex structure of inner blot elements tend to be more open or frank, perhaps more exploratory socially as they are with inkblot perception. Dimensions 4 and 5 were elusive in interpretation, with physical characteristics becoming more subtly differentiated, and property fits being typically poor. Although more subjective properties were suggested for dimension 4 by the subjects' reported determinants, these were not collaborated by the HIT variables. Dimension 6 also reflects a subtle differentiation of blots, but subjects making heavy use of it tended to score high on Penetration, which was evidenced not only in property fitting but also in a canonical correlation of dimensions and factors. In fact, the canonical correlation basically confirmed that 2, 3, and 6 are the dimensions having most in common with variation in the HIT's traditional sense.

Certainly there is considerable slack in the correlations of fit and Rho values to allow that the MDS and the HIT are largely tapping separate and viably important bodies of data. Yet, given that physical characteristics are more clearly the domain of the multidimensional configurations, it is perhaps most critical that the most objectively oriented HIT variables corresponded least to the MDS structure. Color, Shading, Location and Space, for example, shared among the lowest of Rho values and corresponded little to visual inspection of blots along their most collinear dimensions. Instead the more psychological variables such as Pn, R, and factors 5 and 6 were the strongest correspondents to the dimensional structure. On the basis of the HIT properties, it would appear that the MDS configural discriminations are more relevant to subjective and perhaps projective factors. An alternate implication may be that no HIT variables are tapping the major dimensions of physical differentiation among the blots, but that at least some of these dimensions have psychological meaning and potential psychological utility. The presence or absence of an HIT scoring for a variable such as Color seems to have little relationship to the intricate ways that color is repeatedly represented in the MDS configurations. It may be that more potent correlates of the physical aspects of blot differentiation could be derived from MDS procedures.

Multidimensional differences. The most pronounced discriminations of subjects came from multivariate considerations of differences. With regard to first-language differences, the significant discriminant function using Holtzman factor scores as predictors is of its own right important for cross-cultural implications. There appears to be no readily available data on HIT performance for populations of Oriental descent, and the present results would suggest that assessments based on Caucasian standardization samples may be selectively biased. The largest differences evidenced are reflected in factors 2 and 6, differing toward less apparent perceptual sensitivity and bodily concern in the former population sampled.

The significance of the discrimination is especially noteworthy given the relatively small sample for such multivariate analyses. It is also interesting that the same analysis was not significant for the dimensional saliences as predictors, suggesting that the MDS structure is less sensitive to cross-cultural differences. Concerns for power may be warranted, however, given the small sample size and the nearness of the latter discriminant function to an acceptable margin of significance. Dimension 2 through 5 loaded roughly equally on the discriminant function, which attests to a multidimensional configurational discrimination of subject differences if the trend is indeed reliable. Most notably, dimensions (4 and 5) are discriminating the groups which were largely uncorrelated with HIT information, suggesting that different criteria of discrimination are tapped by the MDS saliences.

Another critical instance of discrimination based on MDS configural differences involved subject 8, who was distinguished in both the HIT and MDS analyses. The dramatic differences singling out subject 8 strongly imply that the MDS discrimination potential can apply to the identification of specific personality types. Herein lies the clearest connection of the MDS analysis of inkblots to the role in assessment from which they come. In the case of subject 8, uniqueness of configuration made no obvious detraction from either configurational fit at the individual level or reliability of repeated judgements. Deviation in the HIT protocol was collaborated by deviation in configural structure. In both areas the "typical" pattern of response was rejected, with the most common dimensions of blot differention for other subjects scarcely used by subject 8. Further work to pursue the MDS potentials for discrimination of personality subgroups is clearly warranted, especially with regard to clinical diagnosis.

A short form. Earlier discussion suggested that blots loading similarly and predominantly on a given dimension might represent redundant sources of information as projective stimuli. Following a similar line of reasoning, the short form designed to maximize MDS dimensional variance proved satisfactory empirically in comparison to the Herron (1963) form. The comparisons between forms were limited in thoroughness, however, since more sensitive correlational approaches were not feasible. Based on the standardized mean differences the present approach seemed to be in even closer agreement with full form scores, which again is interesting given the limited correspondence of the MDS and HIT data. Further work is warranted to determine if this or perhaps an even smaller representative sample of blots will reliably correspond in terms of both HIT scores and MDS configuration. A more manageable sub-test derived from the HIT could make a valuable contribution to practicality of frequent applied use.

Conclusions. In general, perception of inkblots was well represented in part by a multidimensional model. Three or four dimensions of variation capture most of the predictable variance in the blot space and the subject space. Higher dimensions also seem interpretable, and indeed the closest correspondents to the HIT variation were the second, third, and sixth dimensions. The dimensions of variation typically correspond lowly to HIT variation, however, and are defined primarily by discrimination of physical characteristics of the blots. However, the more objectively physically oriented HIT variables correspond lowly, and more subjective variations were found to relate systemmatically to the dimensional structures. Differences were also found in dimensional loadings and factor scores between subjects who spoke English versus Chinese as their first language. The MDS analysis was also found effective in identifying a subject whose HIT protocol evidenced clear pathognomic characteristics, and in suggesting a subset of blots maximally capturing perceived variation.

Implications are that a multidimensional structure exists in perception of inkblots which is of sufficient substance and interpretability to serve as a basis for many subsequent extensions and developments. The psychological aspects of individual configural differences are closely tied to physical characteristics and thus further work to finely qualify the dimensions would be profitable. Order of experimental tasks when group administrations of the HIT are also employed is not an apparent concern, but there may be value in an exploration of configuration accuracy and consistency with regard to reliability and an emphasis on utilization of more spontaneous, affective factors in the task. Further work is needed to explore the clinical utility of configuration differences is a more diagnostic sense. Representation of several clinical populations in a series of discriminant analyses of dimensional saliences for example, would address the issues of clinical validity of configuration difference patterns and delineation of the relationship between MDS information and variation untapped by traditional approaches. Such a variety of sampled populations would also serve well in demonstrations of the practicality and clinically validity of a shortened form. Cross-cultural differences need to be pursued in their own right, both in MDS and HIT applications. Ultimately, the feasibility of an assessment procedure based directly on the MDS analysis of a small set of representative inter-stimulus proximities need be addressed.

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APPENDICES

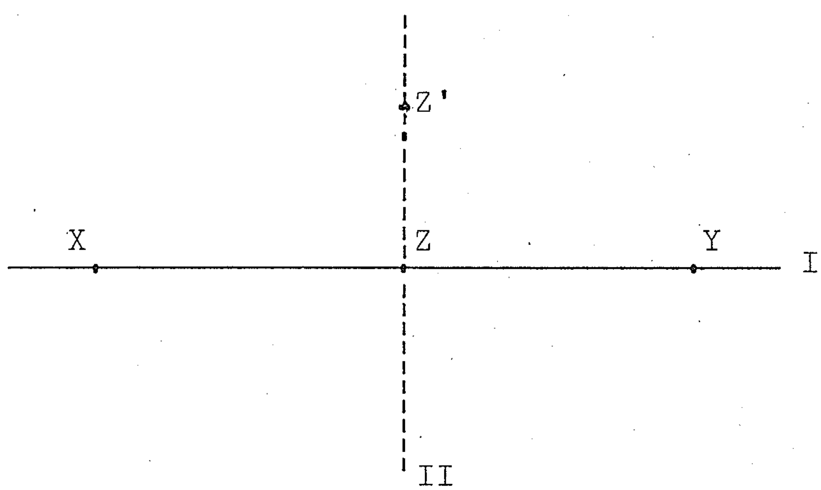
APPENDIX A

A REVIEW OF MULTIDIMENSIONAL SCALING

Multidimensional scaling can best be described as a means of unobtrusively recovering dimensions of variation among a set of stimulus objects. The input to the procedure is some form of measure of the proximity between the objects, which can be physical distance in the simplest case, or scales of preference, association, correlation, etc. Degree of similarity or dissimilarity of the stimuli are commonly used scales in MDS analyses, and are considered to be special cases of correlation-like proximities (Subkoviak, 1975). Typically measures on the proximity scale of choice are required on all possible pairs of stimuli, giving a complete set of proximity data which is arranged for convenience in a square symmetric matrix or half matrix. The analytic procedure is then begun by representing the proximity measures as physical distances. This representation allows the data to be analyzed in a geometric fashion, which ultimately results in a solution analogous to a map, locating the stimuli in a multidimensional space recovered from the data.

The recovery of the multidimensional space is in effect a generalization of the principle of triangle inequality for the group of MDS procedures classified as metric, a distinction which will be taken up later in this text. Given initially two points $\underline{X}$ and $\underline{Y}$, the proximity can be represented as a distance $\underline{d}_{xy}$. The line containing the $\overline{XY}$ segment can be tentatively considered a dimension, and thus the points $\underline{X}$ and $\underline{Y}$ define a dimension of difference, which is labelled I (see Figure 1A). If $\underline{X}$ and $\underline{Y}$ were point sources

Figure 1A. Spatial location of stimuli.



of white light, for example, which a subject had been asked to compare, the difference represented by $\underline{d}_{xy}$ might correspond to solely a difference in brightness perceived between the two lights. If a third point source of light Z is introduced, and all comparisons are collected, one of two things can happen when the inter-stimulus differences are considered. In one case (see Figure 1) Z can fall directly on the line defined by $\overline{XY}$, in which case the interpoint distances are collinear and consequently additive in nature. This would be expected if the brightness of the objects was the sole criterion of comparison. In other words, a unidimensional comparison criterion--such as degree of brightness--is represented linearly, ie., as one dimension of difference, in the geometric model.

A second possibility would be that the proximity of the new stimulus object to X and to Y cannot be adequately expressed solely in terms of distance along the dimension defined by $\overline{XY}$. This can be represented visually as an instance where the third stimulus falls in the arbitrary location designated as Z' (see Figure 1A). The projection of Z' on dimension I may reflect a meaningful quantity--in this case brightness of the light source--but that quantity is not sufficient to fully account for the differences between Z' and X and Y. Correspondingly, the sum of distances between such a point Z' and X and between Z' and Y does not equal the distance $\underline{d}_{xy}$, and in fact $\underline{d}_{xy}$ will equal the quantity ($\underline{d}_{xy}$' + $\underline{d}_{yz}$') only when X, Y, and Z' are collinear. If a second line (labelled II) perpendicular to dimension I is defined by the projection of $\underline{Z}'$, however, all information about the differences between the three points is accounted for by the coordinates in this 2-axis (or 2-dimensional) system. Returning to the example, the geometric orientation in Figure 1 might correspond to circumstances where $\underline{Z}'$ is in fact midway between $\underline{X}$ and $\underline{Y}$ in terms of intensity, but $\underline{Z}'$ also exhibits a redish hue. If color was taken into consideration by the subject as well as brightness, the comparisons would necessarily reflect more information than reducible to one dimension.

The critical features of MDS can be derived or generalized from the preceeding discussion of geometrically locating 3 stimulus objects. In general, where $\underline{P}$ is the number of stimulus objects, the maximum number of dimensions needed to exactly locate the objects in a spatial representation is $\underline{P} - 1$. The extent to which fewer dimensions are necessary to represent the objects relates to the redundancy of dimensions of variation. Only a set of objects each of which varies uniquely from every other object will require the maximum $\underline{P} - 1$ dimensions to exactly locate them. In practice the number of dimensions necessary can be determined by a step-wise consideration of the triangle inequality principle. Whenever the distances between each of two established objects and a third object do not sum to the distance between the two established objects, a new dimension is established by the projection of the new object. As more dimensions are added, the procedure continues except that successive points introduced are compared to the accuracy of placement (termed "fit") possible with the total dimensional structure previously established, and if all variation is not accounted for, a new dimension will be defined.

In practical applications of MDS, the recovery of the necessary dimensional structure is typically not carried to the point of completely accurate representation, for several reasons. First, measurement is rarely perfectly accurate--especially in behavioral applications--and thus even a minimal amount of error variance would likely ensure that $\underline{P} - 1$ dimensions would indeed by needed to account for all unique variation. Indeed, the aim of an MDS analysis is often more the identification of common dimensions of variation than the isolation of unique variance which also results. Furthermore, high dimensionality may be uninterpretable, at times even when in excess of two or three, and dimensions of variation which cannot be labelled are seldom of value. The final and most potent concern is the capitalization on chance which occurs in the absence of perfect measurement as the ratio of dimensions to stimulus objects approaches unity. In fact, rules of thumb dictate a much more stringent ratio of 1:5 or less as a region at which chance occurrence becomes a critical concern (Carroll and Chang, 1970).

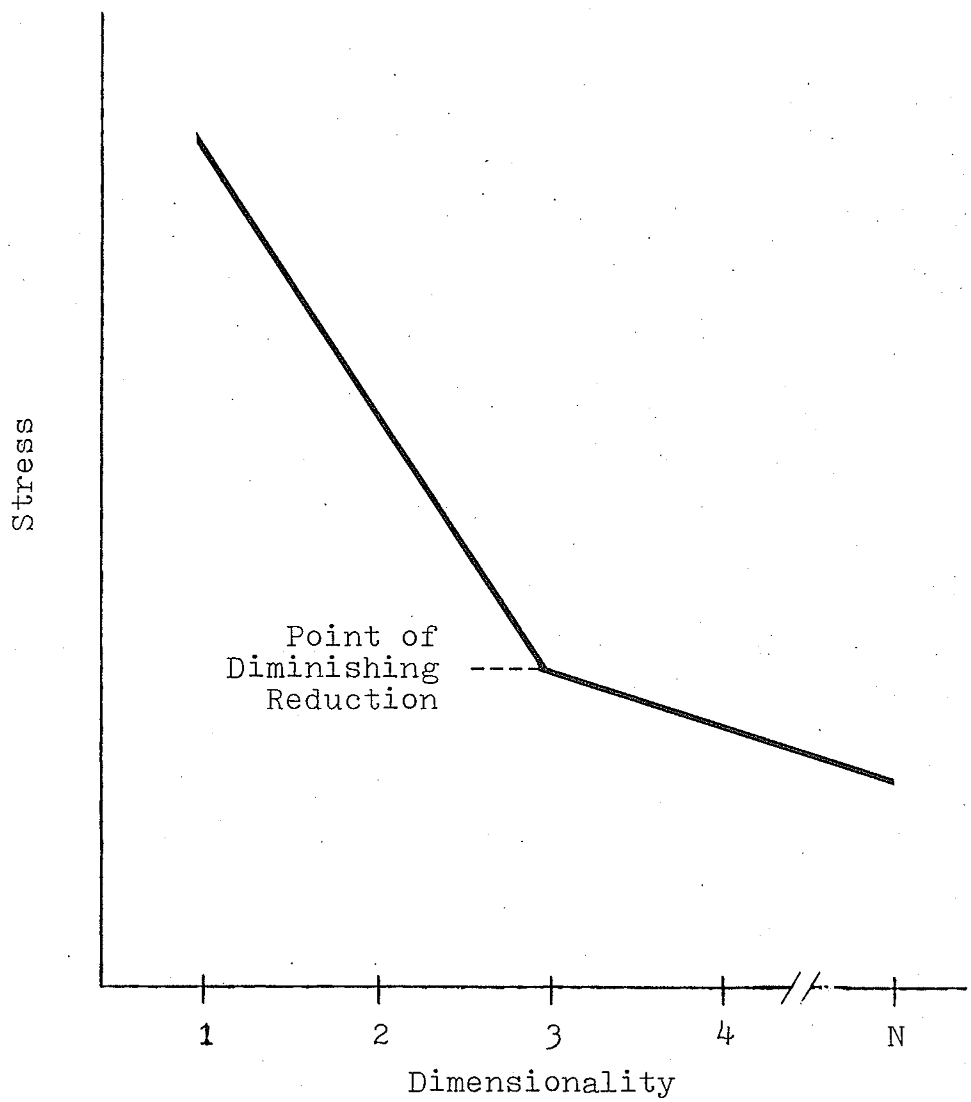
The tradeoffs of parsimony and accuracy are represented by numerical indices which reflect the extent to which all information available is represented by any given number of recovered dimensions. Stress is a concept falling within this class, which represents the variance not accounted for by a given dimensional structure. Since the dimensional structure can be thought of as a monotonic prediction equation, the variance unaccounted for is effectively error variance. Thus, a stress value is similar in function to the standard error of estimate in bivariate regression, with low stress values corresponding to more accurate or complete spatial representations. More specifically, "...stress is a normalized sum of squared deviations about a monotonic curve fit to the scatter plot of corresponding distance and proximity values (Subkoviak, 1975; p. 396)." The poorness of fit reflected in a stress value reflects both the degree of truly unique variance within a set of objects and the accuracy of the measurement scale. These two sources of variation which detract from the appropriateness of parsimonious lower dimensional solutions are hard to distinguish from each other, which becomes a more prominent concern when proximity judgements are derived from subjective scales, as they often are in behavioral sciences. Other measures of goodness of fit or direct investigation of the scale reliability may thus be necessary if the accuracy of measurement cannot be assumed.

There are many specific procedures involved in the interpretation of a MDS analysis. The order of dimensionality to be interpreted is influenced by many factors as already noted, although it warrants mention that stress is often a decisive aid. Stress will always decrease as dimensions are added, but a plot of dimension by stress will often show a sharp bend in the curve, which can correspond to a point of insufficient gain in accuracy with further dimensionality (see Figure 2A). Even a dimensionality thus selected may be subject to more stringent concerns of statistical soundness or suitability to a meaningful label. Procedures for MDS differ considerably in techniques employed in the recovery and interpretation of dimensions, and in the type of data suitable. One major distinction among MDS procedures alluded to earlier is dictated by the scale of measurement employed as the proximity data. Procedures which assume only ordinal scale data are called nonmetric methods, and procedures requiring interval or ratio scale measurement are called metric methods. The present concerns encompass several techniques and procedures within both the metric and nonmetric classes.

Analyses. Accounts of intended analyses are taken up in the main body of the text with further consideration of the relevance to analysis of projective stimuli, which governs the plan of investigation. Additionally, a brief summary of the anticipated sequence of analyses and the accompanying procedures is presented below.

As noted in the main body of the text, INTERSCAL (Cliff, 1977) is the procedure instrumental in collecting the proximity measures and reliability judgements. The program operates interactively during the collection of proximity judgements, identifying in the process the blots which are outliers on

Figure 2A. An Example of Dimensional Reduction in Stress



any dimension at any given time. Subsequent judgements as outliers are identified are collected primarily for only pairs including outliers, thus eliminating considerable redundancy by progressively taking advantage of the inter-point multidimensional structure (since points along a single line need be anchored to only one other point on that line for unique location). The resulting reduction in the number of interpoint distances needed may be from 25% to 50%. The proximity output is a matrix containing the essential information collected and zeros as entries for all distances not collected. Given matrices of distances for each subject, further information is then recovered via several other canned programs.

KYST (Kruskal, Young, and Seery, 1972), a nonmetric scaling program, was used to recover initial dimensional configurations and corresponding indices of fit for each subject. The generality and flexibility of KYST in handling the large amounts of missing data expected from the INTERSCAL distance matrices makes it especially suitable for this purpose.

The configuration matrices provided by KYST were used to solve geometrically for the missing values in the INTERSCAL output. Once completed, the distance matrices were directly submitted to INDSCAL (Carroll and Chang, 1970) for an analysis of individual differences. An overall assessment of individual differences can be accomplished by a comparison of each individual's distance configuration to a configuration derived from an averaged distance matrix, supplied to INDSCAL by the experimenter. Similarly, averaged matrices representing subgroups of the subjects could be submitted as bases for comparison as standards or for comparisons of subgroup configuration differences.

Procedures to be used for the exploration of the recovered configurations with the intent of labelling dimensions, determining correspondence to the HIT variable structure, and so forth, are the most difficult to map in advance, as the sequence will depend on the progression of prior findings. A major approach to the labelling of dimensions is via PROFIT (Chang and Carroll, 1968), a program designed to determine correspondence of an MDS configuration to sets of external measures of properties of the stimulus objects. The property fit is represented by the acuteness of the angle between a vector of the property plotted in the multidimensional space and any particular dimension. In fact, the cosine of the angle corresponds in a correlation-like way to the degree of correspondence. Close correspondence suggests that the property projected is what is being reflected in the dimension, which may lead not only to a label for the dimension but to a rotation of the configuration in the interest of greater interpretability.

Any of the HIT variables or factor scores recorded for each blot can thus be submitted to PROFIT for a direct assessment of correspondence. Factor scores were used initially, and individual variables only to the extent necessary to identify all dimensions, since the procedure is subject to statistical concerns of capitalization on chance.

Several other procedures may be employed if questions remain unanswered by the above procedures. Analysis of clusters of inkblots in multidimensional space, and examination of outliers on specific dimensions may help in the interpretation of meanings of the dimensions. Further considerations of subgroups of subjects, such as anxious, depressed, etc., may be advantageous in interpretation of configural differences.

APPENDIX B

COMPARISON TASK INSTRUCTIONS TO SUBJECTS

Subject Instructions
for Judging Proximities

1. <u>Aware of 1-hour session (if not already completed)?</u>
   - (a) Because there are 2 sessions, we are unable to tell much about the experiment today.
   - (b) You will know more after the next session, where we will be doing a different task.
   - (c) There will be a voluntary meeting to discuss results in late March.
   - (d) I will sign your cards then, at the second session of the two.
2. <u>Today:</u>
   - (a) We will be comparing <u>similarity</u> of pictures of ink-blots, like these.
   - (b) I will first hold up each one, just so you get an idea of the kinds of pictures and how much they differ. (Hold up each blot for approximately 3 seconds.)
3. <u>The Task:</u>
   - (a) I will hold up two pictures at a time, as selected by the computer.
   - (b) Consider:
     - (1) what they look like,
     - (2) remind you of,
     - (3) or could be,

     and then come up with a judgement of how similar the pair is.

Use a scale of 1 to 9--1 = most similar, 9 = least--and any whole number from 1 to 9. Look at the sign periodically (point out a sign describing the scale).

4. <u>Use full scale:</u>

I showed you all blots to get an idea of their range of similarity. Note that:

(1) No two are completely similar or completely different.

(2) Try to use 1's at some time, for the <u>most</u> similar of <u>these</u> pairs, and use 9's at some point, for the <u>most</u> dissimilar.

(3) Try not to use any 1 or 2 numbers all the time--<u>use the whole scale</u>.

(4) It may be difficult at first, but eventually will become easier to judge.

5. <u>Persistance and consistancy are important:</u>

(a) This is the task for the next 3 hours or less.

(b) This is the main part of the experiment, and it is thus important to keep alert and consistant. Also, inconsistancy means that the terminal will request more pairs.

(c) We will take several short breaks to help maintain alertness.

(d) If the task gets tedious, ask for another break.

(e) A couple of minutes of break helps alot.

APPENDIX C

HIT BLOT RANDOM IDENTIFICATION NUMBERS

HIT Blot	Random Number	HIT Blot	Random Number
1	37	24	43
2	41	25	2
3	45	26	15
4	26	27	19
5	8	28	3
6	33	29	27
7	25	30	11
8	23	31	7
9	21	32	28
10	36	33	16
11	24	34	9
12	13	35	14
13	32	36	17
14	34	37	40
15	4	38	22
16	35	39	5
17	20	40	42
18	30	41	18
19	10	42	29
20	12	43	31
21	6	44	38
22	44	45	39
23	1		

APPENDIX D

BLOT EXPOSURE TIMES FOR THE GROUP ADMINISTRATION

Blot Exposure Times

Card	Time (Seconds)
1	120
2	120
3	120
4	100
5	100
6	100
7	90
8	90
9	90
10 thru 45	75

APPENDIX E

SUBJECT INSTRUCTIONS FOR THE HIT GROUP ADMINISTRATION

Standard Holtzman Group

Administration Instructions

Please fill in the top portion of your answer sheet. (Pause while information is completed.) You will be shown a series of inkblots, each of which will be projected on the screen before you for about one minute. Using your imagination, write down in the space provided on your answer sheets a description of the first thing the blot looks like or reminds you of.

Include in your description the particular characteristics or qualities of the inkblot which are important in determining your response--i.e., what about the blot made it look that way? Give as complete an answer as you can in the time available. Also, circle the part of the blot you used or considered in your response on the sketches of the blots in the answer sheets.

None of these inkblots have been deliberately drawn to look like anything in particular. No two people see exactly the same things in a series of inkblots like these. There are no right or wrong answers. (Blot X is projected on the screen.)

A common response--"bat or winged creature"--which might be written "bat because of the form".

Another common response--"pool of oil"--using color and shading. And, still another response might be "a steer's head". (Blot Y is projected on the screen.)

A common response: a. "human figure"--using form.

b. "skeleton"--using form and shading.

c. "blood"--primarily color alone.

(Instructions are repeated in summary. Questions are entertained regarding the procedure. Blot 1 is exposed and the administration begins.)

APPENDIX F

HIT GROUP ADMINISTRATION

RESPONSE REINFORCEMENT SCHEDULE

Scheduled Reinforcements During the Administration

Card Number	Verbal Reinforcement
2	Write out as complete a description as you can in the time and space available.
3	Just let your imagination run and put down what the inkblot suggests to you--what you see in it.
6	This is another one of those blots where you will have to be careful in outlining that part of the blot which you use.
8	Write out as best you can what characteristics of the inkblot were deciding factors in your response.
9	Be sure to draw a line around that part of the blot that suggested your response.
14	We are particularly interested in knowing what aspects of the inkblot influenced your response.
19	Same as for Card 9.
24	Same as for Card 2.

APPENDIX G

POST-EXPERIMENT QUESTIONNAIRE

DIRECTIONS: Please respond to the following questions by circling the appropriate responses or writing in the requested information

1. What is your present age? ________

2. How many younger brothers and sisters (total) do you have? ________

3. How many older brothers and sisters (total) do you have? ________

4. What is your gender? 1) Female 2) Male

5. At about which level have your grades for the present year been?
   1) A to A+ 2) B to B+ 3) C to C+ 4) below C

6. Are you familiar with Inkblot tests such as this one?
   1) Yes 2) No

7. Have you ever completed or participated in an inkblot test before?
   1) Yes 2) No

8. How difficult did you find the comparisons of the blots?
   quite easy 1/____2/____3/____4/____5/ very difficult

9. If you were asked to repeat some of the comparisons, how accurately could you repeat your previous responses.
   not very accurately 1/____2/____3/____4/____5/ quite accurately

10. How did you find the task? (Please respond to each dimension)
    interesting 1/____2/____3/____4/____5/ boring
    unenjoyable 1/____2/____3/____4/____5/ enjoyable
    frustrating 1/____2/____3/____4/____5/ easy

11. What sort of information about the blots did you use in making the comparisons between them? (Please elaborate)

12. Please indicate any other reactions to the task, or comments you wish to make.

APPENDIX H

SUBJECT DEBRIEFING INFORMATION

Concluding Remarks to Subjects

This experiment involved a series of inkblots which you have seen both on cards and in the form of slides. They are part of the Holtzman Inkblot Technique, which is an established general personality test which is used in a wide variety of situations. The group session you attended is the standard way the test is administered to groups of people, though it is administered individually as well, using the cards instead of slides.

The individual session (you attended) was not a typical procedure in inkblot tests. The similarity judgements you made were analyzed with a special statistical procedure called Multidimensional Scaling, and were the focus of the study. Although it's never been done previously, the analysis is expected to make a link between the similarity judgements and the kind of information gotten from the standard administration. In other words, if you were using shading, color, form, etc., in responding in the group session, the procedure should recover or indicate that you were using those characteristics simply by considering your judgements of similarity. The advantage of the latter is that the data may be more objective and perhaps more useful.

The procedures involved are somewhat complicated, and hard to explain briefly any further. If you wish to attend and learn more, I will spend an hour or so at a later date going over projective tests such as inkblots, and Multidimensional Scaling, and how the two may relate.

APPENDIX I

A FORTRAN PROGRAM TO REPLACE MISSING INTERSCAL PROXIMITIES BY REPRESENTATIVE REPLACEMENT

```
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
C
C          PROGRAM TO REPLACE MISSING DISTANCES *************
C          IN AN INTERSCAL DISTANCE MATRIX      *************
C
C          DAVID DUSH, 1978, UNIVERSITY OF MANITOBA
C
       DIMENSION ENTRY(45,45),WEIGHT(45,6),DIST(45,45),
      1DAVG(10),DAVGN(10),ITEM(45,45)
       DO 1000 II=1,10
C
C          READ DISTANCE MATRIX *****************************
       DO 10 I=1,45
 10    READ(5,100) (ENTRY(I,J),J=1,45)
       SUM=0
       SUMSQ=0
       A=0
C
C          CALCULATE MEAN,VARIANCE, AND STANDARD DEVIATION **
       DO 11 I=2,45
       N=I-1
       DO 11 J=1,N
       IF(ENTRY(I,J).EQ.0) GO TO 11
       SUM=SUM+ENTRY(I,J)
       A=A+1.0
 11    CONTINUE
       AVG=SUM/A
       DO 12 I=2,45
       N=I-1
       DO 12 J=1,N
       IF(ENTRY(I,J).EQ.0) GO TO 12
       SUMSQ=SUMSQ+((ENTRY(I,J)-AVG)**2)
 12    CONTINUE
       VAR=SUMSQ/(A-1)
       SDEV=SQRT(VAR)
       WRITE(6,101) VAR,SDEV,AVG,A
 100   FORMAT(5X,45F1.0)
 101   FORMAT(1X,'VAR,SDEV,AVG,N;',4F10.3)
C
C          READ CONFIGURATION WEIGHTS ***********************
       DO 13 I=1,45
 13    READ(5,102)(WEIGHT(I,K),K=1,6)
 102   FORMAT(2X,6F7.3)
C
C          CALCULATE CONFIGURATION DISTANCES ****************
           FOR EACH DATA PAIR                ****************
       DO 14 I=2,45
       N=I-1
       DO 25 L=1,N
       DIFSUM=0.0
       DO 24 K=1,6
       DIFFSQ=(WEIGHT(I,K)-WEIGHT(L,K))**2
```

```
      DIFSUM=DIFSUM+DIFFSQ
 24   CONTINUE
      DIST(I,L)=SQRT(DIFSUM)
 25   CONTINUE
 14   CONTINUE
      DO 26 I=2,45
      N=I-1
 26   WRITE(6,103)(DIST(I,J),J=1,N)
 103  FORMAT(1X,15F5.2,'PD2')
      DISOBV=0.0
      N=0
C
C        CALCULATE AVERAGE CONFIGURATION ******************
C        DISTANCES FOR EACH DATA VALUE   ******************
      DO 28 K=1,9
      DISOBV=DISOBV+1.0
      DN=0.0
      DSUM=0.0
      DO 27 I=2,45
      N=I-1
      DO 27 J=1,N
      IF (ENTRY(I,J)-DISOBV)27,29,27
 29   DSUM=DSUM+DIST(I,J)
      DN=DN+1
 27   CONTINUE
      IF(DN.EQ.0.0) GO TO 88
      DAVG(K)=DSUM/DN
      DAVGN(K)=DN
      GO TO 28
 88   DAVG(K)=98.0
      DAVGN(K)=0.0
 28   CONTINUE
 C
 C       ADJUST FOR CORRESPONDENCE OF *********************
 C       AVERAGE DISTANCE ORDER       *********************
      DO 30 K=1,8
      L=K+1
      IF(DAVG(K)-DAVG(L))30,31,31
 31   IF(DAVGN(K)-DAVGN(L))32,33,34
 32   DAVG(K)=99.0
      GO TO 30
 33   IF(K-5)32,32,34
 34   DAVG(L)=99.0
      GO TO 30
 30   CONTINUE
 C
 C       CALCULATE DISTANCE VARIANCES *********************
      B=0
      DSUM=0
      DO 66 I=2,45
      N=I-1
      DO 66 J=1,N
      B=B+1
       DSUM=DSUM+DIST(I,J)
```

```
 66     CONTINUE
         DMEAN=DSUM/B
        DSUMSQ=0
        DO 61 I=2,45
        N=I-1
        DO 61 J=1,N
        DSUMSQ=DSUMSQ+((DIST(I,J)-DMEAN)**2)
 61     CONTINUE
        DVAR=DSUMSQ/(B-1.0)
        DSDEV=SQRT(DVAR)
        WRITE(6,110)DMEAN,DVAR,DSDEV
 110    FORMAT(/,1X,'DISTANCE MEAN=',F7.3,' VAR=',F7.3,
       1' STDDEV=',F7.3/)
C
C          ESTIMATE BY CLOSEST MEAN *************************
C          DISTANCE (UPPER MATRIX)  *************************
        DO 35 I=2,45
        N=I-1
        DO 35 I=2,45
        N=I-1
        DO 35 J=1,N
        IF(ENTRY(I,J).GT.0)GO TO 35
        VALUE=0
        DO 36 K-1,9
        VALUE=VALUE+1.0
        IF(DIST(I,J)-DAVG(K))37,38,39
 38     ENTRY(J,I)=VALUE
        GO TO 35
 39     IF(K-9)36,42,42
 37     IF(DAVG(K)-99.0)87,36,36
 87     IF(K-1)38,38,42
 42     L=K-1
        AVAL=VALUE-1.0
 43     CONTINUE
        DIFFA=ABS(DIST(I,J)-DAVG(K))
        DIFFB-ABS(DIST(I,J)-DAVG(L))
        IF(DIFFA-DIFFB)38,44,45
 45     ENTRY(J,I)=AVAL
        GO TO 35
 44     IF(DAVGN(K)-DAVGN(L))45,46,38
 46     IF(K-5)38,38,45
 36     CONTINUE
 35     CONTINUE
 C
 C         CONVERT STANDARD DISTANCES   **********************
 C         TO RAW SCALE (LOWER MATRIX)  **********************
        DO 75 I=2,45
        N=I-1
        DO 75 J=1,N
        IF(ENTRY(I,J).EQ.0.0)ENTRY(I,J)=((DIST(I,J)
       1*SDEV)/DSDEV)+0.5
        IF(ENTRY(I,J).LT.1.0)ENTRY(I,J)=1.0
        IF(ENTRY(I,J).GT.9.0)ENTRY(I,J)=9.0
```

```
 75     CONTINUE
C
C          WRITE COMPLETED MATRIX AND AVERAGE DISTANCES *****
        DO 73 I=1,45
        DO 73 J=1,45
        ITEM(I,J)=ENTRY(I,J)
 73     CONTINUE
        DO 47 I=1,45
        WRITE(7,109)(ITEM(I,J),J=1,45),II
 47     WRITE(6,109)(ITEM(I,J),J=1,45),II
 109    FORMAT(5X,45I1,1X,'PARADIM2 SUBJECT ',I2)
        WRITE(6,105)
 105    FORMAT(/,1X,'AVERAGE DISTANCES'/)
        DO 48 K=1,9
 48     WRITE(6,106)DAVG(K),K
        WRITE(7,107)
        WRITE(6,107)
 106    FORMAT(10X,F10.3,5X,'...',I2)
 107    FORMAT(/1X,'********** END OF SUBJECT **********'/)
 1000   CONTINUE
C
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
        STOP
        END
```

APPENDIX J

SUBJECT RANDOM IDENTIFICATION

Subject ID	Random Number	Subject ID	Random Number
1	7	24	17
2	3	25	19
3	4	26	9
4	12	27	39
5	28	28	2
6	33	29	38
7	20	30	29
8	26	31	8
9	32	32	31
10	24	33	13
11	30	34	21
12	14	35	25
13	16	36	22
14	23	37	37
15	34	38	1
16	11	39	36
17	35		
18	27		
19	6		
20	18		
21	15		
22	5		
23	10		

APPENDIX K

BLOTS INCLUDED IN A SHORT FORM HIT

HIT Blot Number	Dimension Represented	HIT Blot Number	Dimension Represented
5	1	41	2
13	1	44	2
17	1	11	3
24	1	23	3
25	1	28	3
27	1	36	3
34	1	40	3
35	1	45	3
39	1	4	4
43	1	12	4
1	2	16	4
2	2	42	4
7	2	8	5
15	2	20	5
32	2	30	6