

PSYCHIATRIC DIAGNOSIS AS A PSYCHOLOGICAL AND STATISTICAL PROBLEM

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INTRODUCTION

This paper is concerned with three closely related problems. The first of these problems is a psychological one, relating to the number and nature of the main dimensions of mental abnormality, and to the question of the continuity or lack of continuity between normal and abnormal personality. The second of these problems is a psychiatric one, relating to the practice of classifying patients into separate diagnostic categories, and the difficulty of reconciling this practice with certain experimental facts. The third problem is the statistical one of obtaining evidence with respect to the question of the number of dimensions required in any particular study. Related to this is the more practical question of allocating patients to that diagnostic category which their pattern of scores (obtained from tests, questionnaires, rating scales, or other diagnostic devices) indicates as that possessing the statistical attribute of *maximum likelihood* (this term will be defined presently). These various problems cannot be treated in isolation; for the purpose of this paper, therefore, they will be discussed together. Results from an experimental study will then be used to give point to the discussion.

We can best start by noting that psychiatric textbooks (as well as textbooks on clinical psychology, which usually follow the lead of the psychiatric ones) are frequently inconsistent in their dealings with diagnostic problems. On the one hand they tend to consider psychiatric disorders as diseases, in line with classical medical practice. This means that each disorder is a separate entity, with its own etiology and nosology; the task of diagnosis is to classify the mental patient into a particular group, membership in which determines to a large extent both treatment and prognosis. If we accept this view, then it is as reasonable to put the question: "Is this man a schizophrenic or an hysteric?" as it is to ask: "Is this man suffering from tuberculosis or scarlet fever?"

On the other hand, psychiatrists are coming more and more to accept the view that mental disorders are not really illnesses in the ordinary medical sense, but are rather defense reactions against stresses of one kind or another in individuals constitutionally overreactive autonomically, or in other ways predisposed to the development of psychiatric symptoms. This view is well put by Kretschmer (21): "There is no jump in thus going over into normal psychology; as we pursue . . . psychological peculiarity from the psychotic, step by step,

through all types of psychopathic personality and get further and further away from those great mental disturbances which form the beginning of our investigation — lo and behold — suddenly we find ourselves among healthy people, among well known faces. Here we recognize as familiar, normal features those traits which previously we had seen in caricature.”

The essential difference between these two views lies in the different assumptions which are made about *continuity*. A disease like tuberculosis, scarlet fever, hemophilia, shingles, or malaria is a qualitatively different state of the organism; there is lack of continuity in the sense that it is a meaningful statement to say that a person *has* or *has not* got the illness. In the same sense there is lack of continuity with respect to sex; in spite of certain freaks, it is meaningful to say that a person is male or female. Given the concept of discontinuity or qualitative differences, current classifications of psychiatric disorders and current diagnostic procedures make sense. If a person can be said to suffer from hysteria or schizophrenia, in the sense of belonging to a group of persons qualitatively different from all those not suffering from that particular disease, having etiological backgrounds different from those of other diseases, and having different systems of treatment and different prognoses, then he may meaningfully be diagnosed appropriately. Unfortunately very few psychiatrists, if any, would nowadays hold the beliefs indicated above as justifying current diagnostic procedures. Yet if we abandon the basis for these procedures, it is difficult to see any justification for continuing our diagnostic practices as if nothing had happened.

If we accept the alternative view of *continuity*, we see the neurotic (or the psychotic) not as something *sui generis*, but merely as a somewhat extreme case lying on a continuum stretching from the one extreme of emotional stability, through the “average” sort of person, to the other extreme of emotional instability, weakness and neuroticism. The case would be analogous to that of the feeble-minded person who is placed towards the one end of a continuous distribution. A view such as this is probably much more in line with modern thought, both psychiatric and psychological, and a formal proof of the continuity with the normal of both neurotic and psychotic persons has been attempted by the writer (5, 7), with very positive results. We may provisionally, at least, accept this hypothesis of the lack of qualitative differences between normal and psychiatrically abnormal groups.

Such a decision would immediately render obsolete current methods of diagnosis, by refuting the very hypothesis which is basic to their acceptance. Instead of thinking in terms of rigid categories of classification, we should be thinking, rather, of different dimensions of personality variation, and of measurement along these dimensions. Our research task would then be that of isolating and measuring the most important and relevant of these dimensions; the task of diagnosis would give way to that of establishing a person's position in the multidimensional space created in this fashion. Work carried out in the last

few years indicates that when this is done, the position of clinical and diagnostic categories can be meaningfully located within the given framework. It has also been shown (9) that this approach enables us to formulate etiological hypotheses, and make verifiable predictions, in a manner which would not be possible along the older lines.

PROBLEM

Inevitably, a new approach throws up new problems. The most pressing problem facing those who wish to adopt the dimensional approach is that concerned with the determination of the number and nature of the required dimensions. An illustration may be helpful here. It has been shown that neurotic and psychotic states are both continuous with normality; the question arises immediately whether we are dealing here with two dimensions (neuroticism and psychoticism), or merely with one dimension, going from the normal through the neurotic to the psychotic. Little help is forthcoming from the psychiatric side. The classical tradition favours the two-dimensional approach; the psycho-analytic, with its concept of psycho-sexual regression, favours the one-dimensional approach. But in neither case is there much experimental evidence, or realization that before such a problem can be answered, there is the necessity of framing it in a definite enough manner to make an empirical answer possible.

The problem may be restated as follows. Let us give q tests to persons psychiatrically allocated to three groups: normal controls, neurotics, and psychotics. Let there be n persons in each group, and let these be equated for intelligence, age, and other relevant parameters. The one-dimensional hypothesis would be satisfied if it were found that in the q -dimensional space generated by the tests, the points indicating the mean positions of the three groups were collinear. The two-dimensional hypothesis would be satisfied if variation extended significantly in more than one direction, so that the three points formed a triangle. A statistical test of significance would of course be required to indicate whether or not the observed departure from collinearity was significant or not. This may appear to be a very formal way of approaching problems historically considered nearly always in semantic terms, but it is difficult to see how any advance can be made in this field without the exact statement of hypotheses, together with the conditions necessary for their testing.

The two alternatives may be presented in diagrammatic form. Fig. 1 shows the one-dimensional hypothesis, Fig. 2 the two-dimensional one. Distributions around the means of each group are indicated on the ordinate in Fig. 1, and by contour lines in Fig. 2. These figures are taken with slight modifications, from Lubin (23), whose discussion of the statistical problems involved has formed the basis of our approach in this paper.

The statistical procedures appropriate for the solution of problems such as those indicated above are of relatively recent development, and not frequently

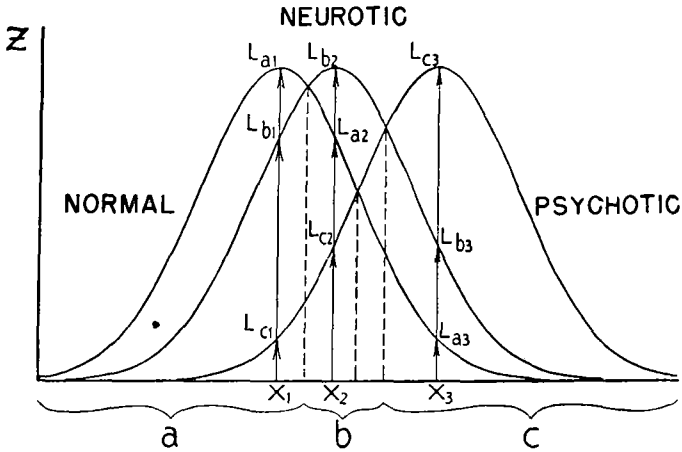


FIG. 1. One-dimensional hypothesis of personality organization.

used by psychologists. As a group, they come under the heading of "multivariate analysis," and several systematic expositions are available (Wilks, 33; Kendall, 20; Bartlett, 3; Tintner, 31; Lubin, 24). In the simplest case, when we are concerned with membership in one of two mutually exclusive groups, such methods as Hotelling's T^2 (18), Fisher's linear discriminant function (11), and Wilks' special case of the lambda criterion (33) are available. When there are three or more mutually exclusive groups, the simpler formulae can easily be adapted. In the same way in which one can find that linear function of variables which gives the biggest t -ratio for the difference between two group means, it is also possible to find a linear function of variables that maximizes the F -ratio for more than two groups — the multi-group or canonical discriminating function (Fisher, 12; Letestu, 22; Rao, 26, 27; Tukey, 32; Bryan, 4; Lubin, 23). Alternatively Hotelling's (19) "most predictable criterion" method may be used, or multivariate analysis of variance (Bartlett 1, 2, 3; Roy, 29; Rao, 25; Wilks, 34; Tukey, 32), called by Rao "analysis of dispersion."

The method of dispersion analysis has been applied to problems of a psychiatric nature only three times. Its first application was made in 1949 by Rao and Slater (28) to differences between neurotic groups; they failed to disprove the one-dimensional hypothesis in this field, probably because of their reliance on ratings instead of objective tests. The second application was made in 1950 by Hamilton (17) in his work on the personality of dyspeptics; he also failed to find significant latent roots other than the first. A third application, by Lubin (24), dealt precisely with the problem we are considering; his results, as summarized by Eysenck (7), indicated the strong probability that the two-dimen-

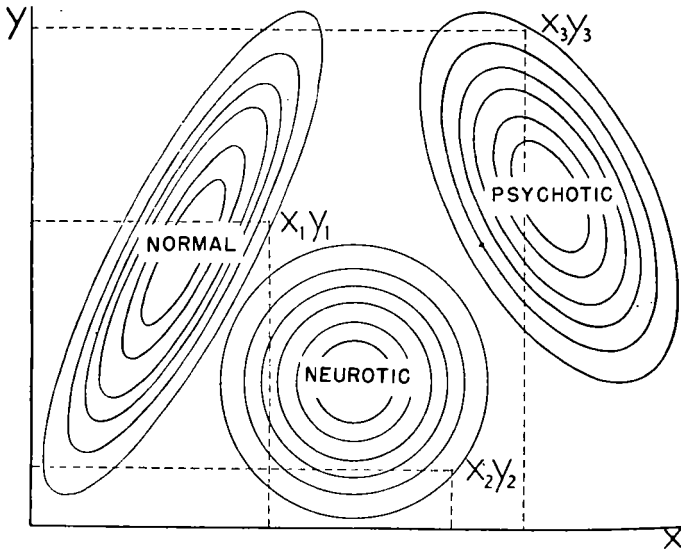


FIG. 2. Two-dimensional hypothesis of personality organization.

sional hypothesis was correct. However, the tests used by him were inferior to those now available, and in any case his interest was more in the elaboration of the methods than in the actual results. It seemed worthwhile, therefore, to repeat this study with a better selection of tests, and greater attention to the psychological results and implications.

PROCEDURE

*Subjects*¹

20 normal controls, 20 neurotics, and 20 psychotics were tested. All were male with ages ranging from 20 to 40. The average age of the three groups was 25, 29, and 27 years respectively. These differences are barely statistically significant; but, as correlations between the tests used and age were insignificant, and, as the means are all at a point in the growth curve where a few additional years make very little difference to mental functioning, it is improbable that this factor has contributed much to produce the results to be reported below.

¹I am grateful to Dr. G. W. Granger and Dr. J. C. Bregelmann for permission to use data obtained by them in a previous collaborative research (10). The interested reader will find a much more detailed description of our subjects, the tests used, and the rationale underlying them in that monograph. For the purpose of the analysis reported in this paper all the records obtained from the neurotic and psychotic subjects were employed, but in order to make numbers equal for the purpose of computation only a sample of our original normal group was used. This sample was drawn by means of random numbers.

Our normal group consisted of soldiers from a reallocation centre located in the neighbourhood. It was known from previous studies and from outside sources that soldiers at this centre tended to be below average from the points of view both of intelligence and of emotional stability. Our abnormal groups were chosen from in-patients at the Maudsley Hospital, psychiatric diagnoses determining their allocation to the neurotic or psychotic category. Patients at the Maudsley Hospital are voluntary and not certified, and may in general be said to be much less seriously ill than certified patients in other institutions. This choice of relatively below-average normal controls and of relatively above-average psychiatric groups was made on purpose. It is very easy to obtain striking differences between University students and deteriorated psychiatric patients; such results are of little practical value. Differentiation is usually required in practice among cases of the kind here considered, and significant results under these circumstances are all the more valuable because of the method of selection used.

All Ss were given the Nufferno test of intelligence. This test, which is of the familiar letter series type, has been developed at this Institute by W. D. Furneaux (14), and has been used extensively on large groups of the population, as well as on psychiatric patients. It is a "level" test, especially constructed so that the influence of speed should be as small as possible. A more detailed discussion and description of the test and the psychological principles underlying it has been given elsewhere by Eysenck (7). Differences among the three groups on this test were quite insignificant, the neurotic group being very slightly brighter than the normal or the psychotic group.

Tests

Four tests were used in this investigation. These tests are probably unusual for investigations of this kind, where normally questionnaires or projective techniques are employed. The writer has argued for a long time that more objective tests not depending on interpretation or self-revelation are more likely to give good discrimination between normal and abnormal groups, and also to be more useful in the objective solution of problems such as the one under investigation now. The results reported below strongly support this belief.

Visual acuity. — Granger (16), in his review of the relevance of perceptual tests to personality study, has argued that there are numerous indications in the ophthalmological literature suggesting that central or personality factors play some part in determining results on the ordinary clinical tests of visual acuity, and Slater and Slater (30) have shown in a well-planned study that neurotics are inferior in visual acuity to normal control Ss of the same age, intelligence, and status.

The test used consisted of an ordinary Snellen chart with reversed type, which was placed immediately behind the S who observed the image of the test-

type in a distortion-free ophthalmic mirror at a distance of 3 metres. The right eye was tested first, with the left eye occluded, and after a short pause the left eye was tested with the right eye occluded. After a further pause, binocular visual acuity was tested. The S's acuity was expressed as a Snellen ratio, but for computational purposes the ratios were converted to scores on a 9-point scale and a total score obtained by summing the scores for monocular and binocular acuity. High scores on this test denote superior visual acuity.

Results of this test are shown in Table 1. It will be seen that the differentiation is highly significant, the normals having the best scores, the neurotics the worst, with psychotics intermediate. There is some difference in the variances.

TABLE 1
PERFORMANCE ON TEST OF VISUAL ACUITY

	Normals	Neurotics	Psychotics
Means	22.550	17.450	18.700
Variances	4.892	48.997	17.168

F = 5.966

Significance = 0.1%

Object Recognition Test. — This test was designed by Brengelmann and has been described in detail in Eysenck, Granger, and Brengelmann (10). Essentially, the procedure is as follows. An object on a table is exposed monocularly for varying periods by means of a photographic shutter arrangement. The S is required to describe what he sees and also to determine whether what he sees is two- or three-dimensional. There are three exposures of 1/100 of a sec., five of 1/25, two of 1/5, two of 1/2, two of 1, three of 3, and three of 5 sec.

The score used for this investigation is the number of exposures required to recognize the three-dimensional nature of the test objects. (There are two objects in all, one the bust of a man's head, the other two pairs of spectacles.)

Table 2 shows the scores of the three groups on this test. It will be seen from the results that the normals have the best score, psychotics the worst, with neurotics very close to the psychotics. The significance level leaves little doubt about the reproducibility of these data.

Mental speed — The test here used, together with its rationale, has been discussed in detail in Eysenck (7). The test used is the Nufferno Speed Test. This consists of a series of very easy letter series problems, in which the S's task is to find solutions as quickly as possible. The actual score used is a logarithm of the time taken over the task. From theoretical considerations and much unpublished work carried out at the Institute, it appeared likely that psychotics would be

TABLE 2
PERFORMANCE ON TEST OF OBJECT RECOGNITION

	Normals	Neurotics	Psychotics
Means	17.700	28.550	31.600
Variances	75.168	90.786	73.937
F = 13.349		Significance = 0.1%	

found very slow in comparison with normals and neurotics. Results are reported in Table 3, and it will be seen that they bear out this prediction at a high level of significance.

TABLE 3
PERFORMANCE ON TEST OF MENTAL SPEED

	Normals	Neurotics	Psychotics
Means	9.386	9.686	11.664
Variances	1.514	2.943	4.090
F = 10.759		Significance = 0.1%	

Accommodation. — The review by Granger (16) suggested that anomalies of accommodation would be found more frequently in psychiatric patients than in normal Ss. The test used here was the Near-Point Rule developed by Giles (15). This consists of a metal rule about 40 cm. in length, one end of which fits into a holder which is pressed against the face of the S. A card bearing test-type is fitted into a clip which slides along the rule. A "blur point" is established by moving this card toward the S, and a "recovery point" by moving it away from him. Details regarding the application of this test may be found in Eysenck, Granger, and Bregelmann (10). Low scores on this test may be interpreted as indicating superior amplitude of accommodation. The particular score chosen here is that of recovery for the left eye, and the actual scores for the three groups are given below in Table 4. It will be seen that normals have the best scores, psychotics the worst, with neurotics almost exactly half-way between the other groups. These differences are highly significant.

TABLE 4
PERFORMANCE ON TEST OF ACCOMMODATION

	Normals	Neurotics	Psychotics
Means	17.260	19.485	22.335
Variances	20.610	20.815	32.256

F = 5.632

Significance = 1.0%

STATISTICAL TREATMENT AND RESULTS²

The technique of discriminant function analysis used here is very much like that of analysis of variance, but being in matrix form requires the calculation of several matrices. First, the total product-sum matrix (G) was computed for the four variables, then the between-groups product-sum matrix (B), the difference between these giving us the within-groups product-sum matrix (W). (The latter was checked by an independent procedure.) Hamilton (17) and Rao and Slater (28) proceeded to maximize the general distance function (D^2); we followed instead Lubin's (23) method of maximizing the square of the correlation ratio, given by

$$R^2 = \left(\frac{\text{deviance between groups}}{\text{total deviance}} \right).$$

In essence, our problem is this. We wish to find a set of weights in order to derive from our four tests a composite score for each S such that the square of the correlation ratio (R^2) between that composite variate and the three groups is at a maximum. Hence, if we take $R^2 = \dot{u}B\mathbf{u} / \dot{u}G\mathbf{u}$, following Lubin (23), we arrive at the equation $(G^{-1}B - R^2I)\mathbf{u} = 0$. (In this expression, G and B have already been defined, \mathbf{u} is the column vector of weights and \dot{u} is its transpose. I is the unit diagonal matrix.) The values of R^2 which satisfy this equation are the latent roots of the non-symmetric matrix $G^{-1}B$, each root having a corresponding latent vector \mathbf{u} . Obtaining $G^{-1}B$ involves calculating the inverse of the matrix G and post-multiplying it by B . This results in the non-symmetric matrix BG^{-1} from which the latent roots and vector are extracted using an iterative method for non-symmetric matrices. As the rank of $G^{-1}B$ is always one less than the number of groups (or of tests, whichever is the smaller), only two latent roots were found.

²I am grateful to Mr. A. E. Maxwell for his guidance on the statistical techniques employed, and his ready advice on the most appropriate methods to be used. He also supervised the computations which were carried out by J. Le Prevost and N. D. Hemsley.

Having obtained these two latent roots, we applied tests of significance, using Bartlett's chi-square test for the significance of the canonical roots: $X^2 = -(N-1 - \frac{q+c}{2}) \log_e(1-\lambda)$, where λ is the root whose significance is being tested, q = number of tests, c = number of groups, and N = number of S s. $\lambda_1 = .543944$, which is significant at beyond the .001 level, and $\lambda_2 = .155406$, which is significant at the .02 level. Both roots are therefore significant, and the two-dimensional hypothesis is supported. The correlation ratio (R) between the three groups and the two variates is .84, a not unreasonably low figure when the unreliability of the criterion is borne in mind.

The next step in the procedure consisted in computing variate scores for each S on both variates. This was done in the following way. The latent vectors furnished us with two sets of weights to apply to the scores, so that two measures could be calculated for each S , one for each canonical variate. The scores, Y_1 and Y_2 , were found by multiplying the score of an S by the appropriate weights and running them over the four tests. A plot of these scores is given in Fig. 3.

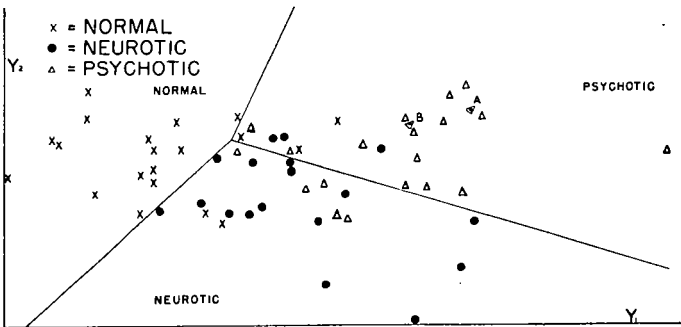


FIG. 3. Variate scores and group segregation using visually fitted lines.

where normals are represented by crosses, neurotics by dots, and psychotics by triangles. Two methods were used to segregate the three groups, and thus determine each S 's proper status according to his test behavior. The first method made use of the Rao quadratic discriminant function to calculate maximum likelihood functions for each S , then allocating him to the most likely of the three groups. This procedure gives 65% of correct classifications, as shown in Table 5.

The second method used fitted the discriminant lines visually; these lines are shown in Fig. 3. The number of correct classifications was considerably higher, amounting to 75%, as shown in Table 6.

It is unusual to find visually-fitted functions superior to functions fitted by statistical formula. The probable explanation has been suggested by A. Maxwell

TABLE 5
 CLASSIFICATION BY DISCRIMINANT FUNCTION BASED ON TEST
 SCORES COMPARED WITH CLASSIFICATION BASED ON PSYCHIATRIC DIAGNOSIS

<i>Diagnosis</i>	Test			<i>Total</i>
	C	N	P	
Control	<u>16</u>	3	1	20
Normal	6	<u>10</u>	4	20
Psychotic	2	5	<u>13</u>	20
				<u>60</u>

TABLE 6
 CLASSIFICATION BY VISUALLY-FITTED DISCRIMINANT LINES BASED ON
 TEST SCORES COMPARED WITH CLASSIFICATION BASED ON PSYCHIATRIC DIAGNOSIS

<i>Diagnosis</i>	Test			<i>Total</i>
	C	N	P	
Control	<u>15</u>	2	3	20
Neurotic	0	<u>15</u>	5	20
Psychotic	0	5	<u>15</u>	20
				<u>60</u>

to lie in the fact that the formula assumes variate scores to give a multivariate normal distribution, whereas it can be shown that in the particular case in question these scores are somewhat skewed. This is an interesting demonstration of the possible superiority (especially in the two-dimensional case) of the simpler procedures. In view of the very time-consuming nature of the quadratic discriminant function and maximum likelihood analyses, it is suggested that in most cases visually-fitted lines will be found at least as satisfactory. On multi-dimensional models no independent check on misclassifications is possible, and great care should be taken to investigate the distributions of variate scores. If necessary, transformations may have to be made to produce optimal results.

DISCUSSION

The fact that both latent roots are significant, in spite of the small number of *Ss* and tests used, and in spite of the fact that *Ss* were chosen on purpose so as to exclude extremely bad "abnormal" cases and extremely good "normal" controls, indicates that the one-dimensional theory of mental abnormality is invalidated, and the two-dimensional theory supported. This result is in line with results previously reported (5), and although no single, small-scale investigation can be considered definitive it may be mentioned that a repetition of the experiment here reported, using six tests and about 250 *Ss*, has given similar results. The weight of the evidence seems to be opposed to the Freudian view.

One or two points may call for discussion. A misclassification rate of 25% may seem rather high, particularly when we have in mind the practical application of the method to clinical and selection problems. It seems unlikely, however, that even a set of perfect tests would materially reduce this figure. As Fraser (13) has shown, an unselected "normal" group contains between 10% and 30% of persons suffering from severe and often incapacitating symptoms of psychiatric disability; it is only because of the absence of appropriate psychiatric facilities that the persons appear as nominally "normal." The test battery would correctly class them in the neurotic or psychotic sectors, but from the point of view of this analysis they would appear to be misclassified.

As regards neurotics misclassified as psychotics, and *vice versa*, the adequacy of the criterion must also be doubted. A review of the reliability of psychiatric diagnoses (7) has shown that agreement between psychiatrists, even on major classifications, is far from perfect, and in view of this known deficiency of the criterion the amount of misclassification found is surprisingly small. That this interpretation of the findings is essentially correct is indicated by the following. Two neurotics marked "A" and "B" in the diagram, were placed by the test scores right in the centre of the psychotic cluster. Both were readmitted to the hospital later on, and both had their diagnosis changed from a neurotic to a psychotic one — "schizophrenia" in one case, "paranoia" in the other. (This change was of course quite independent of the test results: the analysis had not even been completed when it occurred.)

Another point concerns the interpretation and position of the two variates Y_1 and Y_2 . The variates are similar, in some of their properties, to Hotelling's principal components in factor analysis. Their position is partly determined by the chance selection of tests, and would not remain invariant under change of some of the tests in the battery. It follows that they usually cannot be interpreted psychologically, any more than can Hotelling's principal components or Thurstone's centroid factors without rotation. Such a "rotation" in the case of canonical variates is equally permissible, provided it is used to illustrate rather than "prove" a psychological theory. We can shift our origin and redraw our variates anywhere in the two-dimensional space defined by the original variates,

provided that the variates remain orthogonal. Such a rotation has been carried out in an attempt to show that the results of this analysis are compatible with the writer's theory regarding the existence of two orthogonal factors of "neuroticism" and "psychoticism," a theory hitherto largely dependent on factor-analytic support. The original variates, Y_1 and Y_2 , cannot be interpreted as corresponding to these factors as their position is not invariant. The new variates, Z_1 and Z_2 , are shown in Fig. 4; Z_1 corresponds to the factor of "neuroticism," Z_2 to that of "psychoticism."

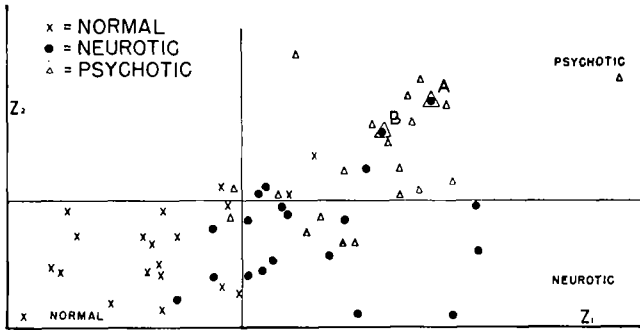


FIG. 4. Result of "rotation" in the case of the present canonical variates.

If this identification is correct, then a rather interesting feature of Fig. 4 may be commented upon. Nearly all the psychotics have high scores on neuroticism, while both normals and neurotics have low scores on psychoticism. The second quadrant (high psychoticism, low neuroticism) is almost entirely empty. Perhaps the most obvious hypothesis to account for this finding is that psychotic involvement produces such strains and stresses that emotional instability or neuroticism appear as a result of this intolerable situation. No data are available to test this hypothesis; however, the mutual positions of the groups are so dramatic in their implications that a direct attack on this problem appears worthwhile.

SUMMARY

An experimental test is reported of two theories regarding the relation between neurotic and psychotic disorders. Using the method of canonical variate analysis, we analyzed scores on four objective performance tests of normal, neurotic and psychotic Ss, equated for sex, intelligence, and approximately for age. The analysis gave strong support to the view that neurotic and psychotic disorders lie along different and independent dimensions. Results were incompatible with the Freudian view of a single dimension of abnormality or "psychosexual regression." Some implications of the findings are discussed.

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