O, P, Q, AND R TECHNIQUES

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Editor's Preface

The following was found among the papers of the late Sir Cyril Burt (1883-1971), Professor of Psychology at the University of London from 1932 onward and early critic of the ideas of William Stephenson. According to L.S. Hearnshaw, Emeritus Professor of Psychology at the University of Liverpool and Burt's official biographer, the manuscript was intended to be an addendum to Chapter VI in a planned second edition of *The Factors of the Mind* (University of London Press, 1940), Burt's major statement on factor analysis. This addendum must have been written about 1954, the date of the most recent citation. Burt's secretary, Miss Grete Archer, informs us that he was accustomed to revising papers many times, hence we can assume that he would have revised it further in light of subsequent developments. There is no mention of Q technique per se, nor of Stephenson, and it is noteworthy that the probable writing date coincides with Stephenson's postwar reentry into academia and with his renewed efforts to promote Q methodology--e.g., "Some Observations on Q Technique" (*Psychological Bulletin*, 1952) and *The Study of Behavior* (1953); these publishing events may have led Burt to reconsider his own emendation which, for whatever reason, was never published and appears here

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for the first time. Slight stylistic alterations have been made. It is obvious at certain points in the footnotes and references that complete bibliographic details could not be obtained. We are grateful to Professor Hearnshaw for having made a copy of the manuscript available, and to Miss Archer for permission to publish it.

GENERALIZED FACTOR ANALYSIS

Factorial techniques have commonly been presented as if their sole task was to analyse or classify mental attributes, and as if the analysis or classification could only be inferred from correlations between the attributes themselves. Thus Thurstone (1935: 48) begins by telling us that "factorial methods have been developed primarily for the purpose of analyzing the relations of human traits," and defines a trait as "any attribute of an individual" (definition 1).* As a rule, the attributes are assumed to be cognitive abilities, and the requisite measurements are nearly always obtained by applying mental tests. Holzinger (1937: 4), for example, explains that the object of the factorist is to sort "a variety of mental capacities into a small number of independent categories," and Thomson (1939: 4) suggests that a factor may be thought of as a "pure test, fictitious, not real, to be approximated to by combining real tests, each so weighted that their unwanted aspects tend to cancel out."

It is assumed then that we begin with a collection of test-data measuring the observable traits of certain individuals, and that the first step is to calculate the cross-products of the measurements for the various traits, taken in pairs, the cross-products being summed over all the persons in the sample. The

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*[The same quote is in the revised and now more accessible version: L.L. Thurstone, *Multiple-Factor Analysis: A Development and Expansion of The Vectors of Mind* (Chicago: University of Chicago Press, 1947), p. 62--*Ed.*]

effect of this is that the persons as such disappear almost at the outset. Indeed, in most factorial researches we never hear of them again. The inquiry usually ends with an attempt to identify and name the hypothetical concepts in terms of which the given trials have been analysed or classified. Nevertheless, this is obviously by no means the only method that could be adopted with such data. We could just as easily calculate our correlations so that the traits would disappear, and in that case what we should analyse or classify would be the persons.

But in my view the whole problem is wrongly conceived because it is stated throughout in terms of the old subject-and-predicate logic.

What we really begin with is not the measurement of an inherent attribute in and by itself, but the measurement of an overt "performance," i.e., of an observable item of behaviour.[1] And each measured performance can, and should be, specified in three ways: (i) it is the performance of a specific individual, and thus has, as it were, a location in the concrete world; (ii) it is a performance observed at a specific time, and thus has a date; and (iii) it is a performance of a specific kind, with an aim or direction of its own, which makes it different in na-

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1. Since an item of behavior is an "event," I am tempted to suggest that this consideration brings the analysis of psychological phenomena more into line with current trends in physical science. The material "substances" of classical physics--atoms, electrons, protons, and the like--are now commonly regarded as "logically complex structures composed of entities which are metaphysically more primitive, which may be conveniently called 'events'." ..."Instead of a permanent piece of matter, we have now... a series of events connected with each other in a certain way" (Russell, 1927: 9, 244). In the same manner we may regard an individual "mind," not as a simple psychic substance with inherent causal attributes, but as itself a highly complex structure. It is the aim of factor analysis to reveal that structure.

ture from other performances that might have been carried out by the individual at the time in question. The nature of the performance depends far more on the environmental stimulus or situation that provokes it than upon the person himself. We may give him words to read, arithmetical problems to solve, pictures to grade according to their aesthetic merit; or we may observe his reactions to the opposite sex, to situations of apparent danger, to objects that are comic, fanciful, or enigmatic. It is primarily these stimuli or "tests" (if we may so widen the word) which the "attributes" or "traits" really characterize.

Thus every one of the measurements that we propose to compare or examine assigns a numerical quantity (perhaps only 0 or 1) to a point-event having a threefold specification: it will refer simultaneously (1) to one of a conceivable number of persons, P_i say, (2) to one of a conceivable number of attributes, traits, or tests, T_j say, and (3) to one of a conceivable number of times or occasions, O_k say, when the observations were or could have been made. Accordingly, to borrow the language of analysis of variance, we are evidently faced with a "three-way classification."[2]

A complete study of this kind, involving variations in all three directions at once, would entail a rather elaborately designed investigation and decidedly large samples. Hence, particularly in the opening stages of his researches, the investigator will usually prefer to separate the different issues, and focus attention on only one of the primary "sources of variation." Since there are three such sources, there will be three conceivable lines of approach: for brevity we may call them *P*-, *T*-, and *O*-techniques respectively; eventually, if we can secure large enough samples, we shall doubtless go on to study the "interactions" (*PT*, *PO*, and *TO*).[3] This simplifica-

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2. Cf. Introduction, Table III. [Burt was apparently referring to a proposed table appearing earlier in the revised manuscript; there is no table of this kind in the 1940 version--*Ed.*]

tion can readily be effected by substituting the method of covariance or correlation for that of analysing variance. Thus, to eliminate (say) variations in time the psychologist will obtain all his measurements at approximately the same time--e.g., all the tests will be applied at the same sitting. Next, to eliminate the effects of differences in the persons tested, he may calculate product-sums, carrying the summation over all the persons in his sample. He is thus left with covariances or correlations between tests or traits, between one type of variable instead of three.

As in analysis of variance, the successive modes of comparison must be independent; and this implies that the factors or functions expressing them will be orthogonal.[4] In any such inquiry, simple or complex, the primary sources of variation will correspond to what the factorist calls "general factors" and the modes of interaction to "bipolar factors." Moreover, inasmuch as each "first-order interaction" involves *two* variables, each bipolar factor can in theory be reached in two ways, according to the subsidiary technique adopted--e.g., correlations between persons can be obtained either by keeping the time constant and carrying the summation over the tests, or by keeping the test constant and carrying the summation over the different times.

In all therefore we have at our disposal six possible modes in which correlational techniques can be applied. Their nature and their methodological differences were described long ago by Stern (1911) with admirable clarity when outlining his programme for "differential psychology." He begins by distinguishing "the three fundamental dimensions of psychology," which he likens to the three fundamental dimensions or units of physics.[5] The purpose of correlation, he

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3. For the notation and terminology, cf. Fisher (1937: 122).

4. This is implicit in the very nature of variance analysis. It is brought out most clearly by Mather (1942), sects 22 and 23 on "The Principles of Partition" and "The Individuality of Degrees of Freedom."

says, is to study relations (*Zusammenhänge*), and there are consequently three main types of relational problem which call for separate study: (I) *Strukturzusammenhänge* [structural relation] (leading to the classification of traits), (II) *Typologische* [typological] or *Symptomatische Zusammenhänge* [symptomatic] (leading to the classification of persons), and (III) *Ätiologische* or *Teleologische Zusammenhänge* [aetiological or teleological relation] (leading to the determination of changes or trends). These form the topics of three different branches of psychology: general psychology, which is concerned solely with traits or attributes (*Merkmale*); individual psychology, which is also concerned with persons (*Individuen*); and differential psychology, which is largely genetic and therefore envisages changes of persons and traits with the passage of time.

Each has its own distinctive method. Thus, starting with a single experiment carried out on a single date, we first collect measurements of a number of different traits, *a*, *b*, ... *m*, *n*, ... *x*, each assessed for a number of different individuals, *A*, *B*, ... *M*, *N*, ... *Z*. The results may be set down in a two-dimensional table or diagram, with the names of the persons arranged along the top and the names of the traits down the side. We thus obtain a rectangular *Schema* (or matrix) such as that shown in Figure 1, reproduced from Stern (1911: 18).[6]

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5. It would, I fancy, have been more natural to compare it with the simplified scholastic scheme of four categories--substances (which are "particular" individuals), qualities ("universals" which are common to many substances), space, and time--and then argue that, since individual minds are not in space, psychology is concerned with only three types of category not four. It should be noted that a somewhat similar classification of both problems and methods is to be found in other German writings of a slightly earlier date: cf. Lipps (1905), Meumann (1907), and Betz (1911); cf. also Bobertag (1915).

6. Stern's lettering makes the number of persons equal to the number of traits, so that the diagram is

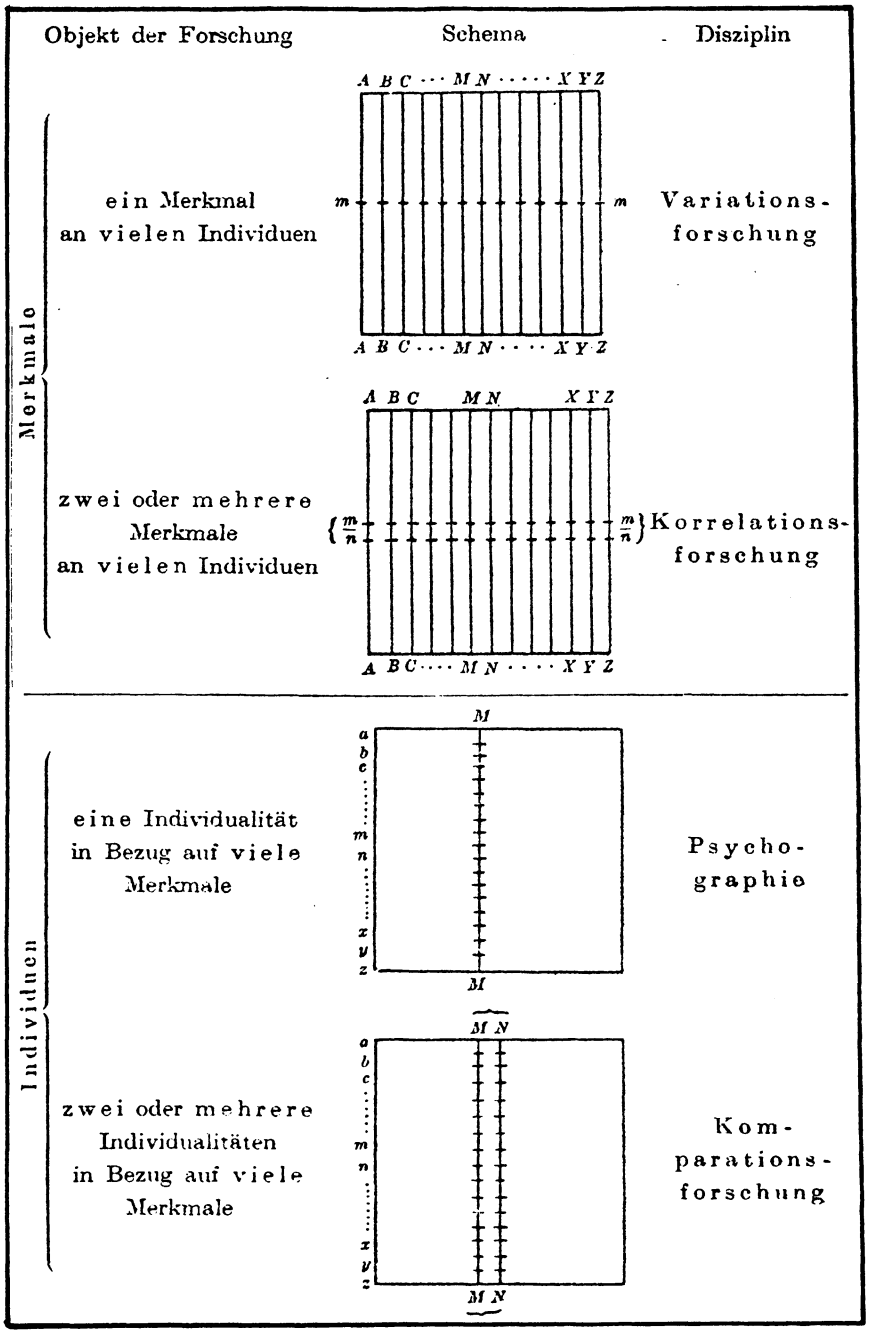

Figure 1 (Source: Stern, 1911, p. 18).

(I) A horizontal line or section (*Schnitt*) across the diagram represents the assessments for a single trait, varying in strength from person to person. The investigation of such personal differences Stern terms *Variationslehre*, and their comparative study "Covariation."

(II) A vertical section down the diagram will represent the assessments for a single person, and the study of such descriptive [...] he calls Psychography. The comparative study of two such psychographs he proposes to term "Comparation." (Bobertag (1915) suggested the term "Form" for the Gestalt-like psychogram, and the terms "Co-formation" or "Conformity" to express the resemblance between two such psychograms.)

The amount of both covariation and comparation may be ascertained by the same statistical procedure, namely, by calculating the correlation. So far, therefore, we have two complementary types of correlational inquiry--*inter-individuelle* and *intra-individuelle Korrelationslehre*.

(III) But modern science is essentially causal and therefore concerned with change. Hence modern psychology can no longer treat mind as a timeless abstraction. The individual mind has a *zeitliche bestimmte Realität* [temporally-determined reality]. And, in describing living creatures, it is absurd to suppose that the strength (*Masszahl*) of their characteristics can be measured once and for all, as if we were dealing with a monument or a mountain: *die Konstanz der geschilderten Eigenschaften ist ja nur eine Fiktion* [The constancy of the portrayed characteristics is only a fiction] (Stern, 1911: 335-337). In the biological fields these changes exhibit not merely causality or retrospective dependence, i.e., causality in the narrower sense, but also prospective depen-

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square: this is inessential and may be misleading. Allport (1937: 10-11, Fig. 1) reproduces the same diagram (from a later edition), but does not quote Stern's discussion of the vertical or temporal dimensions. In Stern's later writings the study of personality received increasing emphasis (cf. Stern, 1923).

dence, i.e., direction towards an end or goal (*Ziel*), or "final" causality. Once this is fully recognized, our science (says Stern) will cease to be static, and become both dynamic and teleological. As before, dependence may be measured by calculating correlations; and to describe the degree of correspondence between two or more temporal changes, Bobertag (1915) suggested the term "Co-mutation."

If we are to include the chronological aspect (*chronologische Charakter*) in our spatial model, we must employ a third dimension; and so our diagrammatic square (or rectangle) becomes a three-dimensional cube (or cuboid). Studies involving only a two-way classification will be represented by sections through this solid block, i.e., one or other of its three coordinate planes--frontal, lateral or sagittal. For example, in dealing with a single individual (whether an actual person or a hypothetical person, e.g., a "class-type") we may take either (1) a frontal or transverse section through the block--*ein synchronistischer Querschnitt, der die gleichzeitig neben einander bestehenden Elemente der Xschen Individualität zeigt* [a synchronic cross-section which shows simultaneous existing elements (traits) of the individuality of person X]; or (2) a sagittal or longitudinal section--*ein chronologischer Längsschnitt, der die zeitlich auf einander folgenden Phasen der individuellen Entwicklung blosslegt* [a chronological longitudinal section which expresses the consecutive stages of individual development], thus obtaining a case-history in quantitative terms. The distinction is analogous to the pathologist's determination of syndromes and of prognoses respectively.

"A science," says Stern, "must proceed by means of general concepts and general laws."[7] In a complex

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7. Stern (1911) himself does not discuss in detail how the *Urfaktoren* or *Grundeigenschaften* [primary factors or fundamental characteristics] (as he variously calls them) are to be discovered. He tentatively suggests the notion of "resultant correlation"; and, in a postscript (p. 294), he cites an early factorial investigation of my own (Burt, 1909) as illustrating the

field like psychological [...] we can only discover the appropriate concepts for classifying traits and persons--concepts of narrower and wider generality--if we apply statistical techniques, namely, correlating both traits and persons; and we can only determine causal and teleological laws if we correlate their temporal variations. Correlation, however, is a device for comparing *two* parallel series only. We need something far more comprehensive. In my view the only satisfactory and rigorous procedure for isolating and establishing the requisite "concepts of greater or lesser generality" will be to undertake a factor analysis of the numerous correlations obtained. The factors themselves will yield the classificatory principles. But to justify my view it is now incumbent on the [...] to show, either by example or by formal proof, that the factorial methods I have described may be validly applied to tables obtained by any one of the six methods we have just distinguished. For simplicity of reference I have set out the six possibilities in Table [...].[8]

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kind of multivariate technique he had in mind.

8. [The table referred to was not in the manuscript, but its essentials can be gathered from the text--*Ed.*] I am myself inclined to deprecate the practice of referring to the techniques by letter only, since different authors now use the same letters in different ways. The notation adopted in the table above is perhaps the simplest and most convenient. The notation $R_{pt.o}$, $R_{op.t}$, etc., is less ambiguous, but tedious to write. An alternative nomenclature, which at one time became popular in our laboratory, was to designate the correlation of traits, persons and occasions T technique, P technique, and O technique, respectively, and if necessary affix a single subscript to denote the type of variable over which the correlation is carried. Thus, the calculation of the ordinary correlation was termed T_p technique, and the calculation of reliability coefficients for repeated applications of the same test O_p technique, and so on. The resulting factors are usually called T, P, and O factors, but we might

CORRELATIONS BETWEEN TRAITS

(i) R_1

As a glance at the literature will quickly show, the commonest method consists in calculating correlations between a number of traits (1, 2, 3, ..., n, say), each measured on a single occasion, the summation being carried over a sample of N persons. This leads to the form of factor analysis which is most widely known and generally regarded as most typical of all such procedures. The factors so obtained yield a classification of traits.

(ii) R_2

Still keeping to the same sample of persons, we can attack quite a different problem. Instead of collecting and correlating measurements for a number of different traits, all tested or assessed on the same occasion, we may correlate measurements for one and the same trait, tested and retested on a number of different occasions. The oldest, simplest, and most familiar instance of this procedure is the calculation of a "reliability coefficient" for a single test which has been applied at two successive trials. However, as has often been remarked, to show that the results of a test remain consistent for a couple of trials only is a feeble way of demonstrating that its measurements are genuinely stable. In the earliest of my published investigations (that cited by Stern) the majority of the tests were applied at least three times, one as many as six times: and the results were found to vary considerably, especially in the later trials (Burt, 1909: 152, 168). With a test that is presumed to depend mainly on innate characteristics, we demand fair-

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subdivide them into T_p and T_o factors, and so on. Nevertheless, in spite of a superficial consistency, such designations are not wholly appropriate and are apt to be easily confused. Indeed, most of the so-called O factors are really T or P factors obtained by an alternative technique.

ly high correlations even when the applications are separated by long intervals;[9] and to test successive generations, we may use the correlations. Hence the method provides one useful way of testing such claims. As is well known, even with a highly efficient test, the correlations between the IQs tend to diminish as the interval between each testing becomes longer and longer.[10] If, however, the correlations prove to be comparatively small, we shall be disposed to conclude that the test is no longer measuring innate or pure ability, but is affected by changes in developmental rates or in relevant types of experience, especially so-called "test-sophistication."

All such correlations may for reference be called correlations between occasions. But in the foregoing cases what we are really correlating are still measurements of traits, not measurements of the occasions as such. Nevertheless, in a few factorial inquiries this method has been used to compare not the traits or tests but the external conditions. Thus in a series of weekly tests with Kraepelin's *Rechenhefte* that I carried out with a batch of school children, I found that the successive trials grouped themselves, not according to consecutive dates, but according to the prevalent atmospheric conditions and their apparent effects on certain susceptible individuals. In these cases therefore the factors may yield a classi-

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9. Or, if we keep to the same families instead of the same individuals, we may correlate measurements for successive generations. Thus Galton's earliest correlational studies were really forms of what would nowadays be called O technique. I have managed to get records of stature for five successive generations, and found a general factor accounting for nearly 53 per cent of the variance. But it is rarely possible to get a series long enough for factorial analysis.

10. In following up London children tested at 7-8, I found that over a period of nine years the correlations declined from 0.96 to about 0.84 (see Burt, 1914-1929, and *Studies in Education*, p. 15; cf. also Carmichael, 1946: 586-588 and refs).

fication of occasions.[11]

(iii) R_3

With the two techniques I have so far described, we keep first to a single occasion and secondly to a single test or trait. There is a third possibility: we may keep to a single person,[12] and compare two or more of his traits over a succession of occasions. In Stern's (1911: 283) words: "man bleibt ganz im Intra-individuellen, indem man an einem einzelnen Individuum die beiden notwendigen Merkmalsreihen durch sukzessive Prüfungen erzielt [One remains totally in the intraindividual while one achieves through successive practice the two necessary series of attributes in only one individual]." The factors obtained will again yield a classification of traits, but now the

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11. With other tests it may be the social or psychological conditions, characteristic of the different occasions, which determine the grouping (cf. Yule, 1912: 60). In a somewhat different field of work, I attempted a factorial study of the geographical distribution of weather in England by intercorrelating 30 assessments of property tax over the various counties from 1086 to 1843 A.D. (data collected by Buckatzsch, 1950), and found a marked bipolar factor separating assessments before and after the middle of the 18th century and a small [factor] separating those before 1500 from those after (Burt, 1952). An analogous piece of factorial research has recently been published by my colleague, Dr. C. Banks (1954: 108, Table 4): using Kendall's data she correlates successive years (not consecutive) for average crop productivity in different counties, and seeks to measure the size of the general factor for different numbers of crops.

12. As already noted, a common device is to correlate the mean of the measurements for a *group* of persons, who are all treated as if they were combined into a single typical or average person. We thus work with what Stern would call the "psychogram for a class."

traits will be grouped, not so much according to their intrinsic quality or nature (except perhaps indirectly), but according to the various trends that they display with the passage of time.[13] Hence this method of calculating correlations is appropriate for two special types of problem--those of (a) spontaneous or primary changes, and (b) artificial or secondary changes: we may accordingly distinguish what Stern (1911) calls *Entwicklungs-Korrelationen* [development correlations] and *Übungs-Korrelationen* [practice correlations]--i.e., correlations due (a) to progressive maturation, and (b) to practice or learning, together with their opposites, (a) deterioration and (b) fatigue.

However, with this type of inquiry an auxiliary set of correlations can be introduced: since the temporal order is independently fixed, we may correlate the successive measurements furnished by each or all of our tests with the amount of time that has elapsed (or with some external condition that happens to act cumulatively with time), treating this as a kind of external criterion.[14]

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13. This is the type of factorial procedure which has perhaps been most strongly criticized. There are, of course, well known difficulties that beset any attempt to correlate two or more temporal series, but they are scarcely enough to vitiate the method entirely, at least for purposes of preliminary exploration. Moreover, several devices can be used to circumvent them: the simplest perhaps is to work with "variate-difference correlations," i.e., to correlate not absolute values, but amounts of change; other procedures have been developed in our laboratory by Dr. Philpott in his studies of work curves (see Yule 1921, 1926; Philpott, 1932).

14. Early examples of these chronological studies are to be found in the investigations on transfer of training by my colleague on the inspectorate, Dr. W. H. Winch (1909; cf. Winch, 1910, 1911). This attempt to supplement "static factor analysis" by "dynamic" is analogous to the change that has recently taken place in econometrics. The type of functional equa-

CORRELATIONS BETWEEN PERSONS

Much the same modifications in procedure are conceivable if, instead of correlating tests (or a single test on different occasions), we correlate persons (or a single person on different occasions).

(i) P_1

Working with data obtained on a single occasion only, we may (as in R_1) obtain assessments for a number of traits (tests or test-items) for a sample of *N* persons; we may then correlate, not the traits, but the persons or their psychograms, and factorize the new table so obtained. This is the form of P technique that has most frequently been used. The factors now yield a classification of persons.

(ii) P_2

Working with data obtained from one and the same person, we may (as in R_3) obtain assessments on a number of different occasions for the same set of traits. We can then correlate the various manifestations of that same personality, i.e., his changing psychograms after increasing intervals of time. This

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tion, introduced by Cournot and Walras, deals with relations between supply, demand, price, etc., in conditions of equilibrium or rest. They are based on static models. The dynamic model explicitly introduces time, and seeks to describe the observable changes in terms of "economic forces" (cf. Samuelson, 1941; Koopmans, 1950). Long ago, Edgeworth (1881), who, it will be remembered, was almost the first to describe factorial procedures, sought to use similar mathematical procedures to develop Bentham's "hedonic calculus." His method was based largely on the notion that mental processes sought to reach conditions of equilibrium, and he foresaw the possibility of building "mind-like run-about machines" on homeostatic principles like those recently embodied by Ashby in his *Design for a Brain* (1952).

method is the statistical version of the pictorial biographies that once figured in the *Strand Magazine*, under the caption "Portraits of a Celebrity at Different Times of his Life." The factors reached in this way will yield a classification of the main phases in the individual's progress. According to the conditions involved, they will suggest stages, aspects, or effects of such progressive processes as growth, deterioration, learning, therapeutic treatment, and the like.[15]

(iii) P_3

Finally, we may confine ourselves to a single trait or test, as in R_2. But now, instead of correlating different occasions over the same series of persons, we correlate different persons over the same series of occasions. As an instrument of research, the method may best be contrasted with R_3. With that procedure the factors furnished a classification of what might be called growth- or practice-curves for traits; with the present procedure they classify what might be called growth- or training-curves for persons: they will, for example, group together those persons whose development follows much the same general course (e.g., identical twins or children of the same sex) and those whose development follows a slightly different or wholly different pattern. As Stern (1911) remarks, the latter (P_3) is the *inter-individuelle* method and the former (R_3) the *intra-individuelle* method of dealing with the same general type of aetiological problem.

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15. To call these O factors, simply because they appear to be obtained from correlations between different occasions, seems to me misleading. In many cases they classify not so much the changing characteristics of the times at which the tests are applied, but the changing character-pattern of the person himself. In my view, as I have already stated, "whether we call the factors *P*-factors or *O*-factors is a question, not of statistical 'technique', but subsequent interpretation" (Burt & Watson, 1951: 184).

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