Fifty Years of Exclusionary Psychometrics: I. Q Technique

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ABSTRACT: It was known in the 1930s that factor theory in psychology and quantum mechanics in physics had the same mathematical foundations. Q technique has developed this over the past 50 years into a system for a subjective science for psychology within the framework of Spearmanian principles of noesis, the creative nexus of so-called "mind." Spearman's search through history pointed to only one fundamental principle, that of states of pleasure-unpleasure, and this was the direction taken by Q technique. This allows an individual to measure any psychological event for its state of pleasure-unpleasure on a "forced choice" scale, by Q sorting, that gives zero score to every such measurement. It corresponds to the ground state of energy of an atom, in quantum theory. Quantization occurs when the individual performs several Q sorts about the event: which means that reality functions are reduced to quantum functions, the operant factors of Q methodology, which we now know are subject to Niels Bohr's Principle of Complementarity.

Introduction

Psychometrika has been a mecca for papers on factor theory since its foundation. Stanley A. Mulaik's review of 50 years of its existence, in "Factor Analysis and *Psychometrika*: Major

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Developments" (1986), observes that papers on factor analysis appearing in *Psychometrika* reflect the initial efforts of L.L. Thurstone and his followers to reformulate psychology as a quantitative science. This was not new to the Thurstonians, Mulaik reminds us, but was taken from British statisticians and psychologists, whose work was then largely ignored. So ignored was Cyril Burt, who had already reported that the mathematical foundations of factor theory in psychology and quantum theory in physics were analogous, and were developed independently (Royal Society of London: Burt, 1938; Burt, 1940). Stephenson was also amongst those ignored, though Mulaik admits his was a major contribution, "one of a very few important" articles to appear in the first five years of *Psychometrika.* The accolade, however, had reference to *cluster analysis*, not to Q technique, which he introduced in the first volume of *Psychometrika* in "The Foundations of Psychometry: Four Factor Systems" (Stephenson, 1936). There were only two independent systems, R and Q. Since then, except for a paper by Burt and Stephenson (1939) representing our distinctly different positions on factor theory, nothing has been published in *Psychometrika* bearing on Q metholology except for a review of *The Study of Behavior: Q-Technique and its Methodology* (Stephenson, 1953a) by Cronbach and Gleser (1954), in which students were admonished not to use Stephenson's methods.

Since the late 1930s, with World War II intervening, Q technique has been developed into foundations for a quantized-theoretical science for subjective psychology (Stephenson, 1980a) in a series of papers (Stephenson, 1935, 1980a, 1980b, 1982a, 1982b, 1983, 1986a, 1986b, 1987a, 1987c, 1988a, 1988b, 1988d, 1988/1989). It happened that the present author held a Ph.D. in experimental (nuclear) physics when he went to London to study psychophysics (as he thought) with Charles Spearman in 1926, and became assistant to both Spearman and his successor Burt. Psychology was then at a meridian point in Britain and one was in a position to develop a new quantized theory of subjectivity in a psychological context. What has emerged is the subject of the present paper.

That the quantum theory evolved from Spearman's principles of cognition (of *noesis* as the nexus for creative thought) is the burden of these pages.

British Psychology Pre-World War I

It is important to recognize that psychology was in perhaps its highest state of sophistication in the pre-World War I decades, beginning with Spearman's introduction of factor theory in 1904. Graduates from all parts of the British Empire (which still ruled the waves) came to the Spearman School to take part in the invention of factorization, and to search for the gold (so to say) in *g* factor. Leading mathematicians, statisticians and psychologists were intrigued by Spearman's work, particularly with regard to *g* factor. The pre-eminent position in Britain when *Psychometrika* was founded is well-represented by a day-long meeting held under the auspices of the Royal Society of London in 1938. Few outside Britain will appreciate what this means: it was momentous to have a meeting of psychologists at the Royal Society of London, and to have the proceedings published in *Proceedings of the Royal Society of London* (1938) under the title "A Discussion on the Application of Quantitative Methods to Certain Problems in Psychology."

There were two sessions. The problem in the first was Spearman's *g* factor. Those in the second concerned statistical applications in British industry. The first was chaired by Professor C.S. Myers, F.R.S., the discussants being Professors Spearman, F.R.S., G.H. Thomson, C. Burt, Dr. H.B. Heywood, Dr. J.O. Irwin, and the present author. It was devoted exclusively to factor theory, and in particular to *g* factor, which dominated the proceedings.

The second session was chaired by Professor M. Greenwood, F.R.S., who introduced a Poisson series which he hoped would have wide use in both theoretical and practical statistical work. Several pioneers in industrial psychology were the discussants, though none touched upon the Poisson series, into which E.M. Newbold (1926) had already made inroads in connection with "a study of the human factor in the causation of accidents."

It is necessary to review, however briefly, the discussion on factor theory to indicate something of the stature of the matter at the hands of British psychologists, statisticians and mathematicians -- not all of whom were the actual contributors to the session. Professor Karl Pearson, for example, was very much in the wings.

The Factor Session

The chairman, Professor C.S. Myers, F.R.S., opened (pp. 415-416) by asserting that "conscious experience can never be measured numerically in its own terms," and that "mathematical physics may have no relation to reality." Mathematical methods are essential in psychology, he admitted, "when the investigation concerns the conducts of an aggregate of individuals," but when it concerns the individual, statistics are ancillary, "as safeguards against unreliable data."

Spearman followed (pp. 416-418) by saying that it was hard to agree with Dr. Myers' views: very different from such distrust in mathematics in general is our curiosity about "factorization." By means of simple mathematical expressions, combined and organized with psychological considerations, it had been possible to build a general theory of mental ability, designated the *Theory of Two Factors.* The methodology included calculation of tetrad-differences as the procedure for factorization of data.

Up to recently, Spearman said, this was the only factorization available: he stressed the close tie-in with ongoing psychology. But now Hotelling (1933) and Kelley (1935) have proceeded differently; traits and abilities were represented as ellipsoidal points in Cartesian coordinates, and the factorization, to quote Spearman, is "no longer Spearmanian, a matter of gradually building by successive stages intimately dependent on various psychological considerations" (Royal Society of London, 1938, p. 417). The method of principal components, instead, gave a complete general solution of a problem, regardless of prior psychological circumstances.

There was also Thurstone's centroid method (1935), and it too, like Hotelling's and Kelley's, gave a general solution to the whole factorization, regardless of prior psychological considerations. Like the method of principal components it tended to provide "artificial and even irrational results," and had to turn to *oblique ones* to save face. Holzinger's bi-factor method (Holzinger & Swineford, 1937) was a single step like the others, but introduced what previous investigations had shown to be important, thus offering a possibility of verification, and thus nearer to Spearmanian methodology.

The papers by Professor Thomson, Dr. Haywood, and Dr. Irwin followed, each cautionary about factorization -- Thurstone's conception of "simple structure" was an example of the notion that "mathematical elegance must indicate underlying reality" (Thomson); it would be impossible to define a unique set of factors (Heywood); there is danger in the transition from psychology to statistical method (Irwin) -- indeed a catalogue of the many technical difficulties facing factor theory to which *Psychometrika* devoted attention during the next 50 years.

The contributions by Professor Cyril Burt and the present author were quite different from the above.

New Thoughts

Professor Burt began by observing that the other contributions to the Discussion had dealt with developments within psychology: he invited us to go with him into fields that were being ignored, outside psychology.

There had been two notable advances. The most important were the methods of testing significance for small samples. (The reference was to R.A. Fisher's *The Design of Experiments* (1935), mainly agricultural application.) Psychologists, Burt said, had abandoned individual studies in the belief that statistical methods applied only to large numbers of persons: by group mental testing they were collecting less accurate data than was warranted. Now they could use variance and covariance analysis, using small numbers of persons. He considered that once this was realized, factor analysis and correlational method would lose their usefulness. Moreover, factor analysis itself is nothing much to talk about -- it is "simply a fresh application of the old principle of least squares" (Royal Society, 1938, Burt, p. 419). When we are seeking to discriminate between two or more groups -- such as between the two sexes, or different temperamental or vocational types -- the appropriate statistical method to use, according to Burt, is variance and co-variance analysis.

The other advance was introduced as follows:

> Perhaps the most fruitful points of contact between the mathematical problems of the modern psychologist and those of other scientists are problems for which matrix algebra or tensor notation has been recently adopted. (Royal Society of London, Burt, 1938, p. 419)

Spearman's factor theorems and much else could be put into this new form with remarkable simplicity:

> The analysis of a set of test scores to find principal factors is analogous to the determination of a spectral set of projective operators by a canonical reduction. (Royal Society of London, Burt, 1938, p. 419)

Thurstone's saturation coefficients emerge as first approximations, and those of Hotelling and Kelley as the final values, for *eigenvalues* and *eigenvectors*, respectively (p. 419). It suggested many further developments: for example, if factors are to be of general applicability -- the same for every matrix -- these matrices would necessarily reduce to canonical form simultaneously.

Such was the bare introduction to quantum mathematics: but Burt became psychologist again, and the rest of his contribution demands complete quotation:

> It is often objected that sensory qualities and sensory intensities...are not, strictly speaking, magnitudes that obey the laws of addition and multiplication: they do, however, conform to the requirements of group theory. The "simple percept," like the simple atom, turns out to be a pattern or structure -- a structure that has to be described without knowing either the material of which it is composed, or the operation which it endures. The aim of the early experimentalist was to connect an isolated sensation with an isolated stimulus of magnitude R, by some simple bivariate laws such as S = K log R; the problem of the contemporary psychologist is to account for the fact that, in spite of ceaseless changes in position, perspective, illumi-

> nation, and the like, I always recognize my chair as my chair, and that in a single glance. It may, I suggest, be solved by regarding both percepts and objects as matrices, and the permanent external object that we invoke to explain the "phenomenal consistency" as a matrix reduced to standard form. (p. 420)

This paragraph expresses the essential problem of modern psychology, at its most fundamental level. It also introduced quantum mathematics to psychology, and with this, the making of a quantum theory for subjectivity.

My own contribution introduced Q methodology, and it was clear that it was meant to probe ahead into Spearman's *noesis*. It reversed Burt's priorities, noting limitations in variance methodology (it concerned categorical definitions, and abnegated self reference), whereas Q technique could apply factorization to "the single case" (Royal Society of London: Stephenson, 1938, pp. 422-423).

The above review captures a small part of the involvement and excitement of the pre-World War I decades. But *g* factor, for those decades, had fascinated psychologists, statisticians and mathematicians alike. Physics was basking in the promise of vast sources of energy, hidden in the atom: there was something of the same fervor about *g* factor, as if it held promise of vast sources of new knowledge about the creative function of the mind -- Spearman's *noesis*.

Spearman Factorization

Mulaik (1986) raised a methodological issue in his review of 50 years of *Psychometrika*. A major shift in factor analytic thinking had occurred in 1970 in the U.S.A., Mulaik indicated, away from the exploratory methodology of Thurstone, Hotelling and Kelley, to a *confirmatory* methodology, meaning that prior deductions could be confirmed. Spearman's factorization was very different: it was from the outset *abductory* (Stephenson, 1961, pp. 9-17). Abduction was philosopher Charles S. Peirce's concept, that in addition to deductive and inductive forms of inference there is another, abduction, which gives rise to hypotheses in the first place, *de novo*, before the scientist can set about consequences and inductive possibilities.

By 1938 much had been done with group tests in Britain along this abductory line, of having a broad theory in mind, in terms of which to make *discoveries* (not by deduction, but by technique). Several so-called "group factors" had been accepted, for "verbal," "spatial," "psychological," "reasoning" and other complex processes of cognition -- indeed the present author was first to *discover* these factors (Stephenson, 1931), fostering them when he directed doctorates at the laboratory of University College, London, when they were placed under his tutelage during the two years after Spearman's retirement in 1932 and Burt's appointment as his successor in 1934. But they were essentially anoetic, leaving *g* factor pristine and intact.

Brown and Stephenson's "A Test of the Theory of Two Factors" (1933) had this abductory methodology behind it. It was undertaken to establish *g* on an adequate statistical basis. Karl Pearson had suggested the necessity for the test, and had provided a formula for the probable error of a distribution of tetrad-differences for "some 12 to 15 abilities." Twenty group tests were applied to 300 boys, age 10-10½. But they were not a random set of group tests: far from this, they were the outcome of decades of research in which *anoetic* processes were winnowed from *noetic*. There was, for example, W. Line's *The Growth of Visual Perception in Children* (1931), and a doctorate dissertation on African fundaments by M. Fortes (1930). The well-known Penrose-Raven test was fostered in the Spearman School, under the same abduction rules -- the present author, upon Spearman's request, put the test into final form. Pearson's probable-error expression for a distribution of tetrad-differences was verified for a matrix of 20×20 group tests, providing 14,535 tetrad-differences.

Earlier, Wilson (1928) and Piaggio (1931) had maintained that *g* could not be proven determinate; and J.O. Irwin (1932) had raised the question in "On the Uniqueness of the Factor *g* for General Intelligence." The indeterminacy had been countered by Spearman, noting that it diminishes with increased number of group tests -- whence the 20 constructed for the Brown-Stephenson experiment.

Factor *g* was now on firm statistical foundations. It was tied to *noesis* as firmly as a tree is to its roots. What had to be asked, next, was why *g* factor and *noesis* should have occasioned such fascination for so many psychologists, statisticians and mathematicians, including the present author.

The Noetic Nexus

The answer to the question just raised is to be found in Spearman's *The Nature of "Intelligence" and the Principles of Cognition* (1923). In this, "Intelligence" was specifically enclosed in parentheses to give the reminder that intelligence-quotient testing and the like was not at issue: it was *noesis*, represented by *principles of eduction*, the creative nexus of mind. The Spearman student was expected to move ahead in that direction, to probe *noesis*.

This was the premise of the letter written to *Nature* (Stephenson, 1935) introducing Q technique.

Spearman's *Nature of "Intelligence"* was based on introspection as an experimental method. Thus, in order to distinguish between *sensorial* and *notional* experiences, one of Spearman's experiments consisted of looking at a match-box on a chair: one could see the front, top, and one side (sensorial) but not bottom, back, or the other side, or inside (notional). Spearman used colleagues as subjects and concluded from their introspections that each experienced *notional* percepts. What could Q technique do about it? It could replace introspection altogether, by recognizing that what was at issue was essentially *verbal* behavior. Each experimental subject could freely talk about the matchbox -- how it was pliable, colored, probably empty, etc., and about events in one's life brought to mind by the matchbox -- how one's grandfather used that brand of matches, how one had nearly set oneself aflame with a box of matches, etc.

Thus, by 1935, Spearman's assistant was preparing to replace introspection by verbal report and factorization.

The question arises, on what grounds? What occasioned the change? The answer concerns *reality* -- a matchbox on a chair with me looking at it. Having already rejected consciousness and mind as substantive, it was obvious that one would look at Spearman's experiment with an eye to what really is at issue. And the answer was, "verbal report."

Psychological Events

Q technique was formed in the context of J.R. Kantor's concept of a behavioral segment (Kantor, 1933; Stephenson, 1953b), represented by his formulation for a *psychological event* (PE), as follows:

$$PE = C(k, sf, rf, hi, st, md) \quad [1]$$

(Kantor, 1959, p. 16), where symbols sf, rf, hi, st, and md stand for *reality*, as stimulus, response, historical connections, the immediate setting, and the medium of interaction, respectively. Symbol k indicates that the situation is unique, and C that it is confined to a given field of interaction.

> *The functions sf, rf, hi, md, st, are with respect to what we assume about the real world in which we live -- that something began it (sf), and it resulted in such-and-such (rf), under this-and-that conditions (hi, md, st).*

Thus, my introspection on Spearman's matchbox on a chair constitutes a behavioral segment -- it had a beginning and an end. My initial thought could have been "I don't believe in consciousness" (sf). The outcome was my couclusion (rf) that "verbal report is all there is to it." The immediate setting was Spearman's effort for introspectionism (st), and the medium of interaction no doubt was my resistance to this (md). What philosophers and Spearman had to say about consciousness was heavy with history (hi). Each of these thoughts gives rise to verbal report, such as "I don't believe in consciousness," "Introspection is fictional," "Spearman is wrong" ...etc., a collection of which constitutes *concourse* for the PE, that is, a statistical collection of self-referential statements for the PE, systematically gathered so as to cover formulation [1].

A *psychological event* (PE), however, is subjective: it is the psychologist, or an experimental subject, reflecting on the behavioral segment -- *and it is now impossible to be certain about its beginnings or end.*

Even so, it is possible to represent each of Kantor's reality functions [1] by a Q sort for a Q sample from the concourse. Thus, for sf a Q sort can be performed with instruction "Describe your feelings as you sat down to perform the introspection." For hi there could be "What is the viewpoint of the Oxford philosophers about mind?" ...and so on. Each reality function can be represented by at least one Q sort, and usually by several. The result is therefore as follows:

PE = C(k, Q sort 1, 2, 3...n) [2]

where C, k have the same meanings as in [1], for n Q sorts. These are correlated and factored, changing the formulation to the following:

PE = C(k, factors f_1, f_2, f_3...) [3]

where again k means the situation is unique, and C that it is for an interactional field.

What is achieved is quantization of the PE: the factor structure has been shown to conform to the principle of complementarity, as for Niels Bohr's Principle of Complementarity (Stephenson, 1986a, 1986b). The structure bears no unique relation to the reality functions of formulation [1], which disappear in the quantization.

The factors are theoretical Q sorts, like those performed by the Q sorter initially, but for states of feeling of which the Q sorter is unaware. They are self referential, and Q sorters recognize them as their own.

How, then, does the quantization occur? This we shall now examine.

Q Technique

The hub of everything is Q technique. It was a new probabilistic and use of statistical method, entirely subjective to the person.

	Unpleasure				Neutral			Pleasure			
Score	−5	−4	−3	−2	−1	0	1	2	3	4	5
Frequency	2	3	5	6	7	7	7	6	5	3	2
						(N=53)					

Figure 1. Forced choice distribution

There were two parts to it. First, a Q sort had to be performed as a "forced choice," quasi-normal frequency distribution (in accordance with a rough use of the "law of error"), typically as shown in Figure 1. The *mean* score for any Q sort is therefore *zero* ($m = 0$). It proposed that if psychology had to become a science of subjectivity (as was its fundamental purpose), then the method of individual differences (R methodology), with its countless group mental tests of abilities, attitudes, personality, etc. could be replaced by one method, Q technique. *It would start subjective science from scratch, giving everyone the same zero score for pleasure-unpleasure for any psychological event -- that is, as measured by themselves, purely subjectively.*

It met with every kind of resistance, for every kind of wrong reasons.

The second part occurred when several Q sorts are performed about the PE by a Q sorter. Now the statements of the Q sample vary, changing saliency for different Q sorts. Each assumes its own variance, and this is what constitutes the "ghost-field" of quantization. It is the Q sorter who introduces this ghost-field, not Q technique as such.

The two parts make up the new probabilistic.

New Probabilistics

In physics a new probabilistic was introduced by Max Born in 1926, described by Abraham Pais as follows:

> On August 10 [1926] he [Max Born] read a paper before the meeting of the British Association at Oxford in which he clearly distinguished between the "new" and the "old" probabilistics in physics: The classical theory introduces the microscopic co-

> ordinates which determine the individual processes only to eliminate them because of ignorance by averaging over their values; whereas the new theory gets the same results without introducing them at all.... We free forces of their classical duty of determining directly the motion of particles and allow them instead to determine the probability of states. Whereas before it was our purpose to make these two definitions of force equivalent, this problem has now no longer, strictly speaking, any sense. (Pais, 1986, p. 258)

If we replace "classical theory" by R methodology, this is very much what Q technique has achieved -- except that in determining the probability of states in Q, nature is allowed to speak for itself. An example of the difference between "classical theory" and Q is given in "Application of Communication Theory: III. Intelligence and Multivalued Choice" (Stephenson, 1973). To the end of his life, Cyril Burt tried to make the two, R and Q, equivalent, as two sides of the same coin; and physics is still trying to make determinism and indeterminism congruent in some quarters.

There could scarcely be better equivalency between Born's and Q's probabilistics. Nine years later, in 1935, I made the same shift to the new probabilistic, for psychology. About Born's contribution, Pais writes as follows:

> Born may not have realized at once the profundity of his contribution.... Much later he reminisced as follows about 1926: "We were so accustomed to making statistical considerations, and to shift it one layer deeper seemed to us not very important." (Pais, 1986, p. 259)

I was not quite so unaffected to judge by my letter to *Nature* in 1935, introducing Q technique: it expressed excitement that Q technique could bring Spearman's *noesis* into the laboratory, for "single case" exploration. On the other hand, I was taken aback by the haste with which Q technique was rejected and totally misunderstood by leading psychometrists such as Thurstone and his followers. I thought that the psychophysical methods, apart from simple statistical considerations, were sufficient to give Q full credibility.

Parallels with Physics

The new probabilistic stemmed from psychology, not by analogy from physics. But it is instructive to see how it corresponds to the basic postulates in physics, as described by Abraham Pais in his authoritative *Inward Bound: Of Matter and Force in the Physical World* (1986).

Niels Bohr, Pais tells us, "plunged" into quantum theory with two basic postulates:

> *First*: an atom has a lowest state of energy (he called it a permanent state, physics now calls it a ground state) which, by assumption, does not radiate. (Pais, 1986, p. 199).

This, according to Pais, was one of the most audacious hypotheses ever introduced into physics.

We have seen that every Q sort is anchored about zero ($m = 0$) amount of state of pleasure-unpleasure. It is a ground state of *no* feeling, the same for everyone, for all subjective psychology, for every person, for every Q sort ever performed -- the lowest (zero) state. It was also audacious, almost unbelievable, proposing as it was the elimination of all group mental testing, and R methodology, as of basic scientific concern.

Then followed the second principle in physics:

> *Second*: higher "stationary states" of an atom will turn into lower ones, such that the energy difference E is emitted in the form of light-quanta with frequency f given by $E = hf$ (where h is Planck's constant). (Pais, 1986, p. 199)

This was important because it offered an explanation for the first time of the spectra of simple atoms. It corresponds to the second stage in Q technique, when several Q sorts are performed by a person about his or her psychological event (PE). The higher stationary state of the event (Kantor's [1]) is shifted to "lower ones," that is, to operant factors. *The two stages together bring about the quantization.* What happens is that although each Q sort is at zero for the average state-of feeling, the statements of the Q sample assume different saliencies in different Q sorts, and it is this that constitutes the "ghost field." It is the Q sorter who provides this "ghost"; it is factorization that tells us what has been so produced. No one can say beforehand what this will be, corresponding with the fact that factorization has no unique relation to the reality formulation [1] of J.R. Kantor. Instead of light quanta and Planck's constant, there is the empirical discovery that operant factors are subject to complementarity. Even so, it is significant that in physics and psychology alike the first step toward quantization was the definition of a new probabilistic.

On this basis we can proceed to fulfill its promises, which will occupy Part II of this exclusionary psychometry. Before doing so, it is helpful to answer a question about the place of lawfulness in Q technique.

Lawfulness

The quantizing formulations [1], [2], [3] are for unique situations: how, then, are any general conclusions to be drawn? Laws are indicative of regularities in nature, but they are also instructions to help the scientist find his or her way about in reality. Thus, D'Arcy Thompson's classic *Growth and Form* (1942) involved Borelli's law (muscle impulse is proportional to its volume), Froude's law (the bigger the fish, the faster it can swim), Stoke's law (dust particles fall very slowly through the air), and so on for Brook's law, Bergmann's, Errera's, and Weber's. All are pragmatic. They point to regularities, but leave the door open for exceptions which may lead to discoveries. Q technique has the same kind of laws at its roots: for example, James' law (some factors represent *me*, others only *mine*), Rogers' law (self and ideal tend to be congruent in adjusted situations), Freud's law (of defense mechanism), and so on (Stephenson, 1953a, 1974). Operant factor structure may mediate any of these laws; but the situation is unpredictable, due to the quantum indeterminism. Only after measurements are made can it be known which laws, if any, mediated.

Continued in the next issue

PART II. DEVELOPMENTS

(References follow Part II)

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Every author, as far as he is great and at the same time original, has the task of creating the taste by which he is to be enjoyed. (Samuel Taylor Coleridge)