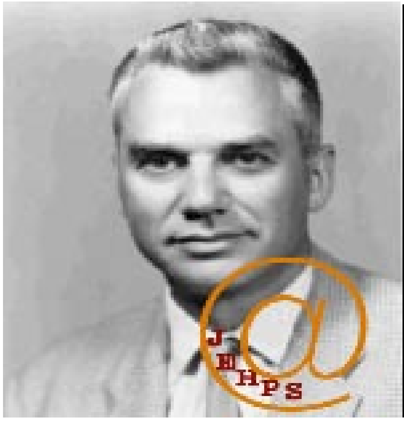

Journ@l Electronique d'Histoire des Probabilités et de la Statistique

Electronic Journ@l for History of Probability and Statistics

Vol 4, n°2; Décembre/December 2008

www.jehps.net

Psychometric Roots of Multidimensional Data Analysis in the Netherlands: From Gerard Heymans to John van de Geer

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Abstract

The development of multidimensional data analysis in the Netherlands can be traced back to early attempts in the beginning of the 20th century by Gerard Heymans to account for individual differences in personality. He was one of the first who collected and analyzed multivariate data sets, including many categorical variables, and who constructed a multidimensional model of personality types. After the first World War, psychological testing expanded enormously, especially in the United States, leading to the development of multiple factor analysis and Guttman's optimal scaling technique for categorical data. The paper discusses the important role of John van de Geer in introducing and expanding multivariate methodology in the Netherlands, and draws some parallels and connections between two major groups of the "Dutch school" of data analysis in Leiden and Groningen.

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At the time when psychology escaped from the strategic alliance of metaphysics and physiology, in the late nineteenth century, its strong ambition to enter the arena of the real sciences made it necessary to emphasize measurement and quantification. Its founding fathers, like Gustav Fechner and Wilhelm Wundt in Germany, Franciscus Donders in the Netherlands, Francis Galton and Charles Spearman in Great Britain, Alfred Binet and Pierre Janet in France, and William James and Charles Peirce in the United States, all developed methods to measure mental events and to classify or quantify differences between individuals (Draaisma, 1988; Porter, 1996). Some of the founding fathers relied on forerunners of what we now call randomized experiments (Danziger, 1990; Stigler, 1999, chapter 10). Although they used statistics in a surprisingly sophisticated manner, their data analysis was in no way multivariate, nor multidimensional. These experiments were in the area of *general psychology*, which studies mental phenomena that occur in all people. However, a second major approach (connected with the names of Galton, Spearman, Binet, and Wundt's student James McKeen Cattell) studied mental characteristics in which people are different, and tried to explain where these differences come from and why they persist. This area was called *differential psychology*. The distinction between general and differential turned out to be one of the pervading dilemmas in psychology (Heiser and Meulman, 2007). The discipline of psychometrics grew out of attempts to give answers to the data analytic and statistical problems arising in differential psychology.

In differential psychology, multivariate data arise quite naturally. When our starting point is to compare individual persons, there are numerous mental operations or behavior tendencies to choose from. Mind and behavior of a person are multi-faceted things, and differences between them multiply the complexity. So it should not surprise us that right from the start of differential psychology there was interest in multiple measurements on the same person, and attempts to deal with multivariate data. I cannot tell the whole story here (for early accounts, see Guilford, 1936, and Gullikson, 1974). An important dilemma in psychometrics has been and still is: Even when data are multivariate, one can either choose an approach that presupposes one-dimensionality or one can aim at results that may be multidimensional (or possibly turn out to be one-dimensional, but only if the data allow). For the history of one-dimensional psychometric modeling, I refer to Bock (1997) and Buckhalt (2002). With regard to multidimensional psychometric approaches, Mulaik (1986) summarized the history of technical aspects of multiple factor analysis in the Thurstonean era (1930 to 1970s), and this account was updated in some of the contributions in Cudeck and MacCallum (2007). Regarding conceptual aspects, Mulaik (1987) offered a critical historical discussion of the philosophical foundations of exploratory factor analysis, trying to show how the fundamental problem that the factors themselves are indeterminate reflects a fundamental problem of inductive methods in general. This position was in line with his more general view (Mulaik, 1985) on how exploratory statistics in the 19th century grew out of British and French empiricists' conceptions of the associative processes of the mind.

In the current contribution, I wish to highlight two important Dutch psychologists, Gerard Heymans (1857-1930) and John van de Geer (1926-2008), who initiated the multidimensional approach to multivariate data analysis in the Netherlands. I discuss what their influence was in the development of psychometrics in the Netherlands, and how this led to the "Dutch School" of exploratory multidimensional data analysis.

GERARD HEYMANS

Gerard Heymans, born in 1857 in Ferwerd, Friesland, studied law in Leiden where he finished his dissertation in 1880 on an economic subject. A year later he obtained a second Ph.D. degree under supervision of professor Windelband in Freiburg im Breisgau (Germany), on a philosophical topic. In 1890 he was appointed in Groningen to a chair of "History of philosophy, logic, metaphysics and psychology". In 1892 he arranged his own lab, at home, for studying visual illusions and other perceptual phenomena, frequently using his own wife Anthonia Barkey as the only subject. In his 1905 book Einführung in die Metaphysik auf Grundlage der Erfahrung, he justified his metamorphosis from speculative philosopher to empirical psychologist. This step resulted in a surprisingly wide range of contributions.

Heymans was strongly convinced that there was a place for both general and differential psychology. In his famous 1909 public address as the rector of Groningen University, he confidently expressed his belief in the 20th century as the "century of psychology": after an era of great technological progress through insight and control over the physical world, psychology would bring happiness and peace of mind through insight and control over human nature, based on psychological laws. Increased control could come from results in general psychology, but also from the insight of an individual who recognizes he is a member of some specific group of some specific class from some specific category of a psychological classification (Heymans, 1909).

While Heymans used experiments for most of his contributions to general psychology, he relied on the biographical method and the questionnaire method for his work in differential psychology. Talking about these approaches of data collection, he remarked:

> "Anfangs verfolgte ich dabei nur das Ziel in meinen Vorlesungen die verschiedenen Charactertypen durch konkrete Beispiele dem inneren Verständnis meiner Zuhörer näher zu bringen; nachgerade kam mir aber der Gedanke, ob sich nicht diese Exzerpte auch für eine exactere Bestimmung solcher Typen methodisch würden verwenden lassen. Denn es wird doch endlich einmal Zeit, auch auf dem Gebiete der speziellen Psychologie mit allen zu Gebote stehenden Mitteln zu versuchen, die Hauptbedingung jedes sicheren wissenschaftlichen Fortschritts, eine zahlenmäßige Bestimmung des Untersuchungsmateriales, zu verwirklichen. Zwar ist als heuristisch wertvoll anzuerkennen, was in der letzten Zeit besonders die französischen Psychologen (Malapert, Paulhan, Pérez, Fouillée, Ribéry, Ribot) mit den Hilfsmitteln der allgemeinen Lebenerfahrung, des Selbstexperiments und der deduktiven Schlufsfolgerung für unsere Erkenntnis der Strukturformen des menschlichen Geistes geleistes haben; es kommen aber die in solcher Weise gewonnenen Einsichten, auch wenn sie durch einzelne Beispiele aus Leben oder Geschichte erläutert werden, über die Stufe subjectiver Plausibilität schwerlich hinaus." (Heymans, 1908, pp. 313-314).

In the same paper, he discussed the results of an extensive biographical study in which he coded 110 mostly well-known historical figures—94 men and 16 women, of which he gives their name, occupation, nationality, and the century in which they lived—on 88 personality characteristics. Apart from the personality characteristics, he also coded all subjects on three major personality traits: emotionality, activity, and the relative importance of the primary or secondary function (corresponding to the present-day distinction extraversion-introversion). These three variables were inspired partly by an attempt to account for the classic humor theory of temperament. Heymans constructed the following eight types by combination of the three variables in binary form:

Type	emotional	active	secondary
nervous	+	−	−
sentimental	+	−	+
sanguine	−	+	−
phlegmatic	−	+	+
choleric	+	+	−
passionate	+	+	+
amorphous	−	−	−
apathic	−	−	+

What is remarkable in this attempt to build a classification of personality types is that Heymans tried to define the classic humorous types in terms of the presence or absence of basic psychological variables or factors—an approach that is typical for the way 20th century psychology still tends to think about classification. The types are formed by the Cartesian product of variable-wise classes. In this case, Heymans accepts that he obtains only three of the classic temperaments (sanguine, phlegmatic and choleric) and not the fourth one (melancholic), but readily identifies the five other types with syndromes mentioned in the recent literature (where the sentimental type in the end turns out to overlap with the melancholic). Heymans' gave his classification a geometrical form that later became known as the Heymans' cube (see Figure 1, reproduced here from his 1929 Dutch book). The emotional types are on the top, the non-emotional types on the bottom;

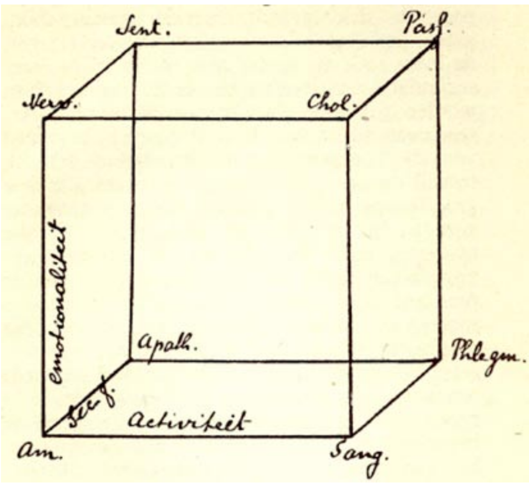

Figure 1. Heymans cube of the eight temperament types.

the active types are on the right, the inactive types on the left; the primary types are in the front, and the secondary types in the back. This cube clearly shows the multidimensional conception of personality, in which any person could be higher or lower on any of the three factors. But the cube should not be taken as an empirical model, because Heymans viewed the types as an idealization, of which only particular persons could be striking examples. For instance, he mentions Benjamin Franklin, David Hume and John Locke as typical phlegmatics, Charles Dickens, Pierre-Joseph Proudhon, and Georges Sand as typical cholerics, and Charlotte Bronté, Søren Kierkegaard, and Anthony Trollope as typical sentimentals. By contrast, the three factors could in principle be measured continuously on any person.

In a large-scale questionnaire study, Heymans and Wiersma (1906-1909, reprinted in Heymans 1927), tried to validate the cube on a sample of 437 families from which they obtained 2415 character descriptions (437 fathers, 437 mothers and 1541 children), as assessed by their family doctors all over the Netherlands. Included were 90 questions, 8 on activity, 8 on mood and emotion, 10 on the secondary function, 17 on intelligence, 38 on habits and attitudes, and 9 miscellaneous behavior tendencies. They gave two major series of results after a lot of counting. First, to study heredity of these psychological characteristics, Heymans and Wiersma calculated 90 four-way tables of the type reproduced in Table 1 for a question on impulsivity. In this case, it is a 4 x 2 x 2 x 4 contingency table of the answers to the 4-category question (is the person

Frage 7. Ist die betreffende Person impulsiv (Handeln oder Sichentschliefsen unter dem Eindruck des Augenblicks) oder bedächtig (nicht Handeln ohne Überlegung des Für und Wider) oder Prinzipienmensch (Handeln nach vorher festgestellten Grundsätzen)? (S. Tab. VII: i = impulsiv, b = bedächtig, P = Prinzipienmensch).

TABELLE VII

			Söhne				Töcher				S. u. T.			
	V.	M.	i	b	P	?	i	b	P	?	i	b	P	?
1	i	i	35	21	4	6	40	13	2	6	75	34	6	12
2	i	b	42	38	5	5	45	38	7	4	87	76	12	9
3	i	P	7	5	1	2	6	2	2	4	13	7	3	6
4	i	?	12	7	0	3	8	4	0	4	20	11	0	7
5	b	i	63	90	4	15	80	53	6	16	143	143	10	31
6	b	b	56	112	21	8	48	77	14	12	104	189	35	20
7	b	P	9	5	2	2	3	5	0	5	12	10	2	7
8	b	?	8	29	2	9	6	12	1	12	14	41	3	21
9	P	i	12	12	1	1	19	19	4	1	31	31	5	2
10	P	b	8	19	3	0	5	10	0	0	13	29	3	0
11	P	P	0	0	6	0	1	0	1	0	1	0	7	0
12	P	?	3	3	1	1	3	4	1	3	6	7	2	4
13	?	i	16	5	2	5	11	4	0	4	27	9	2	9
14	?	b	8	8	1	0	5	8	0	0	13	16	1	0
15	?	P	2	0	0	0	0	2	0	0	2	2	0	0
16	?	?	1	2	1	7	2	2	0	3	3	4	1	10

Table 1. Heymans and Wiersma's Tabelle VII on the association between father, mother, sons and daughters regarding impulsivity.

impulsive, sedate, a principled person, or unknown?), broken down by parent and child, crossed with sex of parent and sex of child. Heymans performed additional calculations, involving even the solution of normal equations in an overdetermined system, to express the amount of heredity. He concludes that impulsivity is hereditary, for both sexes, for an amount between 42 and 48%. This procedure was repeated for all 90 questions. Clearly, Heymans walks in the footsteps of Galton here, but on an extensive basis of multivariate categorical data. Second, Heymans and Wiersma constructed a very large table of the response categories of the ninety questions crossed with the eight personality types of the Heymans cube (their "Tabelle CV" covers 15 pages in the original text), with an extensive discussion. For the question on impulsivity, for example, it turned out that the nervous and choleric types are strongly associated with the category impulsive, while the phlegmatic, passionate and apathic types are strongly associated with the category sedate, which demonstrates the effect of the secondary function.

Heymans was also interested in "an experimental determination of the degree to which different simple intellectual functions cooperate" (Heymans and Brugmans, 1914). In this small-scale study with 15 students as subjects, he used six tasks with numerical responses in several cognitive domains. So he could use the correlation coefficient as a measure of association, and his interest was especially triggered by the interpretation of correlation by his friend and colleague, the astronomer Kapteijn, in terms of the number of common factors shared by two variables (Kapteijn, 1912)—an insight that was later picked up by the influential psychometric textbook of Brown and Thomson (1921). As an example, the results on the domain of flexibility of fantasy are given in

TABELLE II

Beweglichkeit der Phantasie	1. Vexier-bilder	2. Bildung von Wörtern	3. Rätsel	4. Silben-ordnen	5. Tierfiguren	6. Découpage
1. Vexierbilder		0,35	0,27	0,55	0,44	0,24
2. Bildung von Wörtern .	0,35		0,24	0,76	0,12	0,47
3. Rätsel	0,27	0,24		—0,06	0,16	0,44
4. Silbenordnen.	0,55	0,76	—0,06		0,15	0,38
5. Tierfiguren	0,44	0,12	0,16	0,15		0,10
6. Découpage	0,24	0,47	0,44	0,38	0,10	

Table 2. Heymans and Brugmans Tabelle II on the correlations between six tasks testing for flexibility of fantasy.

Table 2. The main conclusion was that all correlations are positive, with one small exception, demonstrating the presence of at least one common factor.

INTERBELLUM

Between the two Wars, interest in Heymans approach to psychology remained alive outside the Netherlands, but faded away in the Dutch universities. Differential psychology was seen as a practical affair, and continued without the urge for methodological innovation and theoretical foundation that Heymans had given it (Dehue, 1990). The study of individual differences also did not lead to the heated controversies that it encountered elsewhere (Mulder and Heyting, 1998).

It was the time of the "Psychotechnik", or applied psychology. Centers of applied psychology were started in Nijmegen in 1918 (by Van Ginneken), Groningen (1920, by Brugmans, a student of Heymans), Amsterdam (1921, various institutions), and Utrecht (1922, by Roels, who was professor in empirical and applied psychology and later moved to Nijmegen, where he was succeeded by Rutten). The year 1938 saw the foundation of the professional organization Netherlands Institute of Practicing Psychologists (NIPP), which was broadened in 1968 to Netherlands Institute of Psychologists (NIP), so as to accommodate the academic, non-practicing colleagues. A major reason for starting this organization was continuous worries about the lack of good academic teaching programmes for psychologists, and the wish to protect the title "psychologist" by law (which was realized in 1971). Nobody worried very much about new ways to analyze psychological data, as is evident, for example, from the paucity of such considerations in the methodological textbook by Heymans' successor Brugmans (first published in 1922 and reaching a third edition in 1958).

The situation was quite different in the Anglo-Saxon world. It was a crucial period for the development of factor analysis---understood as a method to discover latent variables that account for observed correlations between various aspects of individual differences. That development started with only one latent variable, the *g*-factor, which was originally hypothesized by Galton (1869) and empirically verified by Spearman (1904). The hypothesis of the *g*-factor accounts for the fact that all correlations between mental abilities are positive, sometimes called Spearman's

Law. Spearman wrote two monumental books; in The Nature of Intelligence and the Principles of Cognition (Spearman, 1923) he gave an account of the general laws of cognition, and in The Abilities of Man: Their Nature and Measurement (Spearman, 1927), he applied these laws to individual differences in ability and offered the empirical evidence for the existence of *g*. In Chapter XVII he also discusses the psychological "Law of Inertia", or perseveration, which describes the phenomenon that cognitive processes always both begin and cease more gradually than their (apparent) causes. He notes that it is related to the notion of the secondary function of Heymans and his students, whom he praises for their laborious investigation:

> "Pioneers in this field have been the Dutch school, who were the first to devise and employ for this trait of perseveration some definite and serviceable tests. This was brilliantly achieved in 1906 by Wiersma. (…) and subsequent research by Heymans and Brugmans in 1913," (Spearman, 1927, pp. 292-293)

Spearman was also very enthousiastic about the work on the Heymans cube (Spearman, 1927, p. 44, p. 384) and believed that his hypothesis of the *g*-factor was in line with Heymans' (1921) view on mental energy.

Although the first attempt to extend the *g*-factor to multiple common factors was made by the British school (Garnett, 1919a, 1919b), major developments occurred in the United States. Holzinger had given a resumé of Spearman's ideas in a publication issued from Thurstone's lab (Holzinger, 1930), and had worked with Spearman on a clustering method for locating group factors in addition to the *g*-factor, in which the tests represented in a table of intercorrelations are grouped and regrouped in various ways until those containing each group factor are isolated (Holzinger, 1935). Then Thurstone took off with a series of papers and a book in which he developed the alternative approach to factor analysis in which *g* disappeared and was replaced by multiple common factors that would jointly account for intercorrelations between tests (Thurstone, 1931a, 1931b, 1934, 1935, 1937). He brought to bear standard mathematics to the factor problem:

> "Thurstone presented his problem to Bliss in mathematics and Bartky in statistics one noon at the Chicago Quadrangle Club. He explained that he had a square symmetric array of numbers and wanted to express it in terms of summed products of a smaller array. Their reaction was, "Oh, you mean the square root of a symmetric matrix" In this way Thurstone learned that matrix theory existed and was relevant to the factor problem, so he embarked

on a year or two of tutoring and published The Vectors of Mind (1935), followed later by Multiple Factor Analysis (1947), giving a concise summary of the crucial aspects of matrix theory and their use in factor analysis." (Gullikson, 1974, p. 255.)

Thurstone's approach soon became the dominant way in which psychologists use factor analysis after the World War II, until the present day.

During the War, at the request of the U.S. War Department, Samuel Stouffer took leave from the University of Chicago to lead a group of quantitatively oriented sociologists and psychologists in studying characteristics and adjustment problems of American soldiers. One of the most influential reports from this study—published much later—was the volume Measurement and Prediction (Stouffer et al., 1950), which was devoted to innovations in data analysis. Louis Guttman was among this group and contributed several papers (Guttman, 1950a, 1950b). These papers elaborated on his method of scale construction on the basis of multivariate categorical data, first presented in a Symposium organized by the Social Science Research Council in 1941 (Horst et al., 1941). In the Guttman (1941) paper, he set out the method that is now known as multiple correspondence analysis, optimal scaling (quantification), dual scaling, or homogeneity analysis. In an Appendix, Guttman included the iterative solution method exploited and generalized by the Dutch "Gifi group" under the name alternating least squares. Guttman also produced a series of papers that deepened the mathematical foundations of factor analysis, and contributed to the mathematical theory behind matrix approximation in general (Hubert, Meulman and Heiser, 2000).

JOHN VAN DE GEER

John van de Geer, born in 1926 in Rotterdam, studied psychology in Leiden, in a rudimentary psychology program that began just after World War II. The war had turned the whole Dutch society by 180 degrees, from an orientation towards Germany to an orientation towards the U.S.A., and academic fields began to follow this movement. Van de Geer soon became assistant to professor Chorus, the only chair in psychology at the time, who delegated the whole new empirical, American psychology to him, especially statistics and experimental psychology. During his student days, Van de Geer had been strongly influenced by the existential philosophers and phenomenology, especially by Maurice Merleau-Ponty, who had argued for the primacy of perception in his Phénoménologie de la Perception (1945), and from whom he had picked up the necessity for a strict empirical point of view in psychology and at the same time a critical attitude towards behaviorism. He then wrote a dissertation about a cognitive topic, problem solving (Van de Geer, 1957), in which he started using Fisher's experimental design in several ingenious ways.

His interest in codability as a factor in perception—the idea that the perceiver has a limited capacity for processing the incoming information—led to cooperation with Nico Frijda on the recognition of facial expressions (Frijda and Van de Geer, 1961) and with Willem Levelt on the detection of stochastically specified events (Van de Geer and Levelt, 1963). He was one of the early adopters of Joe Kruskal's non-metric multidimensional scaling technique (Kruskal, 1964), in a tone perception study that tried to explain how and why the sensorial experience of consonance in tone intervals is related to simple frequency ratios (Levelt, Van de Geer, and Plomp, 1966). This paper included as a technical innovation an original procedure for fitting quadratic curves in the plane. Van de Geer's work in general psychology led to an invitation to write the first Annual Review of Psychology paper on cognitive psychology (Van de Geer and Jaspars, 1966), an area which since then has grown enormously, even expanding outside psychology into cognitive science.

But like Heymans, Van de Geer did not limit himself to the laboratory. From 1953 to 1963 he was affiliated as a consulting psychologist with a shelter home for female juveniles, and he became convinced that the hypothetical-deductive way of reasoning of the research psychologist applies equally well to diagnosis by the practitioner (Van de Geer, 1961), albeit of course in a less formal way. In a long-term project on data collection relevant for the coaching of the young women in the shelter home, run by students under his supervision, he encountered the importance of individual differences, objective measurement, and unprejudiced analysis of data. The most important thing was, "finding out how things really are", the desire to explore psychological data in a principled way, but without too many presumptions, and this aim brought him deeper into the realm of exploratory multivariate data analysis. Soon he discovered that much what looked different in the psychological literature on quantitative methods was in fact the same, and he decided to delve into mathematics and start a quest for unification of analysis methods.

He began teaching factor analysis and other multivariate techniques, culminating in his first, Dutch book in this domain (Van de Geer, 1967). He followed Thurstone's geometrical style that was rather abstract in representing variables as vectors, correlation as angles between vectors, and projection as an elementary operation. But, unlike Thurstone, he used this style also for multiple and partial regression, canonical correlation, and discriminant analysis, and he presented the unique factors in factor analysis in a very elegant display, where Thurstone (1947) had to resort to Venn diagrams to illustrate the algebra. Van de Geer's integrated display for partial and multiple regression is given in Figure 2, and the lucid vector display of the single common factor model of two variables with two unique factors is given in Figure 3.

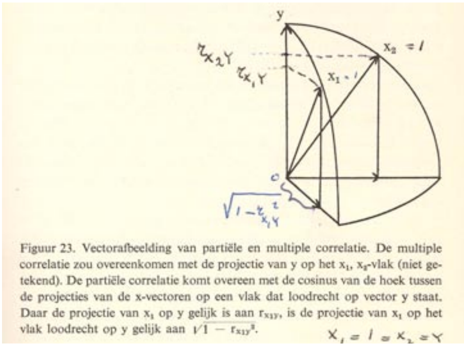

Figure 2. Van de Geer's vector diagram of partial and multiple regression (Van de Geer, 1967, p. 111; added handwriting by Van de Geer's student Leo van de Kamp)

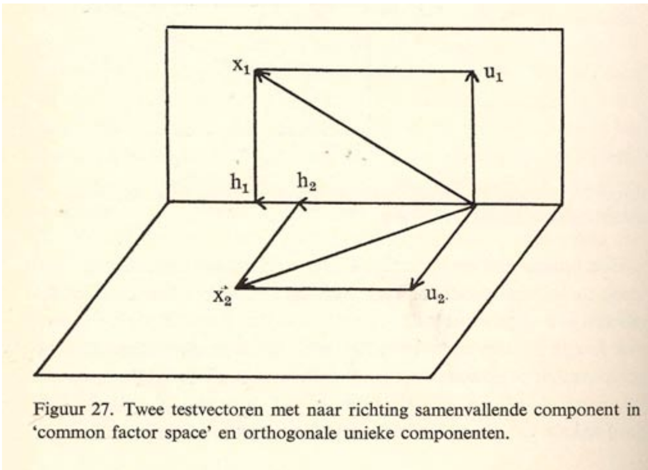

Figure 3. Van de Geer's vector diagram of a single common factor and two unique factors in factor analysis (Van de Geer, 1967, p. 134).

His second multivariate analysis book (Van de Geer, 1971) was not only a translation of the earlier Dutch volume, but also an extension with the language of path diagrams. As noted by De Leeuw and Mooijaart,

> "The book was written during a stay at the Center for Advanced Study in the Behavioral Sciences at Stanford University, at the time of the rise of path analysis in econometrics and sociometrics. The achievements of econometrics (systems of structural equations) and of sociometrics (causal analysis) were incorporated in the book, and integrated with classic psychometric material (factor analysis). That yields a successful combination, which was ahead of its time by some ten years" (De Leeuw and Mooijaart, 1987, p. 168, translation WH).

A typical display from this book is given in Figure 4, which shows canonical correlation analysis.

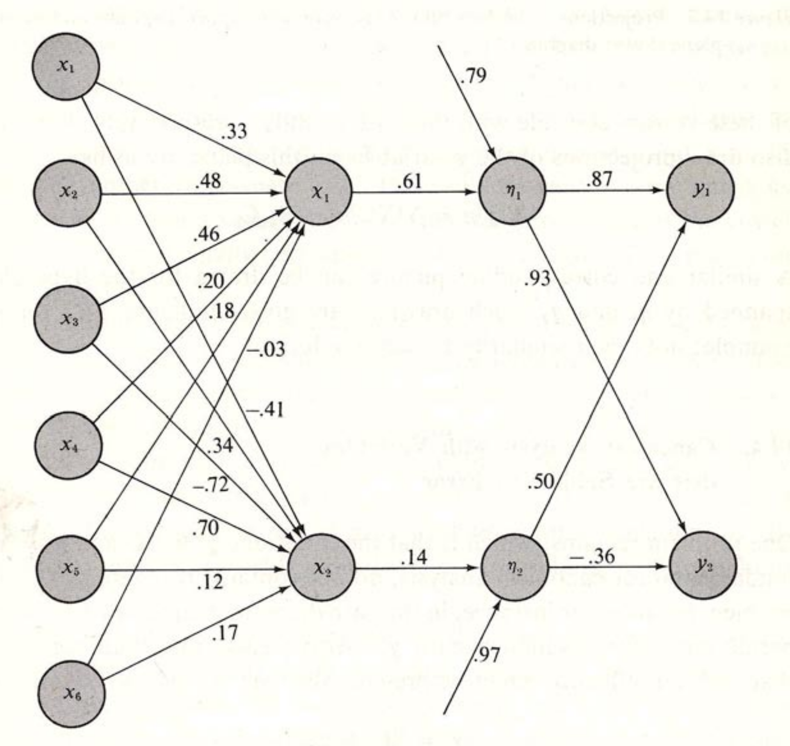

Figure 14.1 Path diagram for canonical correlation analysis.

Figure 4. Van de Geer's path diagram of two couples of canonical variables (Van de Geer, 1971, p. 167).

The book was well read overseas; later Psychometric Society Presidents like Peter Bentler, Larry Hubert, and Jim Ramsay learned their multivariate analysis from it. Also, part of it appeared in France (Van de Geer, 1970).

In his third book, focusing on categorical data, Van de Geer (1988) took a further radical step. His point of departure was that categorical data, even if we give them some (a priori specified, or optimal) quantification, form a lattice of points in high-dimensional space. The book describes various techniques (principal component analysis, canonical correlation analysis, multiple correspondence analysis) as particular projections of these lattices onto a (two-dimensional) subspace, while preserving the lattice structure in terms of auxiliary points and lines that exist in high-dimensional space, and that are projected along with the lattice points. Figure 5 gives one example of such projected lattice displays (a PCA of three variables, each with three categories).

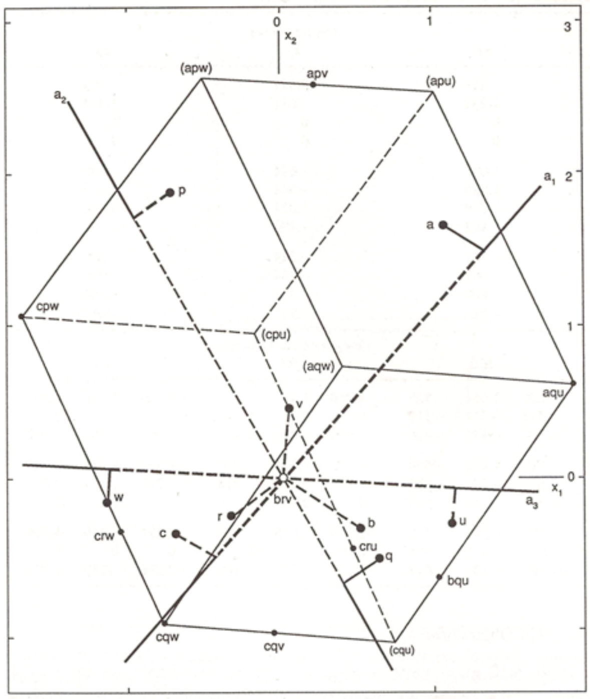

Figure 3.13. PCA lattice of Table 3.10. Lattice points where there are no objects have labels in parentheses. The *a* vectors are solid lines outside the lattice, and dashed inside. MC points have single letters and are connected with their SC points (where the solid *a* vector changes into a dashed line).

Figure 5. Van de Geer's diagram of the PCA projection of 12 objects coded on three categorical variables with three categories quantified in standard scores (Van de Geer, 1993, p. 40).

A difficult problem that fascinated Van de Geer for years was how to generalize analysis objectives involving two sets of variables to the case of more sets of variables, where the number of possibilities seemed to become overwhelming. He finally managed to come up with three basic distinctions describing a large family of *K*-set techniques and systematically described all their solutions (Van de Geer, 1984). He regarded this paper, originally conceived in 1968, as his masterpiece.

There were several ways in which Van de Geer exerted his professional influence in the Netherlands. In 1960 he became a consultant of the Institute for Perception TNO, at Soesterberg. He successfully persuaded the incumbent biophysicists, physiologists and engineers of the added value of experimental psychology. A whole generation of leading Dutch cognitive psychologists was trained is this environment, and completed their dissertation under his supervision (including Willem Levelt, John Michon, Willem-Albert Wagenaar, Len de Klerk, Charles Vlek, and others). In the sixties, he was also actively involved in organizing a series of well-attended Nuffic Summer Schools in The Hague, where leading international experts like Duncan Luce, Georges Miller, Georg Rasch, Lee Cronbach, Patrick Suppes, Masanao Toda, Amos Tversky, and many others were introducing new formal approaches to young Dutch researchers in the social and behavioral sciences. Van de Geer brought famous visitors from abroad to Leiden as well, such as Hans Eysenck, a multivariate personality psychologist who—inspired by Heymans—elaborated an updated three-factor model of personality types, Herman Wold, econometrician and father of partial least squares modeling, and Clyde Coombs, major protagonist of the geometric approach to data analysis in psychology, with whom he developed a long-lasting friendship. At Leiden University, Van de Geer had been Dean of the Faculty in 1968, and was highly regarded in the university administration. He contributed to the establishment of the Central Computing Center and served in the board of Leiden University Fund, together with the mathematical statistician Willem van Zwet, with whom he entertained good relations.

A powerful institutional move was to arrange a split of his chair into three new chairs, one in "Experimental psychology", one in "Methodology and statistics", and a third one in "Data theory". The last chair, the one that he retained himself, served two purposes: (1) to create a research environment for advanced multivariate analysis, and (2) to exchange solutions to similar data analysis problems in different parts of the social and behavioral sciences. This idea of "crossfertilization" would be best served if the new department, called the Department of Data Theory in recognition of the vision of Clyde Coombs, would be independent of psychology and serve the whole Faculty of Social and Behavioral Sciences. The Department of Data Theory informally started in 1968, and was officially established in 1970, with three research positions and a teaching assistant.

MEERLING AND GIFI

After several years of physical separation between Data Theory and the Methodology and Statistics group in psychology, the two groups shared offices for a few years in a small building at Rijnsburgerweg 96, away from the main psychology building. Van de Geer took the initiative for a collective undertaking. He was worried about the lack of a good methodological textbook for psychology students that recognized a research style with attention for creatively building models, and for a flexible interplay between data and ideas. In the University of Amsterdam, Adriaan de Groot had developed a version of Popper's hypothetical-deductive system of conducting research, as expounded in the widely-read volume Methodology (De Groot, 1961). It had a major impact in the Dutch social and behavioral sciences (Dehue, 1990). But Van de Geer was "not happy" with the long-winded prescriptions, and the emphasis on theory-driven hypothesis testing. He wanted something in which models were more prominent (both psychological models and statistical models) and something that integrated statistics into a more general framework of decision procedures. He started planning and writing important parts himself, and organized a process that led to the two-volume Dutch textbook by Meerling (1980, 1981). The name Meerling (Dutch for multiplet) was the collective pseudonym of 16 co-authors from the two groups. The books saw four revised editions and served as a textbook for psychology students during 25 years, in Leiden, but also elsewhere, for example in Groningen.

A second collective effort soon followed. Jan de Leeuw, the first person who Van de Geer recruited for his Data Theory department, had completed a remarkable dissertation in 1973 on a broadly conceived generalization and modernization of Guttman (1941). He then became post-doc for a year at Bell Telephone Laboratories upon invitation by Doug Carroll. It was the same lab that Jean Paul Benzécri—who had been closely following the work of Coombs, Shepard, Kruskal and Carroll on the analysis of proximities—visited a few years earlier. De Leeuw started a collaboration with Forrest Young and Yoshio Takane, the fruits of which are described in Young (1981). When back in Leiden he wanted to launch a similar project, developing a series of computer programs for the multivariate analysis of categorical data. When several of these programs were mature enough to be used by outside users, program guides had to be produced, and a post-doctoral course was scheduled in 1980 to introduce the work to a larger audience of researchers.

This occasion gave birth to the name Albert Gifi, a second collective pseudonym for a Leiden group that slightly overlapped with Meerling, but included several other researchers. The inspiration for choosing a collective pseudonym came from the French group of mathematicians who created Nicolas Bourbaki. However, there had to be a relation with the origins of multivariate statistics. The name Gifi refers to Sir Francis Galton's faithful Swiss servant of 40 years, who took good care of him until the end. What appalled the core members of the group was the fact that Galton, who died in 1911, bestowed £45,000 to the University of London to endow the Chair of Eugenics, with the explicit wish that Pearson be his first occupant, while Albert Gifi received only £200 for his loyalty and devotion. Clearly, Galton's will demonstrated his doubtful priorities in life, and adopting Gifi's name would compensate for the injustice. For the 1980 post-doctoral course, a Dutch mimeographed text was made, which was translated into English for the second course in 1981. This translated version evolved into the volume finally published as Gifi (1990), edited by Heiser, Meulman and Van der Berg, and also started off a long series of publications and dissertations.

CONCLUSION

Statistics and the social and behavioral sciences have an intertwined history that goes back to the days of Wundt and Galton. If we look for roots of exploratory multivariate data analysis, it turns out that differential psychology provided lots of statistical questions that spurred the development of many of the data analytic methods as we know them today. In the Netherlands, Gerard Heymans and John van de Geer each played a key role in their time.

While they acted in quite different circumstances, there are some striking similarities. Both were generalists, and received recognition in wider circles outside psychology. Both had a serious interest in general psychology as well as in differential and applied psychology. Both emphasized the importance of precision and objectivity—not as a matter of speech, but as a matter of action, and by the example they set for others. Both were open to novelty and eager to cross the borders of disciplines. These are desirable characteristics for anyone with ambition in statistics, a pre-eminently interdisciplinary field.

In what sense are there parallels between developments in Leiden and in Groningen? Heymans' tradition was continued in Groningen after World War II by the appointment in 1954 of professor Snijders, who was active in the development of psychological tests and who was a great advocate of psychology as a profession. In the same year, professor Kouwer, a recognized existential phenomenologist from Utrecht, was appointed to a chair in "Applied psychology", which was extended in 1960 into "Psychology, personality theory and statistics". After his sudden death in 1968, Kouwer was succeeded by his student Willem Hofstee, who prepared a posthumous edition of Kouwer's lecture notes on factor analysis entitled Inleiding tot de Factor Analyse (Kouwer, 1971). It is noteworthy that Kouwer used in one of his examples a simplified version of the factor structure of the Heymans cube, corresponding to what he found when analyzing Heymans' original material with a modern factor analysis technique (Kouwer and Van der Werff, 1968). In the preface of the 1971 posthumous edition, Hofstee claimed that Kouwer brought factor analysis home from Paris in 1946, and was the first in the Netherlands who actively pursued its application. The Groningen group reached a deeper level of technical expertise when Jos ten Berge entered the scene in 1977, when he defended his dissertation under supervision of John van de Geer and started the longest streak of high quality Psychometrika papers in the history of the journal. He was appointed in 1988 to a chair in "Psychometrics".

There is also a remarkable institutional parallel. In 1971, upon the initiative of Willem Levelt, the Faculty of Social and Behavioral Sciences in Groningen established a faculty-wide department outside psychology, called the Department of Statistics and Measurement Theory, chaired by Ivo Molenaar until 2000. It had a different name and a slightly different orientation, but the aims were very similar to its Leiden counterpart. In this paper, I cannot do justice to the important contributions of Ivo Molenaar for psychometrics in the Netherlands and abroad. More generally, I had to be very selective in this story, and refer the reader for a more balanced account of Dutch psychometrics in the second half of the 20th century to Van der Heijden and Sijtsma (1996).

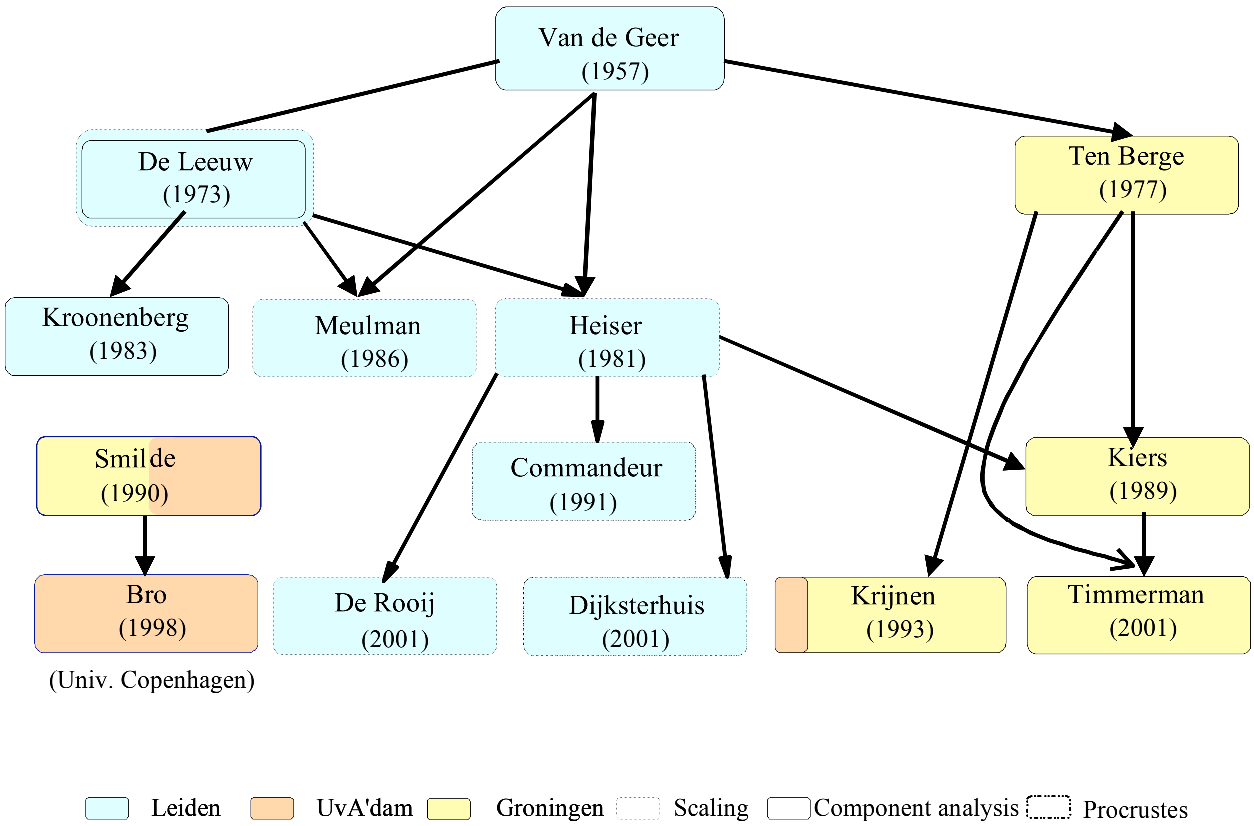

Figure 6. Tree of Ph.D. students of John van de Geer in Three-way analysis and related topics. *Source*: Kroonenberg (2005)

Note 1: Commandeur's supervisor was not Heiser, but Ten Berge. *Note 2*: people without any link to Three-way analysis are not shown. [of the Gifi team, these are: Van der Burg, Van Rijckvorsel, Bettonvil, Stoop and Nierop. Other Ph.D. students who worked on Gifi topics are, amongst others: Van der Heijden, Bijleveld, Van Buuren, Verboon, Van der Lans, Van der Berg, Markus, Groenen, Van der Kooij, and Linting. The first Ph.D. student in the area of multidimensional data analysis was Roskam in 1968.]

To conclude, if we look at the tree of Ph.D. students prepared by Pieter Kroonenberg (2005), reproduced in Figure 6, it seems fair to say that John van de Geer was crucial for the "Dutch School" of exploratory data analysis with its two main centers in Leiden and Groningen. Inclusion of researchers in the tree was on the basis of their contributions to the subfield of three-way analysis, another topic for which Van de Geer paved the way in an application with multiple time series on hospitals in the Netherlands (Van de Geer, 1975). Due to this selection in relation to our current broader theme, the tree is rather limited compared to an estimated total of 24 Ph.D. students supervised by Van de Geer, and a multiple of that number supervised by the other people in Kroonenberg's tree. It does not contain, for example, Van de Geer's first Ph.D. student specializing in nonmetric multidimensional techniques, Edward Roskam, who graduated in 1968. Nevertheless, after Gerard Heymans' early steps, John van de Geer managed to bring a highly visible group of methodological researchers active within the social and behavioral sciences to the international forefront of multidimensional data analysis.

Acknowledgment: The author is indebted to the following colleagues who commented on an earlier draft of this paper and provided useful suggestions for improvement: Hans Crombag, Nico Frijda, Matthijs Koornstra, Willem Levelt, Jacqueline Meulman, John Michon, Jos ten Berge, Sara van de Geer, Leo van der Kamp, Willem van der Kloot, and Charles Vlek.

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