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Peters, D.

Publication date
1997

Published in
Addiction

[Link to publication](#)

Citation for published version (APA):

Peters, D. (1997). A natural classification of alcoholics by means of statistical grouping methods. *Addiction*, 1649-1661.

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RESEARCH REPORT

A natural classification of alcoholics by means of statistical grouping methods

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Abstract

Aims. *The results of previous studies using statistical grouping methods for subtyping of alcoholics did not converge to a coherent natural classification, probably among other things as a consequence of improper selection of methods. As an alternative an analytic strategy is formulated and tested. First, a cluster procedure tests a categorical model of the data. If no compact isolated groups are detected non-metric multi-dimensional scaling is used to unravel the complex relations in the data by reconstructing a low dimensional spatial solution.* **Design.** *Cross-sectional study.* **Setting.** *In and outpatient treatment programs of the Amsterdam health region in The Netherlands.* **Participants.** *A consecutive sample of 277 men and women voluntarily seeking treatment for their alcohol problems. No exclusion criteria were applied.* **Measurements.** *A sample of 102 symptoms reflecting various aspects of alcoholism measured by structured self-report questionnaire (93 symptoms) or derived from a semi-structured interview taken by treatment staff (nine symptoms).* **Findings.** *The cluster procedure failed to show a fitting categorical model. Non-metric multi-dimensional scaling produced a three-dimensional spatial solution. The first dimension reflects the alcohol dependence syndrome. The second bipolar dimension reveals a male-dominated anti-social alcoholism, and a female-dominated pattern of isolated home drinking. The third bipolar dimension represents chronic alcoholism, and young quarrelsome people from troubled families.* **Conclusions.** *The three-dimensional solution obtained has a high face validity and incorporates a number of aspects of previous classifications. The results illustrate the strength of the analytic strategy in unravelling complex symptomatology. Limitations of the classification obtained are stressed and directions for subsequent validation research are given.*

Introduction

Devising optimal treatment and prevention for a disease or disorder is facilitated by knowing the causal process(es) involved. Because a specific causal process often leads to a specific constellation of symptoms in subjects exposed to or involved in that specific causal process, researchers—in their search for causes—often try

first to identify the different types of subjects, each type characterized by a unique symptomatology. Given the intricacy of this endeavour, a good number of researchers resorted to an approach with statistical grouping methods. The outcomes of empirical classification studies in the alcohol field have been reviewed a number of times and although some have drawn similarities

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Submitted 21st February 1995; initial review completed 24th August 1995; final version accepted 14th March 1997.

between classifications, a lack of convergence to a coherent classification has been noticed.^{1,2} Babor & Dolinsky³ concluded that "despite more than a century of research and speculation, alcohol typology theorists are still struggling ... to construct a scientific methodology that will bring order out of the complexity that is alcoholism (p. 262)". In this article a promising combination of statistical grouping methods will be given, by which the complex symptomatology of alcoholism can be better unravelled than by methods used before. The potential value of this strategy⁴ is illustrated by applying it to a broad sample of treated alcoholics.

Although it is recognized nowadays that a rigorous categorical classification is probably a distorted model of the phenomenological psychopathological domain, many empirical grouping studies still choose to use precisely those cluster procedures that produce only categorical groups, i.e. compact and non-overlapping groups (e.g. the cluster procedures K-means and Ward's method). The use of such procedures on a "fuzzy" domain results in a grouping where the delineation is dependent in an erratic way on specific sample characteristics.^{5,6} To come to a classification which can model the complex alcoholism domain, a more versatile method has to be used. Non-metric multi-dimensional scaling (abbreviated as MDS in the remainder of this article) is such a method, as it does not impose a rigid structure on the data. On the contrary, the structure has to be deduced from the spatial solution found. MDS can therefore be used to grasp mixtures of all kinds of groups, e.g. dimensions, compact clusters, overlapping clusters, types and chains.^{7,8} However, when the data enclose only compact isolated groups (that is, when a categorical classification is the best-fitting model), MDS has a tendency to produce an invalid spatial solution (i.e. a "degenerate" solution⁹). Because detection of such solutions is too dependent on the skill of the analyst, in this study an appropriate cluster analytic procedure was used as a preliminary test to see if a categorical model fits the data.

It was not expected that in this study alcoholics would be easily identified in clear compact isolated groups. The lack of convergence to a coherent classification and the widely differing characteristics of typologies have led to the suggestion that it is unlikely that there are pure types,¹⁰ or even that alcoholism is an unitary

disorder.¹¹ For the same reasons it was considered too speculative to hypothesize a MDS solution, and this study can be viewed as a bootstrapping attempt¹² with the aim of obtaining a preliminary coherent classification. First, the important components of the strategy are described. Subsequently, the results are presented by applying the statistical methods to a broad sample of treated alcoholics. Finally, the merits of the bootstrapped MDS solution are discussed.

Method

Subjects

Subjects were alcohol abusers voluntarily seeking treatment at the in and outpatient programs of the "Jellinek Institute", which is the only treatment provider for alcohol problems in the Amsterdam health region. For nearly all clients treatment is free, and the clients are representative of the population at large in educational level and social class.^{13,14} No exclusion criteria were applied because this might exclude possible subtypes.

After acceptance into treatment and adequate detoxification, clients were invited by their therapist to participate in the study. It was explained to them that the aim of the research was to improve the treatment programmes in the future, and that the information provided remained confidential and was not meant to be used for their personal treatment.

Nine per cent of the admitted clients in the sampling scheme were lost to the study due to refusal, and doubtful responses to the questionnaire. The responders consisted of 171 men and 106 women. The mean age of these 277 subjects was 41 years (SD 10; range 20–78). The mean duration of problem drinking before admission was 12 years (SD 16; range 3 months–35 years), and the mean amount of alcohol consumed on a typical drinking day was 238 grams of pure alcohol (SD 132; range 45–630). Nine per cent had used illegal drugs earlier in life. Forty-four per cent had previous clinical treatment for their drinking problem, and 48% had received psychiatric treatment (28% as an inpatient and 20% as an outpatient).

Variables

It is probably not the method but the selection of the variables that has the strongest influence on

the results of a grouping study.¹⁵ The researcher is faced with a problem which in theory cannot be solved: to know which variables to select one has to know the classification, and to know the classification one has to know the variables. The pragmatic approach is bootstrapping,¹² i.e. first obtaining an initial classification, and then developing it further by validating and searching for missing groups. For bootstrapping one assumes that there is an over-determination of relevant symptoms for every group, i.e. not all relevant symptoms of every group have to be sampled to detect such a group (this is the hypothesis of non-specificity as formulated in taxonomic studies in biology¹⁶). The aim of a bootstrapping study is to achieve a random sample of the symptoms from the alcoholism universe. The choice of variables then depends on how strict or lenient one has to be in what is considered the core alcoholism universe and the alcoholism periphery (i.e. the related symptoms). If one is very strict there is a good chance of overlooking groups. If one is very lenient all relevant information is blurred by noise and nothing will be discovered, or only the most rudimentary structure shows up. There is no logically correct answer: a mixture of scientific knowledge of alcoholism, insight and experience about the potency and limitations of the statistical techniques, and last but not least "intuition", provide a good balance.

Given this general starting point the following reasoning has led to the choice of variables.

First, it is important to work with symptoms and not with "summed scales" or principal component scores, as this results in blurring of independent influences which in turn hinders the recognition process in the statistical grouping procedures.¹⁷

Secondly, no supposed aetiological elements were included. One of the aims in finding symptom constellations is to have them as a means for further aetiological research. Further, a practical problem is created by filling the variable pool with assumed causal variables without any clear idea as to the symptom constellations, as so much noise is enclosed in the data that finding the symptom constellations themselves is prevented. Therefore no symptoms were included about heredity, assumed primary psychiatric disorder other than alcoholism, and assumed underlying alcoholic personalities.

Thirdly, it was decided that a good balance would be 75% of the symptoms as core symptoms and 25% as peripheral symptoms.

The core came from the following areas: dependence symptoms, drinking behaviour and drinking pattern. The reference period for these areas was the year before admission, as this appears optimal.¹⁸ Further core areas were: symptoms concerning onset and course and lifetime consequences of drinking.

A limited number of peripheral symptoms was taken from the variables that the treatment staff of the Jellinek Institute used for treatment matching and referral. The following areas were involved: treatment history, social background, home environment during youth and insight into the dependence on alcohol.

The selection of the 102 symptoms took place in two stages: starting from review articles concerning alcohol instruments and alcohol typologies, in combination with symptoms used by the treatment staff, a pool of potential symptoms was defined. Subsequently, symptoms with conceptual overlap were excluded. The actual symptoms can be found in Table 1.

To strive for maximal reliability and validity, the symptoms were measured by questions referring to simple factual behaviours without mixing them with intentions, norms, values and subtle judgements.^{19,20} The formulation of the questions was mainly modelled to the form used in the Alcohol Use Inventory (AUI).²¹ In the data pre-processing phase the ordered response categories were dichotomized near the median.¹⁵

Nearly all variables ($N=93$), including most peripheral variables, were incorporated in the client questionnaire (indicated by C in Table 1). For a limited number of variables ($N=9$), information was supplied by the staff (indicated by S in Table 1) who used a semi-structured interview. After the instruments were field-tested, a psychologist trained the treatment staff (mostly social workers) and organized and supervised the process of data collection.

To check the reliability of the measurement process two analyses were performed.

First, a check of the intra-instrument reliability was done. If a relevant taxonomic structure is detected, then a good deal of the core symptoms will contribute to the common variance, i.e. to the internal criterion validity.¹⁶ As validity is a lower boundary of the reliability of these discriminating symptoms, they have to be measured

Table 1. Results of multiple regression of symptoms (independents) on the three MDS-dimensions (dependents)

Var. No.	Symptom	Normalized regression weights (direction cosines)			
		Dim. 1	Dim. 2	Dim. 3	Multiple Correlation
I ^A Main pole on the first MDS dimension: high dependence					
c89	"Panicky" the morning after drinking	0.96	- 0.15	- 0.24	0.65
c87	"Cannot face day" the morning after drinking	0.96	- 0.29	- 0.03	0.63
c88	"Gloomy, depressed" the morning after drinking	0.96	- 0.26	- 0.10	0.62
c86	"Very tense" the morning after drinking	0.95	- 0.30	- 0.14	0.62
c83	"Vague anxieties" the morning after drinking	0.95	- 0.17	- 0.26	0.61
c69	"Tiredness" the morning after drinking	0.98	- 0.19	0.06	0.56
c55	After one or two drinks an irresistible urge to continue with drinking	0.90	0.35	0.26	0.59
c44	Drink every day until intoxicated when in a period of drinking	0.92	0.38	0.11	0.57
c68	"Listless" the morning after drinking	0.99	- 0.13	0.10	0.53
c79	"Trembling hands" the morning after drinking	0.94	0.33	0.14	0.54
c90	"Restlessness" the morning after drinking	0.99	0.10	0.06	0.49
c80	"Inner shakes" the morning after drinking	0.94	0.18	- 0.30	0.50
c82	"Sweating" the morning after drinking	0.95	0.28	0.13	0.50
c42	First glass at a draught	0.99	- 0.01	- 0.09	0.45
c92	"Feeling guilty" the morning after drinking	0.97	- 0.13	- 0.21	0.45
c47	Recovery drinking the morning after drinking	0.74	0.33	0.59	0.58
c53	Missing meals when drinking	0.88	0.12	0.45	0.49
c76	"Nausea" the morning after drinking	0.98	- 0.01	0.18	0.43
c49	"Frightening dreams" the morning after drinking	0.93	- 0.13	- 0.34	0.46
c72	"Confused" the morning after drinking	0.92	0.36	- 0.14	0.45
c39	Drinking throughout the day	0.76	0.33	0.56	0.51
c93	"Easily irritated" the morning after drinking	0.98	- 0.04	- 0.22	0.40
s102	According to the staff has a big alcohol problem	0.90	0.01	0.44	0.43
c91	"Think people are against me" the morning after drinking	0.95	0.03	- 0.30	0.40
c74	"Difficulty in breathing" the morning after drinking	0.90	0.14	- 0.42	0.41
c51	"Loss of memory" (no black-out)	0.91	0.22	0.35	0.40
c70	"Headaches" after a day of drinking	0.88	- 0.22	- 0.42	0.41
c71	"Dizziness" after a day of drinking	0.99	0.05	- 0.02	0.36
c57	Have seen or heard things that were not there (hallucinations)	0.90	0.39	0.18	0.39
c37	High consumption on typical drinking day	0.73	0.57	0.38	0.48
c27	Do not want to drink socially after treatment	0.78	0.27	0.56	0.45
c26	Client considers "use of alcohol" a problem	0.76	0.10	0.64	0.45
c56	When drinking stumble about, stagger and weave	0.98	- 0.05	- 0.19	0.34
c73	"Singing in the ears the morning after drinking"	0.99	0.14	0.01	0.34
c81	"Palpitations of the heart" the morning after drinking	0.85	- 0.01	- 0.53	0.40
c50	Black-outs	0.79	0.61	0.04	0.41
c52	Drinking enough to pass out	0.94	0.29	0.20	0.35
c9	Ever attempted suicide	0.83	0.32	- 0.46	0.38
c40	Never missed a day drinking when in a period of drinking	0.85	0.25	0.47	0.35
c36	No preference for type of beverage	0.89	0.36	- 0.27	0.32
c54	Sleeping less after drinking	0.81	0.07	0.59	0.33
c75	"Stomach pains" the morning after drinking	0.76	0.14	- 0.63	0.35
c85	"Indigestion" the morning after drinking	0.84	0.51	- 0.20	0.32
c84	"Itching" the morning after drinking	0.88	0.41	0.24	0.25
c23	Short duration of social alcohol use	0.79	0.56	- 0.24	0.28
c43	Start to drink by gulping from the bottle	0.72	0.37	0.59	0.24

Table 1. (continued)

Var. No.	Symptom	Normalized regression weights (direction cosines)			
		Dim. 1	Dim. 2	Dim 3	Multiple Correlation
I ^B Antipole on the first MDS dimension: denial or low dependence					
s101	Staff: client denies or hides the drinking problem	- 0.94	- 0.32	0.14	0.46
c3	Currently not living alone	- 0.86	- 0.36	- 0.35	0.31
s100	Came into treatment due to external pressures	- 0.95	- 0.31	- 0.04	0.24
c17	A good relationship with mother when growing up	- 0.73	- 0.26	0.64	0.28
II ^A Main pole on the second MDS dimension: anti-social alcoholism					
c29	Mainly drinking in pubs	- 0.01	0.99	- 0.11	0.74
c32	Mainly drinking in company with others	- 0.28	0.95	- 0.13	0.58
c24	Young age when drinking became a problem	0.50	0.81	- 0.29	0.62
c22	Young age when started with social drinking	0.39	0.87	- 0.31	0.58
c65	Ever had debts due to drinking	0.33	0.90	0.27	0.54
c64	Ever had legal problems due to drinking	0.02	0.94	0.34	0.50
c2	Male	- 0.46	0.77	0.44	0.57
c33	Preference for beer	- 0.46	0.89	- 0.06	0.42
c45	Benders (intoxicated for at least 2 days)	0.59	0.76	0.28	0.46
c61	Heavy smoking	0.49	0.85	0.21	0.34
c63	Ever divorced due to drinking	0.56	0.75	0.35	0.39
c62	Ever lost a job due to drinking	0.44	0.79	0.42	0.36
c60	Increased tolerance	0.39	0.71	- 0.58	0.32
c59	Fighting when drinking	0.49	0.73	- 0.47	0.29
c4	Low educational level	0.07	0.71	- 0.70	0.30
c11	Parents divorced when young	- 0.59	0.75	- 0.31	0.28
c78	"Belching" the morning after drinking	0.61	0.79	- 0.11	0.26
c13	Ever in children's home or foster family	0.29	0.92	0.26	0.20
c67	Ever in hospital due to concussion of the brain	0.33	0.75	0.58	0.24
c96	Ever used illegal drugs	0.61	0.70	- 0.37	0.25
II ^B Antipole on the second MDS dimension: isolated home drinking					
c34	Preference for wine	- 0.01	- 0.96	- 0.28	0.53
c28	Mainly drinking at home	0.12	- 0.97	0.20	0.48
c31	Mainly drinking alone	0.49	- 0.85	0.20	0.41
s97	Ever used sleeping tablets	0.66	- 0.71	- 0.23	0.33
III ^A Main pole on the third MDS dimension: chronic alcoholism					
c8	Previously been treated clinically for drinking	0.40	0.16	0.90	0.50
c48	Kept some beverage for the next morning	0.65	0.24	0.72	0.58
s95	Ever had paraesthesias	0.36	0.02	0.93	0.38
c35	Preference for hard liquor	- 0.17	0.20	0.97	0.32
c66	Ever had convulsions	0.42	- 0.05	0.91	0.26
s98	Consumed alcohol on day of admission to treatment	- 0.44	0.18	0.88	0.27
c38	Drink every day (no periodic drinking)	0.50	0.25	0.83	0.27
c7	Physical illness due to drinking	0.31	- 0.33	0.89	0.21
s99	Unkept appearance on day of admission to treatment	- 0.27	- 0.54	0.80	0.22

Table 1. (*continued*)

Var. No.	Symptom	Normalized regression weights (direction cosines)			Multiple Correlation
		Dim. 1	Dim. 2	Dim 3	
III ^B Antipole on the third bipolar dimension: quarrelling youngsters					
c1	Young age on admission	0.29	0.41	- 0.87	0.56
c15	Fighting in parental home	- 0.03	0.33	- 0.94	0.39
c19	A bad relationship with father when growing up	0.34	0.61	- 0.71	0.49
c14	Quarrelling in parental home	0.18	0.24	- 0.95	0.36
c58	Arguing while drinking	0.33	0.35	- 0.87	0.37
c5	Dropout from school	0.22	0.50	- 0.84	0.35
c6	Lower occupational level	- 0.06	0.61	- 0.79	0.29
Symptoms not significant on 1% level or undirected vector (cos. < 0.70)					
c10	Older child in parental home	0.23	- 0.66	0.71	0.14
c12	Parent deceased when young	0.67	- 0.31	0.68	0.11
c16	Mother had physical or mental problems when young	0.58	0.39	- 0.72	0.11
c18	Father had physical or mental problems when young	0.23	- 0.22	- 0.95	0.17
c20	Family or friends addicted to alcohol	0.67	0.52	- 0.53	0.23
c21	First alcohol provoked a special feeling	0.63	0.67	- 0.40	0.18
c25	Long duration of problem drinking	0.40	0.68	0.61	0.46
c30	Drinking in socially uncommon sites	- 0.30	0.68	0.67	0.14
c41	Consumed every day roughly the same amount	0.18	- 0.35	0.92	0.20
c46	Ever a period when completely stopped with drinking	- 0.75	- 0.66	0.07	0.09
c77	"Aching stomach" the morning after drinking	0.65	0.68	- 0.34	0.28
s94	Physical injury due to drinking	- 0.07	0.70	- 0.71	0.16

*Symptoms with a starting C were incorporated in the client questionnaire, and symptoms with a starting S were part of the semi-structured interview by staff-members of the treatment programs.

The symptoms are sorted on the non-normalized regression weights within the dimensions.

in a sufficiently reliable way. Not all core symptoms and certainly not the greater number of the peripheral symptoms will contribute to the taxonomic structure in a bootstrapping study, but this does not imply a lack of reliability. It is reasonable to assume that the measurement process was done adequately (i.e. the greater number of the symptoms were measured reliably) if a good deal (e.g. 50%) of the core symptoms showed sufficient common variance. To make classic reliability theory usable in this context, an operationalization of the common variance was sought in the standardized regression weights of the symptoms on their most relevant MDS dimension, as described in the MDS method section. Due to the binary nature of the symptoms, the standardized regression weights are equivalent with the point-biserial item-test correlations

as used in classic reliability theory. As correlations above 0.30 are usually considered good,²² the first check of the reliability of the data was considered positive if 50% of the core symptoms showed a standardized regression weight of at least 0.30 on their most important MDS dimension.

The second check of the reliability of the measurement process was done by means of a small test-retest analysis. A limited number of 14 subjects, who during the study period were transferred from one treatment programme to another programme, participated in a second testing 2-3 weeks after the first one. Because such a small sample precludes a meaningful analysis on a symptom level, the test-retest data were used to study the stability of the MDS dimensions by means of the Pearson correlation

coefficient. To derive MDS scale values for the second testing they were included in a MDS analysis in which they were given no weight.

Similarity measure

The most relevant issue concerning similarity measures involves the choice between a measure of covariation and a distance measure such as the Euclidian distance. The distance measure is a more general measure and is composed of a part "covariation" and a part "level". By including the level component in a similarity measure one adds another restriction to the similarity, but this may have the effect that subjects with a certain disease are dissected in homogeneous groups according to disease severity. As disease severity will present itself as a dimension in a MDS solution, it does not make sense to choose a dissecting measure such as the Euclidian distance. The choice can therefore only be to use a measure of covariation and because of the nature of several variables in this study it had to be a binary measure. Due to dependence on the relative values of the marginal totals, in the binary case the classic measure of covariation (i.e. the Pearson correlation coefficient) is a distorted measure of the true population covariation.²³ A suitable measure of covariation for the binary case is Yule's *Y*, as this measure is independent of the marginal totals.²³

A second issue of importance in similarity measures concerns the problem of inclusion of negative matches, i.e. the cases when both subjects do not have the symptom. In biology it sometimes makes sense to drop a negative match.¹⁶ To make such a decision one has to have prior knowledge concerning the classification sought, which one does not have in a bootstrapping study. Of course, one can choose to drop all negative matches and use Jaccard's similarity measure.¹⁶ However, the critique of the distance measure referred to above, concerning dissecting by the "level" part of the measure, also applies for Jaccard's similarity measure, and in this class of measures there is no alternative without this undesirable property. The measure of covariation, Yule's *Y*, and the Euclidian distance measure implies the inclusion of negative matches.

As Jaccard's similarity measure is (inversely) monotonically related to most other similarity measures excluding negative matches and the distance measure is (inversely) monotonically re-

lated to most other similarity measures including negative matches,²⁴ and as MDS solutions of (inversely) monotonically related measures are identical, the specific influence of the kind of similarity measure in this study is adequately controlled by studying the MDS solutions of all three similarity measures. Given the above-mentioned arguments, it was expected that a MDS solution based on the Yule's *Y* similarity measure would be more meaningful clinically than the one based on the Jaccard's similarity measure or the Euclidian distance measure.

A last issue in calculating similarities between subjects is the weighing of the symptoms. In a bootstrapping study no prior knowledge is available, so there is no other choice then to give all symptoms equal weight.⁶

Cluster procedure

A cluster procedure was used to check for the existence of isolated compact groups in order to prevent a "degenerate" MDS solution. As most cluster procedures lack a probabilistic foundation mathematicians regard them as heuristics, often generating artificial clusters.²⁵ To avoid finding an artificial solution, a cluster procedure was used which does have a probabilistic foundation: Wong's *k*th nearest neighbour method.^{25,26} A number of Monte Carlo trials showed that the "diagnostic plot"²⁷ for establishing the number of isolated groups in this cluster procedure has adequate sensitivity, i.e. is able to detect isolated groups if the data contain isolated groups. Therefore this diagnostic technique was used to check for isolated groups in the data.

Multi-dimensional scaling

The selected MDS analysis (one mode, two-way^{9,28}) is the most elementary of all the possibilities, and is described adequately in several introductory textbooks.^{9,29} As the analysis is an elementary one, and as the ratio of similarities to the number of estimated geometric coordinates is very high, all MDS algorithms as implemented in different computer programs produce nearly equal results.²⁹ The program KYST-2A^{29,30} was used with the default options.

MDS is a type of data reconstruction technique as it transforms similarities between subjects in subject-points in a low dimensional space (compare, e.g. the distances between cities that are transformed in a map). To reject the null

hypothesis that the data are only random, the stress value—an index of lack of fit—has to be significantly lower than the stress value for random similarities. As the table with stress values for random similarities in Spence & Ogilvie³¹ did not include one for the number of subjects of this study, the necessary value was derived by the method described by them (NB: 1000 Monte Carlo runs were performed^{32,33}).

The test of the null hypothesis of the obtained MDS solution is a minimal requirement, and it is often advocated^{16,29} that a kind of stability analysis is performed to form an impression of in what way the obtained solution is distorted by the random variations operating in any sample. A favourite method is to split the sample into two halves. However, the sample in this study was not large enough for this method. Instead, based on a suggestion of Kruskal & Wish,²⁹ it was decided to perform 10 stability analyses where in each analysis 10% of the subjects and 10% of the variables were randomly^{32,33} dropped (i.e. 19% of the information in the data was dropped). The consistency of each of the 10 disturbed MDS solutions with the MDS solution based on the complete dataset was determined by canonical correlations.

A standard strategy was used to determine the number of dimensions: first looking for an “elbow” in the plot of stress values with dimensions, followed by judging the interpretability.

Because even one strongly deviating subject can invalidate the MDS results,⁹ the stress contribution of the subjects was tested for outliers by means of the range/spread test.³⁴

To describe which symptoms are important in what part of the solution, a standard approach²⁹ was followed: the dimensions were used as predictors in a multiple regression analysis with the symptoms as the dependent variables. The symptoms are vectors in the dimensional space and will be presented in a table that can be interpreted as results from factor analysis. A symptom is only considered relevant if the significance level is at least 0.01 and if the angle of the symptom-vector to one of the dimensions is less than 45 degrees (otherwise the symptom-vector is considered non-specific, i.e. relevant for more than one dimension).

Results

As the results of the cluster analysis and MDS analysis for the three similarity measures were

very similar, only the results for Yule's *Y* will be presented.

Before using MDS, a search for isolated groups was done with Wong's *k*th nearest neighbour cluster procedure. The “diagnostic plot” showed a gradual drop to a stable range of unimodality for the density value $k = 8$. When this plot was compared with the plots of Monte Carlo trials²⁷ the conclusion could only be that these data come from a unimodal distribution, and in all likelihood did not contain isolated groups.

In the MDS analysis the null hypothesis that the data are only random was rejected: the stress value for the real data was clearly lower than the one for chance (the stress value for the data was for the dimension 1–6, respectively: 0.15, 0.17, 0.20, 0.25, 0.33, 0.49 and the stress value for chance was, respectively: 0.21, 0.23, 0.27, 0.32, 0.41, 0.57). The gap in stress value ranged from 0.06 to 0.08, clearly significantly larger than zero ($p < 0.001$): none of the 1000 deviations of the mean stress value in the Monte Carlo runs even approached the size of this gap.

The determination of the number of dimensions could not be done formally, because no “elbow” could be detected in the plotted stress values (a frequent observation). The number of dimensions in the data were therefore derived by interpreting the different solutions. To determine the consistency between the two- and three-dimensional solution, canonical correlations were calculated. The computed correlations of 0.999 indicated nearly perfect similarity between the first two dimensions of the two- and three-dimensional solutions. The third dimension did have sufficient clinical validity (see below) to allow acceptance of a three-dimensional solution. The fourth dimension of the four-dimensional solution appeared of limited interest as it was considered too specific (factor specialists would call this a trivial or tautological factor). Besides, rules—derived from a Monte Carlo study³⁵ in the field of factor analysis—concerning the number of variables with adequate loading in relation to the number of subjects raised doubts about the stability of the fourth dimension obtained.

The MDS analysis was not invalidated by deviating subjects. None of the subjects could be considered an outlier in their contribution to the stress ($p > 0.05$).

Inspection of the distribution of the subjects in the MDS space made clear that the solution obtained is trivariate normal.

Table 1 shows the results of the regression analysis, which was used to describe which symptoms were relevant for which dimension. The table contains a variable number (starting with "C" indicating "from the client form", and with "S" indicating "from the staff form"), the symptom, three columns with direction cosines of the angle of the symptom with the dimensions, and the multiple correlation. The multiple correlation indicates the strength on the symptom for the three dimensions. The direction cosine shows how specific the symptom was for that dimension (a cosine of 1.00 means an angle of 0 degrees, which indicates perfect specificity). The dimensions were split into a pole and an antipole. The symptoms were placed under the most relevant pole of the dimension involved (or in a residual group). The first dimension reflects the alcohol dependence syndrome with one pole representing high dependence and the other pole representing low dependence or denial. The second bipolar dimension reveals a male-dominated antisocial alcoholism and, in contrast, a female-dominated pattern of isolated home drinking. The third bipolar dimension shows chronic alcoholism and opposite to it young quarrelsome people from troubled families.

The logical weakness of the Euclidian distance measure led only to a small distortion. There was a very strong Spearman's rank correlation (-0.90) between the calculated coefficients for the distance measure and the ones for Yule's Y . The MDS solution was also very similar (canonical correlation for dimension 1, 2 and 3 was 0.89, 0.94 and 0.94), but—as expected—compared with the results for Yule's Y the slight deviations in the regression analysis made less sense clinically. The findings for Jaccard's similarity measure were in the same direction, but not as strong as for the distance measure (Spearman rank correlation: 0.65; canonical correlations: 0.89, 0.81, 0.78), and the MDS solution also made less sense clinically.

The 10 stability analyses of the MDS solution indicated its robustness: the mean canonical correlation of the 10 analyses (and the range) for dimension 1, 2 and 3 was 0.98 (0.96–0.99), 0.94 (0.84–0.98) and 0.91 (0.85–0.95).

The first check of reliability of the measurement process concerns the percentage of core

symptoms with a standardized regression weight of at least 0.30 on their most important MDS dimension. Compared with the stated minimal level of 50%, the results showed that 70% of the core symptoms had a minimal weight of 0.30. This indicates a satisfactory level of internal criterion validity and therefore a satisfactory level of intra-instrument reliability. From the peripheral symptoms a reasonable number (39%) also had a weight greater than 0.30.

The second check of reliability concerns the test–retest reliability of the three MDS dimensions in 14 subjects retested after 2–3 weeks. The Pearson correlation (and 95% confidence interval) for dimension 1, 2 and 3 was, respectively, 0.81 (0.49–0.94), 0.76 (0.38–0.92) and 0.68 (0.24–0.89). These values suggest acceptable test–retest reliability.

Discussion

The conclusion of the analysis with the cluster procedure was corroborated by the MDS solution: the trivariate normal distribution of the MDS subject points corroborated the failure of the cluster procedure to isolate groups.

Before discussing the MDS solution, the complicated relationship of underlying causal processes to the phenomenological level of a MDS solution needs to be mentioned. MDS solutions are certainly not self-explaining devices, but this is also the case for the results of factor analysis, although most take an underlying dimensional model for granted when using factor analysis. A normal distribution of phenomenological data does not preclude the possibility that underlying categorical groups—reflecting discrete causal processes—remain unravelled due to, for instance, fuzzy or inadequate representation of their cardinal features.³⁶ Particularly relevant to the discussion of the results of this study is the fact that two underlying prototypes of widely different character can mimic, on the phenomenological level of the MDS solution, a true underlying dimensional disorder (the MDS method is able to fit two disorders into a one-dimensional space if most of the subjects have only one of the disorders). For this reason one must interpret the obtained MDS solution for the most plausible explanation.

The MDS solution obtained seems to have high face validity. In the first dimension of the MDS space one recognizes the now well-accepted dependence syndrome as originally

formulated by Edwards & Gross.³⁷ The highest loading symptoms on the main pole of this dimension reflect withdrawal, but there are also symptoms reflecting other features indicated by Edwards & Gross: "narrowing of the drinking repertoire" (e.g. drinking throughout the day), "compulsive usage" (e.g. irresistible urge to continue with drinking), "salience" (e.g. missing meals) and "usage to avoid withdrawal symptoms" (e.g. relief drinking). Of the features covered in this study, only "increased tolerance" had a very low weight, which has also been noticed in other studies.^{38, 39} In this study "increased tolerance" was relevant mainly for the other two MDS dimensions ("increased tolerance" for "antisocial alcoholism", and to a lesser extent "decreased tolerance" for "chronicity").

A remark has to be made concerning the finding that affective withdrawal symptoms were the most important ones in characterizing the dependence dimension. Although the questions referred to the withdrawal state, it is possible that in a number of "high dependence" subjects a co-occurrence existed with long-term primary affective symptomatology or disorder.⁴⁰ This certainly needs further research.

On the opposite side of the high dependence pole a number of symptoms are grouped around the staff-judgement of "denial of alcohol problems by the subject". The common variances of these "denial" symptoms with the first MDS dimension can be derived from Table 1 (see, e.g. appendix A from Kruskal & Wish²⁹) and are roughly half the size of the common variances of the high dependence symptoms. This observation suggests that only a part of the subjects on the opposite pole of the high dependence pole consists of people who deny, and the other part consists of subjects with true low dependence. Inspection of a plot confirmed this interpretation. In a number of factor analytic studies^{41, 42} a similar co-occurrence of denial and low dependence was found.

The second dimension of the MDS space reflects on the main pole an already well-known constellation of symptoms, which has been variously described and has different labels attached to it, such as antisocial alcoholics,⁴³ essential alcoholics⁴⁴ and early-onset drinkers.⁴⁵ The provisional label antisocial alcoholic was chosen as it is a commonly used name for these subjects, and because other labels take the name from only one symptom (early-onset), include a depen-

dence component (type B¹⁰) or imply aetiological connotations (type II⁴⁶), which still have not been corroborated convincingly (see, e.g. the study of Vaillant⁴⁷ and the commentaries on it). As Zucker⁴³ has indicated, it "is a type that is most frequently studied and the one we know most about". In this study most—but not all—were men.

The antipole of the second dimension of the MDS space reflects a pattern of isolated home drinking, which was chosen tentatively as a descriptive label. Most—but not all—were women. There were not many distinguishing symptoms which might describe these subjects. In a literature review⁴³ a female alcoholic subtype with negative affect drinking was postulated. Clearly, more research is necessary for a better description of this antipole.

It is unclear whether the second dimension should be interpreted as a true dimension (e.g. uncontrolled impulse expression, against inhibition and withdrawal), or that it makes more sense to consider it as two prototypes which, due to their divergent characters, are placed opposite each other in the multi-dimensional space.

The main pole of the third dimension refers to symptoms indicating "chronic alcoholism". In recent typology literature chronicity is neglected, although in classical typologies chronicity was considered an important criterion in grouping alcoholics.^{3,48}

The antipole on this third dimension refers to "young persons raised in troubled families". The main theme of the symptoms characterizing this pole seems to be "quarrelling": "quarrelling and fights in parental home", "having trouble in school and work", and "arguing whilst drinking". In a factor-analytic study among alcoholics,⁴⁹ a second-order factor "general childhood instability" was found which has similar features, and in a retrospective study⁵⁰ based on a sample from the general population "violence in parental family" appeared to be a predictor of alcoholism. It is of interest to investigate the developmental and personality disorders that are involved.

The third dimension does not seem to be a true dimension, but a composition of two opposing prototypes where age is a probable connecting factor. Quarrelsome people evoke responses from their environment by which they are pushed into treatment at an early age. Of course, chronic alcoholics belong to an older age group.

The MDS solution obtained seems to have a good potential for fruitful matching of alcoholics to treatments. Lindström's⁵¹ in-depth review of the literature indicates that: (a) high dependence subjects may benefit most from an intensive treatment with abstinence as goal, while low dependence subjects may only need a brief intervention; (b) antisocial subjects may benefit most from a structured therapy; and (c) chronic alcoholics, who in this study did not benefit from earlier treatments, may not need another casual treatment episode but will probably need well-organized aftercare (e.g. the community reinforcement approach) or in the worst case a sheltered living environment. A good deal of research will be necessary to find out the exact merits of the MDS solution obtained for treatment-matching. It is most likely that only after unravelling the causal processes can optimal treatments be devised.

After the analysis for this study was completed, an article by DelBoca⁵² appeared which proposed an analysis with MDS and formulated the hypothesis that one of the dimensions will measure "risk/severity", and that another dimension represents a male-female distinction interwoven with antisocial personality features. The first two dimensions of the solution obtained are in line with this hypothesis, with the exception that the bivariate normal distribution in this study is not in agreement with the sharply divided clustering as hypothesized by DelBoca.

It is worth emphasizing that the hypothesis of non-specificity of the symptoms, as formulated in taxonomic studies in biology, in this study was corroborated by the 10 stability analyses of the MDS solution. At random, dropping 10% of the variables and 10% of the subjects led to nearly the same classification.

The main limitation of this study, one inherent in a bootstrapping study, concerns the possibility of missing "types" or "dimensions" by not incorporating enough relevant variables or relevant subjects. Further, one must realize that the symptoms studied in this bootstrapping study are probably only weakly related with the causal processes and therefore in all likelihood led to a more fuzzy spaced subject domain than actually exists in reality. Using the correct—and only the correct—variables will show clear categorical grouping or a more accurate dimensional distribution. As a first step to improving the obtained preliminary classification, cross-validation stud-

ies need to be done in which special attention is given to a more balanced set of symptoms for each of the poles of the MDS dimensions. In this way the current ambiguity of a dimensional or prototypical view of the obtained second dimension might be (partly) solved. Further issues which need to be addressed in future research are: developing specific diagnostic rules, describing the course of symptomatology, exploring the causal pathways and, as mentioned above, devising optimal treatment modalities.

In summary, this study illustrates the strength of analytical strategy in unravelling the complex symptomatology in alcoholic subjects, and also provides a preliminary natural classification of alcoholics with high face validity.

Acknowledgements

Many thanks are due to the clients and staff of the Jellinek Institute in Amsterdam. I am especially grateful to Wim van den Brink for his stimulating advice in completing the study and writing this article, to Udo Nabitz for the organization of the data collection, to Arnold de Gelder for his assistance in the data analysis, to Panos Nanitsos for his help in editing the English, and to Martien Kooyman for his support in implementing this study at the Jellinek Institute. This research was supported by the Netherlands Foundation for Preventive Medicine ('Praeventiefonds' grantnr. 28-682).

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