Eur Arch Psychiatry Clin Neurosci (2012) 262:227–238
DOI 10.1007/s00406-011-0271-x

ORIGINAL PAPER

Exploring the structure of psychopathological symptoms: a re-analysis of AMDP data by robust nonmetric multidimensional scaling

Damian Läge · Samy Egli · Michael Riedel · Hans-Jürgen Möller

Received: 21 October 2011 / Accepted: 27 October 2011 / Published online: 8 November 2011

Abstract This paper investigates the structure of psychopathological symptoms. Based on AMDP symptom profiles, a symptom space was calculated by robust nonmetric multidimensional scaling (NMDS) and the symptom structures of a sample dating from 1980 and a sample from 2002/2003 were compared. The method of NMDS presented in this study allows results from other studies to be confirmed and complemented. The symptom factors identified in the past by factor-analytic studies were replicated as clusters in two-dimensional symptom maps. Additionally, some theoretically assumed clusters of symptoms were detected that were not found in previous factor analysis approaches. From the results, which are depicted in a continuous space, new insights can be gained, especially with regard to questions of categorical and dimensional classifications. The comparison of the structural aspects of the symptomatology across more than two decades resulted in only small divergences and allows conclusions to be drawn about the stability of these structures and consequently of the symptom clusters and dimensions.

Keywords Nonmetric multidimensional scaling (NMDS) · Psychopathological symptom structure · Factor-analytic syndromes · Mental disorders · Classification

D. Läge (✉) · S. Egli
Institute of Psychology, Applied Cognitive Psychology, University of Zurich, Binzmühlestrasse 14/28, 8050 Zurich, Switzerland
e-mail: d.laege@psychologie.uzh.ch

M. Riedel · H.-J. Möller
Psychiatric Hospital of the Ludwig-Maximilians University, Nussbaumstrasse 7, 80366 Munich, Germany

Introduction

Psychopathological symptoms play a pivotal role in clinical research and practice in the field of mental disorders. The symptoms constitute the most elementary level of the diagnostic process [41] and consequently form the basis for the classification of mental disorders. The classification in turn can be seen as a prerequisite for research about the aetiology and at the same time as the basis for therapy [33]. Given the importance of the symptoms in the field of classification of mental disorders, this study explores structural aspects of a set of psychopathological symptoms in detail: The AMDP symptom rating scale [2, 21], which covers a broad spectrum of 100 psychopathological and 40 somatic symptoms, is the most widely used and best known psychiatric documentation system in the German-speaking area [31]. Moreover, the AMDP system has also been translated into many other languages [21] and has been used in various international studies [e.g. 9, 11, 24, 37, 38]. To investigate structural aspects, some of the most commonly used methods are factor-analytical approaches: Depending on the spectrum of interest, some researchers employ factor analysis to identify specific factors themselves [e.g. 10, 37–39], while others rely on the syndromes already extracted using factor analysis more than 20 years ago by Pietzcker et al. [36], [e.g. 7, 24]. Surprisingly, however, some of the questions that arose regarding the factors extracted by Pietzcker et al. still remain unanswered today. Although clinical relevance and test theoretical indicators pointed in favour of the validity of certain factors, it was never actually possible to confirm them by factor analysis. Other popular methods for extracting groups or syndromes such as cluster analysis are seen less frequently [e.g. 1, 27, 38]. In the study by Sato et al. [38], in which the authors identified phenomenological subtypes

of acute mania, cluster analysis was combined with factor analysis, but in a sequential manner. In other words, it was not AMDP scores that were analysed but rather factor scores of the factor analysis. Nevertheless, this study does show an interesting approach to combining cluster analysis and factor analysis methods. In the present study, we present a complementary approach, which allows the strengths of clusters and factors to be considered at the same time: nonmetric multidimensional scaling (NMDS, see for example [6]. Like cluster analysis and factor analysis, NMDS is also a multivariate structure-detecting method, but it also allows additional structural insights to be gained, as will be demonstrated further below in the "Discussion" section. Multidimensional scaling methods have already been employed in the past in combination with AMDP symptoms. In the study by Angst et al. [1], multidimensional scaling was used to make nonmetric similarity matrices accessible for metric procedures in order to test the hypothesis of a continuum of psychoses from depression to schizophrenia. The hypothesis was not disproved by the results of the study. Sulz and Gigerenzer [42] investigated the individual diagnostic schemata of clinicians by analysing rank similarities of diagnoses using NMDS. They found that the clinical diagnosis showed a closer coherence to the individual diagnostic scheme than to the internalized nosological theory. However, to date, no study has attempted to directly analyse AMDP symptom scores using NMDS. In this paper, we present such an approach and highlight some of the advantages and insights resulting from it. At the level of data selection, for instance, it is not necessary to exclude symptoms with a low prevalence from further analysis, as was the case in some recent factor-analytic studies [e.g. 37]; rather, it is possible to capture the whole spectrum of all AMDP symptoms. Furthermore, at the level of data analysis, no prior assumptions about the underlying structure have to be made in order to look at either dimensional or categorical aspects. Consequently, the symptoms do not have to be separated into groups prior to analysis to enable statements to be inferred about the relationships between symptoms or groups of symptoms based on the analysis of sum scores. The interrelationships of the various symptoms can be directly explored and interpreted. On the level of conclusions, for instance, this allows symptoms to be identified, which lie between clusters or syndromes, and enables the positions of the clusters/syndromes to be interpreted in relation to each other. Additionally, it can be explained why it was not possible to identify some a priori assumed syndromes by factor analysis in other studies. With regard to the study by Pietzcker et al. [36], which is still frequently cited today, we present an approach for explaining why the factor analysis did not fully succeed in identifying all of the factors that the authors hoped to find. Therefore, we analysed a partially intersecting sample from 1980 and compared it with a current sample from 2002/2003, enabling new conclusions to be drawn about the stability of syndromes over time.

Methods

Sample

The sample consisted of inpatients at the psychiatric hospital of the Ludwig-Maximilians-University, Munich. The records were included of all patients who were admitted and discharged between 1 January 1980 and 31 December 1980 ($N = 1{,}458$) and of another group of patients who were admitted and discharged between 1 January 2002 and 31 December 2003 ($N = 2{,}485$). The detailed sample characteristics are presented in Table 1. For reasons of readability, the ICD-9 diagnoses were translated into ICD-10 [13] diagnoses by drawing on the reference tables by Freyberger et al. [18]. Since the diagnostic frequencies in Table 1 mainly serve as a rough characterization of the sample, no statistics were run to test these figures for significances.

There were no significant differences between the 1980 group and the 2002/2003 group in terms of the distribution of sex ($\chi^2(1) = 1.48$, ns), or the length of stay (Kolmogorov–Smirnov test for the 1980 group: $z = 4.31$,

Table 1 Sample characteristics

	1980	2002/2003
N (cases)	1,458	2,485
Sex (female)	52.5%	50.5%
Mean age in years	39.7[a] ± 15.9	46.7[a] ± 16.7
Mode length of stay in days	22	22
Organic, including symptomatic, mental disorders[c]	3.9%[b]	9.8% (F0)[c]
Mental and behavioural disorders due to psychoactive substance use[c]	12.0%[b]	21.4% (F1)[c]
Schizophrenia, schizotypal and delusional disorders[c]	32.7%[b]	25.6% (F2)[c]
Mood (affective) disorders[c]	30.6%[b]	30.7% (F3)[c]
Neurotic, stress-related, and somatoform disorders[c]	12.8%[b]	7.4% (F4)[c]
Behavioural syndromes associated with physiological disturbances and physical factors[c]	0.5%[b]	0.7% (F5)[c]
Disorders of adult personality and behaviour[c]	3.6%[b]	3.1% (F6)[c]
Other disorders[c]	3.9%[b]	1.3%

[a] Mann–Whitney *U* test: $z = -13.0$, $P < 0.001$

[b] ICD-9 diagnoses

[c] ICD-10 categories

$P < 0.001$, mean = 40.10 days, SD = 32.07 days; Kolmogorov–Smirnov test for the 2002/2003 group: $z = 7.13$, $P < 0.001$, mean = 40.16 days, SD = 35.21 days; Mann–Whitney U test: $z = -1.50$, ns). However, the 2002/2003 group was significantly older at admission than the 1980 group (Kolmogorov–Smirnov test for the 1980 group: $z = 3.53$, $P < 0.001$, mean = 39.69 years, SD = 15.89 years; Kolmogorov–Smirnov test for the 2002/2003 group: $z = 3.28$, $P < 0.001$, mean = 46.69 years, SD = 16.66 years; Mann–Whitney U test: $z = -12.99$, $P < 0.001$). This may partly be associated with the general increase in the percentage of older people in the population of Munich during that time span [43] and particularly with the increase in organic, including symptomatic, mental disorders (F0) from 3.9% (1980) to 9.8% (2002/2003), of which the dementia in Alzheimer's disease (F00) holds the biggest percentage (3.9% out of 9.8% of the 2002/2003 group, with an average age at admission of 74.19 ± 7.4 years). The increase in cases diagnosed with dementia in this 2002/2003 sample might also be associated with the fact that in 1980, there was no special unit for these cases in the psychiatric hospital of the Ludwig-Maximilians-University, while such a unit does exist today. Similarly, the increase in cases diagnosed with substance use (12.0–21.4%) might be associated with the establishment of a special unit for such cases, which did not exist back in 1980.

Clinical data

All patients were routinely assessed with the AMDP system 1–4 days after inpatient admission and on the day of discharge. All included patients gave informed consent to be assessed using this instrument. The study analysed the admission records of the patients. The AMDP system is an operationalized documentation system for psychopathology conceived for a broad clinical use [5] and was developed by the German–Swiss–Austrian "Association for Methodology and Documentation in Psychiatry" (Arbeitsgemeinschaft für Methodik und Dokumentation in der Psychiatrie) [2]. The symptom spectrum comprises affective, behavioural, cognitive, psychotic, sensory, and social dimensions of psychopathology. The AMDP originated from the translation of the traditional psychopathology according to Jaspers [25], Schneider [40], and others into a modern, standardized rater system, including operationalized criteria and definitions. Based on a multitude of empirical studies, it can be considered a well-established test, for which reliability and validity are reported to be good to very good [4]. Symptom items are rated by clinicians from 0 (symptom not present) to 1 (mild), 2 (moderate), and 3 (severe). In this study, the psychopathological status (symptoms 1–100) and the somatic status (symptoms 101–140) were considered for further analysis (see Appendix Table 2 for a complete list of the symptoms).

Statistical analyses

Nonmetric multidimensional scaling was used to calculate multidimensional spaces based on difference matrices. The difference coefficients of these matrices were calculated based on the AMDP symptom profiles, i.e. pairwise between all symptoms across all patients. This procedure resulted in a triangle matrix with $N = 9{,}730$ difference measures between all symptoms $\left(\frac{n\cdot(n-1)}{2}\right.$ pairwise combinations of symptoms with $n = 140$ symptoms). Taking into account that the nature of the data strongly influences the choice of a coefficient [20], a Minkowski coefficient was tailored to optimally fit the data in this study: $\delta_{ij} = \frac{\sum_{a=1}^{m} |x_{ia} - x_{ja}|}{n_{i>0}}$ where δ equals the dissimilarity between two symptoms i and j and a equals the number of attributes, or as in this study, cases with $n_i > 0$ for the number of all $x_{ia} > 0$, when $n_i > 0$, $n_i > n_j$, $n_j > 0$ and $\delta_{ij} = \frac{\sum_{a=1}^{m} |x_{ia} - x_{ja}|}{n_{j>0}}$ with $n_j > 0$ for the number of all $x_{ja} > 0$, when $n_j > 0$, $n_j > n_i$, $n_i > 0$. In a systematic evaluation and comparison to other difference and correlation measures, this coefficient proved to be the most adequate [14]. Based on the triangle matrix, a multidimensional space was calculated by means of the robust NMDS algorithm ROBUSCAL [29]. NMDS is an algorithm that iteratively approximates a configuration in an n-dimensional Euclidian space in order to maximally correspond to the given proximities or, as in this case, dissimilarities. Within this Euclidian space, which resulted in this study in two dimensions (see "Results" section), a small distance between two points corresponds to a small difference between the corresponding symptom profiles or a high covariance, respectively, and vice versa. The resulting two-dimensional NMDS spaces were compared with each other by means of Procrustes transformation [23]. Procrustes transformation compares the structures of two NMDS solutions by extending, shifting, rotating and mirroring the configurations in order to approach a maximal congruence and then determines the remaining deviation as a numerical value (in this case the AverageLoss) between the compared NMDS solutions. The AverageLoss is the averaged and standardized value of all ObjectLoss values, i.e. the deviations of the various corresponding objects in the NMDS spaces. For the comparison of the sample characteristics between the 1980 group and the 2002/2003 group, the distribution of sex was tested by employing a Chi-square test, the age and the length of stay variables were tested for normal distribution using the Kolmogorov–Smirnov test and were compared using a Mann–Whitney U test. All

statistics were computed using SPSS for Windows, Microsoft Excel and ProDaX.

Results

Since a scree test [8], which was adopted for multidimensional scaling [28], showed no substantial superiority of a three-dimensional solution, the two-dimensional NMDS solutions (or maps) are presented in Figs. 1, 2, 3. Two symptoms that present a similar profile across all patients, i.e. show a pattern of covariance, are located in proximity to each other and vice versa. Figure 1 shows the map that was calculated based on the 70 AMDP symptoms described by Baumann and Stieglitz [3, 4], which were included in the factor analysis by Gebhardt et al. [19] from the 1980 group. The dots in the maps correspond to the AMDP symptoms, which are labelled with the corresponding numbers (for a table of the AMDP symptoms, see Appendix Table 2 or consult a corresponding Refs. [2, 21]). The letters behind the numbers and the plotted convex hulls denote the affiliation with the syndromes extracted by Gebhardt et al. [19]. All of the groups could be delineated from each other quite well. Intersections can be mainly observed in connection with the apathy syndrome (AP), the autonomic syndrome (AU), and the obsessive-compulsive syndrome (OC). The depressive cluster (DE) is located opposite the mania cluster (MA) and both show an extension towards the centre of the map.

Figure 2 also shows the map of the 1980 group, but this time the map was calculated based on all 140 AMDP symptoms. Ignoring the plotted convex hulls, a first glance reveals more clearly the underlying symptom structure. The map shows a smaller cluster of symptoms in the upper left corner and a bigger cluster in the upper right corner. The upper left cluster can be delineated from the rest of the structure quite well, while the upper right cluster exhibits an expansion towards the middle and the lower left corner. Hence, the symptoms show a marked variance in this orientation but a much smaller variance towards the orthogonal orientation. However, a pronounced variance in this orientation can be observed in the lower right cluster towards the upper left cluster, but almost no variance can be seen in the orientation of the upper right or lower left corner. A variance of symptoms with regard to the orientation towards other symptoms implies differentiated similarities with regard

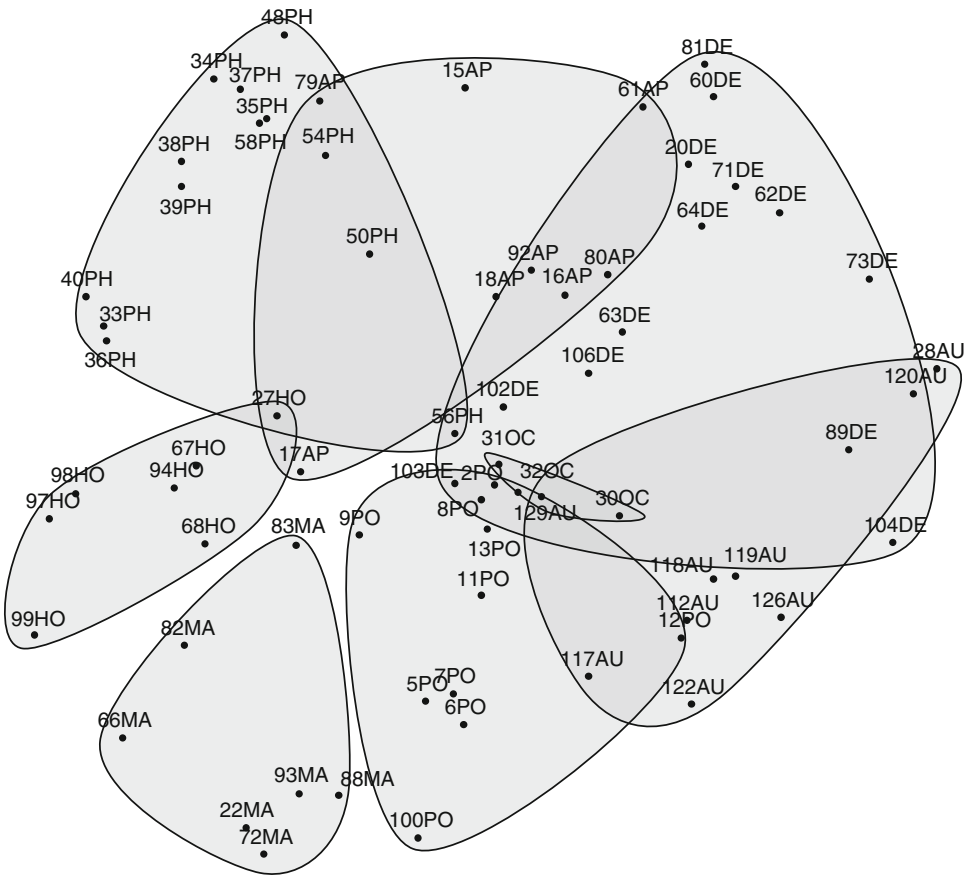

Fig. 1 NMDS map of the 70 AMDP symptoms of the 1980 group. NMDS stress 0.19. Convex hulls define syndromes as assumed for AMDP construction: Syndromes: Paranoid-hallucinatory (PH), depressive (DE), psycho-organic (PO), manic (MA), hostility (HO), autonomic (AU), apathy (AP), obsessive-compulsive (OC)

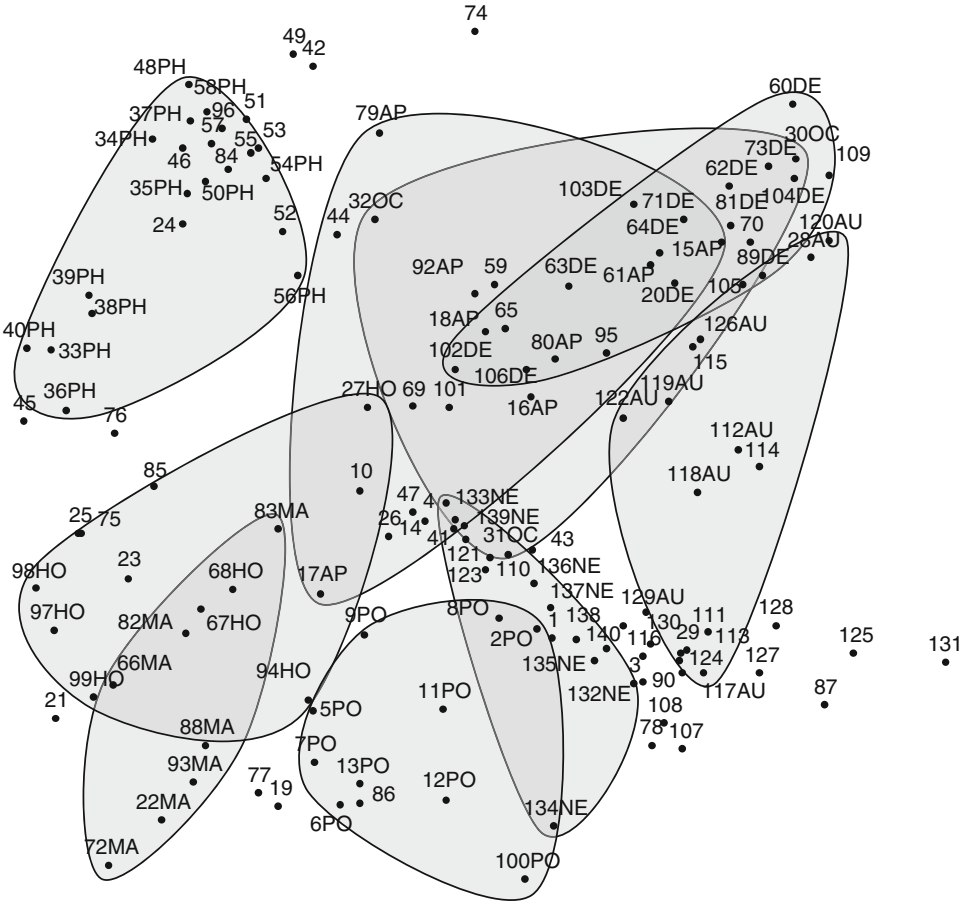

Fig. 2 NMDS map of the 140 AMDP symptoms of the 1980 group. NMDS stress 0.32. Syndromes: Paranoid-hallucinatory (PH), depressive (DE), psycho-organic (PO), manic (MA), hostility (HO), autonomic (AU), apathy (AP), obsessive-compulsive (OC), neurological (NE)

to those symptoms and vice versa. If one then takes a closer look also considering the plotted convex hulls, it is revealed that there are not eight but nine clusters plotted in this map. The biggest overlap of the new neurological cluster (NE) is shared with the adjacent cluster of the psycho-organic syndrome (PO). The orientation of the depressive cluster (DE) and the mania cluster (MA) strongly resemble those observed in Fig. 1, while the hostility cluster (HO) now also shows a more pronounced orientation towards the centre.

In Fig. 3, the map of all 140 AMDP symptoms of the 2002/2003 group is presented. The clusters in this map strongly resemble those observed in Fig. 2, but with more clearly pronounced overlaps between the psycho-organic (PO), neurological (NE) and the autonomic (AU) cluster and a marked dislocation of the obsessive-compulsive (OC) cluster. The comparison between the map of the 1980 group and the map of the 2002/2003 group was conducted by a Procrustes transformation, which resulted in a moderate AverageLoss of 0.33. (Losses <0.50 indicate that the same basic structure underlies both maps.)

Discussion

Sample of 1980 (reduced item pool of 70 symptoms)

Figure 1 shows the two-dimensional NMDS space that was calculated based on the symptom profiles of the 1980 group. In this analysis, only the 70 symptoms considered for factor analysis by Baumann and Stieglitz [3] were included. Since the convex hulls were plotted according to the syndromes that they extracted, Fig. 1 illustrates that these syndromes could be replicated quite well by NMDS. For the most part, the clusters were adequately delineated from each other. The most striking intersections can be observed in connection with the apathy syndrome (AP), the autonomic syndrome (AU), and the obsessive-compulsive syndrome (OC). The apathy syndrome in particular is an interesting case: Gebhardt et al. [19] were not able to find this syndrome using the same procedure that identified the other factors. However, since a comparable factor occurred in some partial solutions and the clinical relevance of this syndrome was assessed to be high, the syndrome was nevertheless considered. In Fig. 1, it becomes apparent

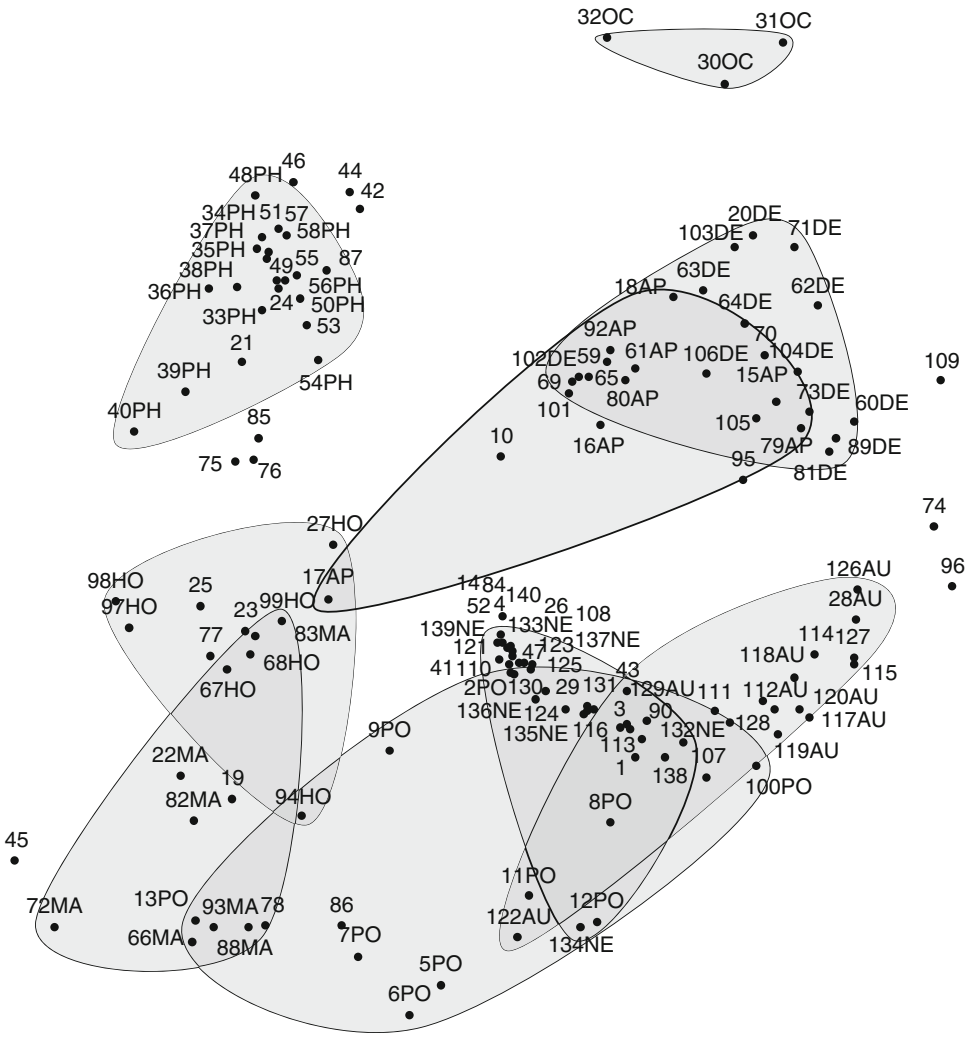

Fig. 3 NMDS map of the 140 AMDP symptoms of the 2002/2003 group. NMDS stress 0.30. Syndromes: Paranoid-hallucinatory (PH), depressive (DE), psycho-organic (PO), manic (MA), hostility (HO), autonomic (AU), apathy (AP), obsessive-compulsive (OC), neurological (NE)

why the factor might not have been found. On the one hand, Gebhardt et al. stated that there were substantial loadings of apathy items on the depressive factor, which is well illustrated by the overlap of the apathy and the depressive cluster in Fig. 1. On the other hand, the majority of the overlap of the apathy with the paranoid-hallucinatory cluster can be attributed to the position of item 17 (circumstantial thinking). Although this item is subsumed in the apathy cluster or factor, respectively, it shows the highest loading in the rotated factor loading matrix by Gebhardt et al. on the hostility factor, which is reflected in the map by the proximity to this cluster. Considering that the factor analysis sequentially subsumes those items with the highest inter-correlations in a factor, it can be assumed that the items of the apathy cluster, had it not been defined a priori, would have been assigned to the factors that were previously extracted. The autonomic syndrome, which also exhibits substantial intersections with other clusters, was described as having a lower reliability than other syndromes, with an even smaller number of items, and together with the apathy syndrome to have low mean discriminatory power coefficients [3]. The obsessive-compulsive cluster is problematic insofar as it is constituted by only three items. As will be demonstrated below, the aforementioned key finding of why the apathy cluster was not discovered by factor analysis will be confirmed in the sample of 2002/2003. This sample will also confirm the (not yet described) orientations of the manic and the depressive cluster in relation to each other and the positions of the items within those clusters with regard to the manic-depressive continuum.

Even at this point, these findings already highlight the new perspectives and insights gained by employing the method of NMDS. The map further encourages a new interpretation of the item structure (see Fig. 4). The general impression of a radix structure can hardly be overlooked, with a number of central, syndrome unspecific items and a circle of highly syndrome-specific items forming the outer

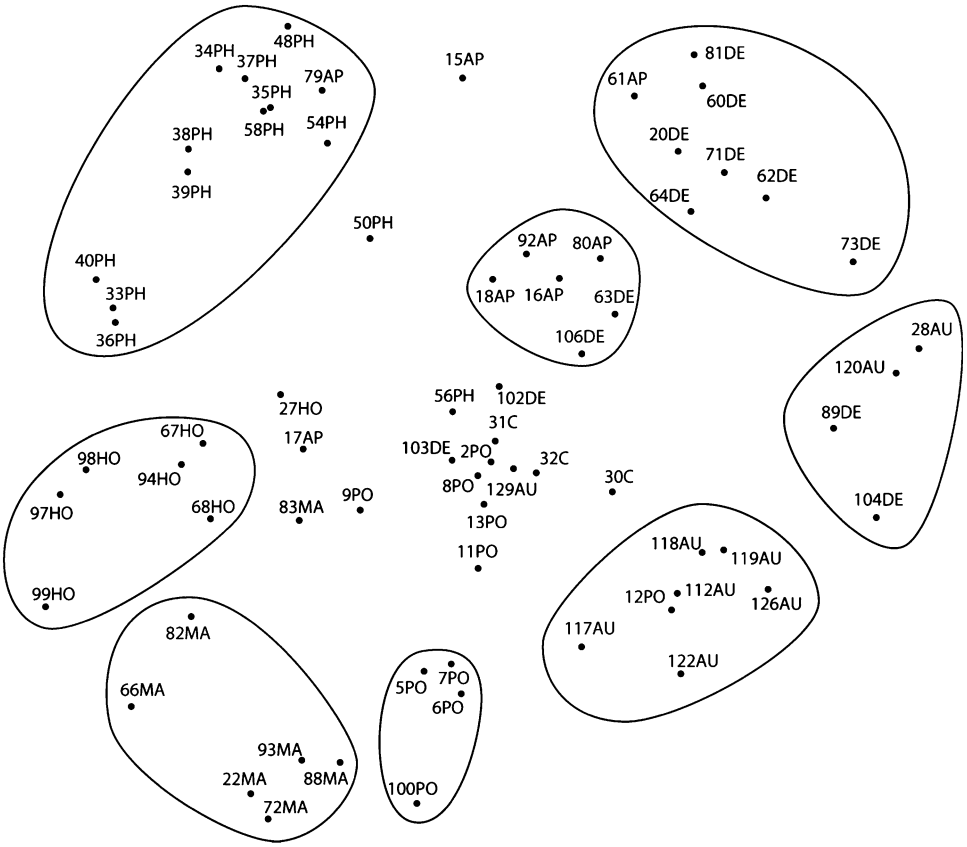

Fig. 4 NMDS map of the 70 AMDP symptoms of the 1980 group. Clusters as revealed by the re-analysis presented in this paper. Syndromes: Paranoid-hallucinatory (PH), depressive (DE), psycho-organic (PO), manic (MA), hostility (HO), autonomic (AU), apathy (AP), obsessive-compulsive (OC)

layer. Moreover, on the right, a new group, consisting of symptoms 28 (hypochondriasis), 120 (cardiac pain), 89 (worse in the morning), and 104 (early wakening), can be identified as a clinical homogeneous cluster. Finally, symptom 15, inhibited thinking, positioned in the "noon position" of the map, might be seen typical for all three syndromes surrounding it but highly atypical for the syndromes located in the other regions of the map.) This clustering, of course, is based on the data analysed in this paper and needs further replicating research for identifying its stability. If confirmed, however, it opens a new field for "easy reading" of a patient's syndrome composition: Just imagine the dots would be coloured according to the individual data, then the radix would give a clear and easy to grab overview of this patient.

Sample of 1980 (full item pool of 140 symptoms)

The map in Fig. 2 also presents the data of the 1980 group, but this time all 140 AMDP symptoms were included in the analysis. At first glance, it can be seen that there are not eight but nine convex hulls plotted in this map. The additional neurological syndrome has again been defined based on clinical considerations (like the apathy syndrome) rather than being the result of the factor-analytic procedure. Pietzcker et al. [36] argue that the symptoms subsumed in this syndrome can rarely be found at admission, but are needed for the description of side effects in the course of psychopharmacological treatment. With the exception of symptom 134 (tremor), however, unlike the apathy syndrome, this syndrome can be delineated quite well from the other syndromes/clusters. Its biggest overlap is shared with the semantically adjacent cluster of psycho-organic syndrome. Nevertheless, there is a limitation that should be mentioned in this regard. Although our proximity measure did account for the fact that an average of 88% of all symptoms of the admissions scored "0" (no symptom present), there might be a frequency bias and a tendency for extremely rarely occurring symptoms to be subsumed in this cluster. With the exception of item 134, the symptoms subsumed in this cluster scored "0" in at least 97% of the cases. This observation is congruent with the above-mentioned statement by Pietzcker et al. The overlap of the apathy with the depressive cluster can still be observed, but since symptom 56 (thought withdrawal) is now much more closely associated with the other paranoid-hallucinatory symptoms, the overlap between the apathy and the paranoid-hallucinatory cluster disappeared. The problem of a syndrome or cluster consisting only of three items is highlighted by the fact that the associations of the

symptoms of the obsessive-compulsive cluster with other (previously not included) symptoms can lead to a major change in the cluster. Whereas symptom 31 (compulsive impulses) did not show a major change in position, symptom 30 (obsessive thoughts) and symptom 32 (compulsive actions) did show a substantial change in their positions. For symptom 30, this might be connected with its dissimilarity to the ego disorder symptoms 53 (derealization), 55 (thought broadcasting), and 57 (thought insertion), which were previously not considered in the reduced sample of 70 symptoms by Baumann and Stieglitz [3] and are now associated with the paranoid-hallucinatory cluster (PH). The difference of symptom 30 from all of these symptoms is bigger than the mean differences (2.38) plus one standard deviation (0.47) of all obsessive symptoms compared to all other symptoms. For symptom 32, the same observation holds true, for instance, for the previously not considered symptoms 138 (ataxia) and 140 (paraesthesia), which are now subsumed in the neurological cluster (NE). In anticipation of the clusters observed in the map of the 2002/2003 group, the obsessive-compulsive cluster again proved to exhibit the smallest stability. An overlap in the 1980 map that could not be observed previously is found between the manic and the hostility cluster. Clearly, the exclusion of the symptoms and the procedure of a factor analysis did not detect the overlap of the semantically similar symptoms that often co-occur such as irritability (68) and motor restlessness (83). This newly emerged overlap can be attributed to a substantial extent to the positions of symptoms 68 and 94 (aggressiveness). These symptoms, in turn, exhibit some of their biggest similarities [mean difference (2.16) minus one standard deviation (0.33)], for instance, to the centrally located symptoms 10 (disturbances of concentration) and 26 (neologisms), which were not included in the limited selection of 70 items. Hence, these newly incorporated symptoms may contribute to the overlap between the manic and the hostility cluster.

Sample of 2002/2003 (full item pool of 140 symptoms)

Figure 3 presents the map calculated based on the analysis of all 140 AMDP symptoms of the 2002/2003 group. At first glance, there is a striking similarity in the positions and the overlaps of the clusters compared to the map of the 1980 group including all 140 symptoms. The AverageLoss of 0.33 corroborates this impression. Indeed, this value is slightly above an AverageLoss of 0.29, which defines the limit below which 95/100 AverageLosses of a split half bootstrap simulation are found to range (calculated based on 100 random split half Procrustes transformations of the sample of 2002/2003). Consequently, with an estimated error rate of just below 5%, these differences cannot be attributed to chance but should rather be explained as an effect of the two different samples. Nonetheless, the value is clearly much further away from an AverageLoss of 0.98, above which 99% of the values lay in an earlier Monte Carlo study with 10,000 Procrustes transformations of randomly distributed configurations [unpublished data]. Additionally, only 7/140 (5%) ObjectLoss values are >1, which is the expected ObjectLoss value of two randomly chosen objects, and 88/140 (63%) of the ObjectLoss values are <0.29, which is the AverageLoss value of the above-mentioned split half simulation. These two observations also underline the similarity of the two maps and therefore speak in favour of the stability of the symptom structures. With the exception of the obsessive-compulsive cluster, practically all major intersections and delineations were comparable to the sample of 1980 (including all symptoms) and remained stable in these two samples that are separated by more than 20 years. The paranoid-hallucinatory cluster, which was the strongest factor in all factor analyses conducted by Gebhardt et al. [19], was even more clearly separated in the 2002/2003 group than in the 1980 group. This shows that the structural aspects already observed in the 1980 sample in Fig. 2 still emerge 20 years later and can be meaningfully interpreted in accordance with earlier established research results. The intersection of the apathy cluster with the depressive cluster, as well, is even more pronounced. Were it not for the association of item 17 (circumstantial thinking) with the hostility cluster, the two clusters would be practically congruent. In the study by Gebhardt et al., the inter-correlation between these two clusters ($r = 0.34$) was the second strongest, coming just after the inter-correlation of the mania and the hostility cluster ($r = 0.37$), which also proved to be a stable intersection in the 1980 group and the 2002/2003 group. One important factor of the overlap between the autonomous, the psycho-organic, and the neurological cluster (which could not be observed in the 1980 group) can be seen in the closeness of the symptoms 11 (disturbances of memorization), 12 (disturbances of retention), 122 (increased perspiration), and 134 (tremor). Together with the surrounding symptoms 5 (disturbances of time), 6 (disturbances of place), and 8 (disturbances of the self), which are also located in proximity, these are all symptoms of a delirium tremens, which can be seen in a substantial degree of patients with alcohol dependence who discontinue their alcohol intake abruptly [32]. As we have seen, there are substantially more F1 (mental and behavioural disorders due to psychoactive substance use) cases in the 2002/2003 group than in the 1980 group, and alcohol dependence represents over 75% of the F1 cases in this sample. Therefore, the clearer emergence of this syndrome might be associated with the increase in cases exhibiting these symptoms across the past two decades. Another very clear finding is the manic-depressive continuum [22] with its two poles, which can also be seen as a

dimension. Characteristic manic symptoms such as exaggerated self-esteem (72) or euphoria (66) are located at the lower left corner of the manic syndrome/cluster, and characteristic depressive symptoms such as feelings of inadequacy (71) or depressed mood (63) are located at the upper right corner of the opposite positioned depressive syndrome/cluster. The closer the symptoms within one cluster are located in relation to the opposing cluster, the more likely it is that these symptoms can be observed in manic as well as depressive syndromes. This can be observed, for instance, in the case of psychomotor symptoms (e.g. 83: motor restlessness, 69: inner restlessness), disturbances of thought (17: circumstantial thinking, 10: disturbances of concentration), or sleep disorder symptoms (101: difficulty falling asleep, 102: interrupted sleep). Again, the emergence of the manic-depressive continuum or dimension was already visible from a purely structural point of view, as described for the 1980 group in Fig. 2. Another interesting case is item 10 (disturbances of concentration), which was the most frequently observed symptom in the sample (65% of all cases exhibited this symptom) and can be observed in paranoid-hallucinatory, depressive, manic, and neurological syndromes. The optimal position in the map is therefore in the middle of all clusters.

Conclusions

In conclusion, the comments above indicate that it is possible to replicate the major aspects of the syndrome structure extracted using factor analysis by calculating symptom spaces with NMDS. Distinct separations of syndromes revealed by factor analysis clearly emerge in the maps. The structure that was extracted in this study was replicated in two independent clinical samples, separated by more than 20 years, which speaks in favour of a high stability of the AMDP symptom structure, as was also found in other studies [3, 36]. In terms of the intersections, a great advantage of the method employed in this study becomes apparent. In a factor analysis or a cluster analysis, an item (or symptom in this case) can only be assigned to either one or the other factor or cluster and the clusters/factors are categorically delineated from each other (in factor analysis this is at least true for the most frequently used orthogonal rotation of the factors). Hence, the relations of the factors/clusters to each other cannot be adequately interpreted, and potentially important structural information is lost. The Euclidian symptom spaces calculated by NMDS, on the other hand, allow all interrelations between the symptoms to be directly illustrated and interpreted. Consequently, it is possible to identify factors that could not have been found before. Additionally, it is possible to identify those symptoms that are located in the intersections and might be seen as links between factors. This opens up the possibility to consider categorical and dimensional aspects at the same time, while not sacrificing one perspective in favour of the other on the level of interpretations. On the level of data selection, no symptoms had to be excluded due to low prevalence or low intercorrelations (as is the case in a factor analysis), which led to the emergence of previously undiscovered structural aspects. On the level of data analysis, no prior assumptions about factors or groups had to be assumed or extracted for further analysis of dimensional or categorical aspects based on sum scores. It was possible to directly analyse the AMDP scores.

This paper describes a consistent continuation of a method that proved to be successful in combining categorical and dimensional aspects in an earlier study of our research group that was carried out on a level of diagnostic categories and based on expert knowledge [16, 17]. In the current study, the method was applied on the level of clinical symptoms. Therefore, it offers an approach for employing multivariate methods in order to complement traditional nosological concepts [34] and is able to illustrate the equivalence of the categorical and dimensional perspective [12, 26], which in another study was even metaphorically compared to the duality of light [35]. Furthermore, on a more applied level of clinical practice, the combination of such maps with the strength of symptoms of diagnostic subgroups or individuals at admission and discharge offers a quick overview for clinicians regarding the distribution of symptom characteristics before and after treatment. Finally, the results of this study can be combined with patient spaces and clinical diagnoses [15, 30]. In such a space, patients can be positioned in relation to each other based on the similarity of their symptom profiles. By applying the diagnostic labels to these patients (given by the diagnosis at discharge), it is possible to demarcate the diagnostic entities from each other and to define the transitions between them. The technical implementation of this scientific groundwork would result in an automated symptom-based diagnostic tool offering an automated overview of the diagnostic embedding of a patient.

Acknowledgments This study was supported by a grant from the Swiss National Science Foundation (fellowship, project no. 117011).

Conflict of interest None.

Appendix

See Table 2.

Table 2 AMDP symptoms

AMDP item no.	AMDP symptom name	AMDP item no.	AMDP symptom name
	Disorders of consciousness	71	Feelings of inadequacy
1	Lowered vigilance	72	Exaggerated self-esteem
2	Clouded consciousness	73	Feelings of guilt
3	Narrowed consciousness	74	Feelings of impoverishment
4	Expanded consciousness	75	Ambivalence
	Disturbances of orientation	76	Parathymia
5	Time	77	Affective lability
6	Place	78	Affective incontinence
7	Situation	79	Affective rigidity
8	Self		*Disorders of drive and psychomotility*
	Disturbances of attention and memory	80	Lack of drive
9	Apperception	81	Inhibition of drive
10	Concentration	82	Increased drive
11	Memorization	83	Motor restlessness
12	Retention	84	Parakinesia
13	Confabulation	85	Mannerisms
14	Parmnesias	86	Histrionics
	Formal disorders of thought	87	Mutism
15	Inhibited thinking	88	Logorrhoea
16	Retarded thinking		*Circadian disturbances*
17	Circumstantial thinking	89	Worse in the morning
18	Restricted thinking	90	Worse in the evening
19	Perseveration	91	Better in the evening
20	Rumination		Other disturbances
21	Pressured thinking	92	Social withdrawal
22	Flight of ideas	93	Excessive social contact
23	Tangential thinking	94	Aggressiveness
24	Blocking	95	Suicidal tendencies
25	Incoherence	96	Self-mutilation
26	Neologisms	97	Lack of feeling of illness
	Phobias and compulsions	98	Lack of insight
27	Suspiciousness	99	Uncooperativeness
28	Hypochondriasis	100	Lack of self-care
29	Phobias		*Disturbances of sleep and vigilance*
30	Obsessive thoughts	101	Difficulty falling asleep
31	Compulsive impulses	102	Interrupted sleep (middle insomnia)
32	Compulsive actions	103	Shortened sleep
	Delusions	104	Early wakening
33	Delusional mood	105	Drowsiness
34	Delusional perception		*Appetite disturbances*
35	Sudden delusional ideas	106	Decreased appetite
36	Delusional ideas	107	Excessive appetite
37	Systematized delusions	108	Excessive thirst
38	Delusional dynamics	109	Decreased libido
39	Delusions of reference		*Gastrointestinal disturbances*
40	Delusions of persecution	110	Hypersalivation
41	Delusions of jealousy	111	Dry mouth
42	Delusions of guilt	112	Nausea

Table 2 continued

AMDP item no.	AMDP symptom name	AMDP item no.	AMDP symptom name
43	Delusions of impoverishment	113	Vomiting
44	Hypochondriac delusions	114	Gastric discomfort
45	Delusions of grandeur	115	Constipation
46	Other delusions	116	Diarrhoea
	Disorders of perception		*Cardiac-respiratory disturbances*
47	Illusions	117	Breathing difficulties
48	Verbal (phonemic) hallucinations	118	Dizziness
49	Other auditory hallucinations	119	Palpitations
50	Visual hallucinations	120	Cardiac pain
51	Bodily hallucinations (coenesthetic)		*Other autonomic disturbances*
52	Olfactory or gustatory hallucinations	121	Blurred vision
	Disorders of ego	122	Increased perspiration
53	Derealization	123	Seborrhoea
54	Depersonalization	124	Micturition difficulties
55	Thought broadcasting	125	Menstrual difficulties
56	Thought withdrawal		*Other somatic disturbances*
57	Thought insertion	126	Headache
58	Other feelings of alien influence	127	Backache
	Disturbances of affect	128	Heaviness in the legs
59	Perplexity	129	Hot flashes
60	Feeling of loss of feeling	130	Chills
61	Blunted affect	131	Conversion symptoms
62	Felt loss of vitality	132	Hypertonia
63	Depressed mood	133	Hypotonia
64	Hopelessness	134	Tremor
65	Anxiety	135	Acute dyskinesia
66	Euphoria	136	Hypokinesia
67	Dysphoria	137	Akathisia
68	Irritability	138	Ataxia
69	Inner restlessness	139	Nystagmus
70	Complaintiveness	140	Paraesthesia

References

1. Angst J, Scharfetter C, Stassen HH (1983) Classification of schizo-affective patients by multidimensional scaling and cluster analysis. Psychiatria Clin 16:254–264
2. Arbeitsgemeinschaft für Methodik und Dokumentation in der Psychiatrie (1981) Das AMDP-system. Manual zur Dokumentation psychiatrischer Befunde. Springer, Berlin
3. Baumann U, Stieglitz RD (1983) Testmanual zum AMDP-system. Empirische Studien zur Psychopathologie. Springer, Berlin
4. Baumann U, Stieglitz RD (1997) Das AMDP-system: ein psychologischer test? In: Haug H-J, Stieglitz RD (eds) Das AMDP-system in der klinischen Anwendung und Forschung. Hogrefe, Göttingen, pp 30–45
5. Berner P (1983) Diagnostic classification based on the AMDP-system. In: Bobon D, Baumann U, Angst J, Helmchen H, Hippius H (eds) The AMDP-system in pharmacopsychiatry. Karger, Basel, pp 68–73
6. Borg I, Groenen P (2005) Modern multidimensional scaling—theory and applications, 2nd edn. Springer, New York
7. Bottlender R, Strauss A, Möller HJ (2000) Prevalence and background factors of depression in first admitted schizophrenic patients. Acta Psychiatr Scand 101:153–160
8. Cattell RB (1966) The scree test for the number of factors. Multivar Behav Res 1:245–276
9. Cuesta MJ, Peralta V (2001) Integrating psychopathological dimensions in functional psychoses: a hierarchical approach. Schizophr Res 52(3):215–229
10. Cuesta MJ, Peralta V, Gil P, Artamendi M (2003) Psychopathological dimensions in first-episode psychoses. From the trunk to the branches and leaves. Eur Arch Psychiatry Clin Neurosci 253:73–79
11. Cuesta MJ, Peralta V, Zarzuela A (2000) Reappraising insight in psychosis. Multi-scale longitudinal study. Br J Psychiatry 177:233–240
12. De Boeck P, Wilson M, Acton GS (2005) A conceptual and psychometric framework for distinguishing categories and dimensions. Psychol Rev 112(1):129–158
13. Dilling H, Mombour W, Schmidt MH (2000) Internationale Klassifikation psychischer Störungen ICD-10 Kapitel

V(F) Klinisch-diagnostische Leitlinien. World Health Organization, Geneva
14. Egli S, Läge D (2007) Selektion eines Proximitätsmaßes für einen klinischen AMDP-Datensatz. Forschungsberichte aus der Angewandten Kognitionspsychologie: Universität Zürich, Psychologisches Institut. Report no.: 48
15. Egli S, Riedel M, Möller HJ, Strauss A, Läge D (2009) Creating a map of psychiatric patients based on psychopathological symptom profiles. Eur Arch Psychiatry Clin Neurosci 259:164–171
16. Egli S, Schlatter K, Streule R, Läge D (2006) A structure-based expert model of the ICD-10 mental disorders. Psychopathology 39:1–9
17. Egli S, Streule R, Läge D (2008) The structure-based expert model of the mental disorders—a validation study. Psychopathology 41:286–293
18. Freyberger HJ, Schulte-Markwort E, Dilling H (1993) Referenztabellen der WHO zum Kapitel V(F) der 10. Revision der Internationalen Klassifikation der Krankheiten (ICD-10): ICD-10 vs. ICD-9. Fortschr Neurol Psychiatr 61:128–143
19. Gebhardt R, Pietzcker A, Strauss A, Stoeckel M, Langer C, Freudenthal K (1983) Skalenbildung im AMDP-system. Arch Psychiatr Nervenkr 233:223–245
20. Gower JC, Legendre P (1986) Metric and Euclidean properties of dissimilarity coefficients. J Classif 3:5–48
21. Guy GW, Ban TA (1982) The AMDP system. Manual for the assessment and documentation of psychopathology. Springer, Berlin
22. Haug HJ, Ahrens B (2002) Affektive Störungen. In Freyberger HJ, Schneider W, Stieglitz R-D (Hrsg) Kompendium Psychiatrie, Psychotherapie, psychosomatische Medizin. Karger, Basel, pp 100–118
23. Hurley JR, Cattell RB (1962) The Procrustes program: producing direct rotation to test a hypothesized factor structure. Behav Sci 7:258–262
24. Jäger M, Bottlender R, Strauss A, Möller HJ (2004) Fifteen-year follow-up of ICD-10 schizoaffective disorders compared with schizophrenia and affective disorders. Acta Psychiatr Scand 109(1):30–37
25. Jaspers K (1913, 1997) General psychopathology. Johns Hopkins University Press, Baltimore
26. Kraemer HC, Noda A, O'Hara R (2004) Categorical versus dimensional approaches to diagnosis: methodological challenges. J Psychiatr Res 38:17–25
27. Kruger G, Haubitz I (1980) Classification of organic brain syndromes by cluster analysis. Arch Psychiatr Nervenkr 228:299–315
28. Kruskal JB, Wish M (1978) Multidimensional scaling. Sage, Beverly Hills
29. Läge D, Daub S, Bosia L, Jäger C, Ryf S (2005) Die Behandlung ausreißerbehafteter Datensätze in der Nonmetrischen Multidimensionalen Skalierung—Relevanz, Problemanalyse und Lösungsvorschlag. Forschungsberichte aus der Angewandten Kognitionspsychologie: Universität Zürich, Psychologisches Institut. Report no.: 21
30. Läge D, Egli S, Riedel M, Möller HJ (2011) Combining the categorical and the dimensional perspective in a diagnostic map of psychotic disorders. Eur Arch Psychiatry Clin Neurosci 261:3–10
31. Lauterbach E, Rumpf HJ, Ahrens B, Haug HJ, Schaub R, Schonell H, Stieglitz RD, Hohagen F (2005) Assessing dimensional and categorical aspects of depression: validation of the AMDP Depression Scale. Eur Arch Psychiatry Clin Neurosci 255:15–19
32. Lee JH, Jang MK, Lee JY, Kim SM, Kim KH, Park JY, Lee JH, Kim HY, Yoo JY (2005) Clinical predictors for delirium tremens in alcohol dependence. J Gastroenterol Hepatol 20:1833–1837
33. Möller H-J (2005) Allgemeine Psychopathologie. In Möller H-J, Laux G, Deister A (Hrsg) Psychiatrie und Psychotherapie. Thieme, Stuttgart, pp 40–71
34. Möller H-J (2005) Problems associated with the classification and diagnosis of psychiatric disorders. World J Biol Psychiatry 6:45–56
35. Pickles A, Angold A (2003) Natural categories or fundamental dimensions: on carving nature at the joints and the rearticulation of psychopathology. Dev Psychopathol 15:529–551
36. Pietzcker A, Gebhardt R, Strauss A, Stöckel M, Langer C, Freudenthal K (1983) The syndrome scales in the AMDP-system. In: Bobon D, Baumann U, Angst J, Helmchen H, Hippius H (eds) The AMDP-system in pharmacopsychiatry. Karger, Basel, pp 88–99
37. Salvatore P, Khalsa HMK, Hennen J, Tohen M, Yurgelun-Todd D, Casolari F, DePanfilis C, Maggini C, Baldessarini RJ (2007) Psychopathology factors in first-episode affective and non-affective psychotic disorders. J Psychiatr Res 41:724–736
38. Sato T, Bottlender R, Kleindienst N, Möller HJ (2002) Syndromes and phenomenological subtypes underlying acute mania: a factor analytic study of 576 manic patients. Am J Psychiatry 159(6):968–974
39. Sato T, Bottlender R, Kleindienst N, Möller HJ (2005) Irritable psychomotor elation in depressed inpatients: a factor validation of mixed depression. J Affect Disord 84:187–196
40. Schneider K (1959) Clinical psychopathology. Grune and Stratton, New York
41. Stieglitz RD, Freyberger HJ, Mombour W (2002) Klassifikation und diagnostischer Prozess. In: Freyberger HJ, Schneider W, Stieglitz R-D (Hrsg) Kompendium Psychiatrie, Psychotherapie, psychosomatische Medizin. Karger, Basel, pp 17–31
42. Sulz KD, Gigerenzer G (1982) Psychiatrische diagnose und nosologische Theorie: Untersuchungen zum individuellen Diagnoseschema des Arztes. Arch Psychiatr Nervenkr 232:39–51
43. Thien-Seitz U (2006) Bevölkerungsbäume für München im historischen Vergleich. Münchner Statistik 3:19–21