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A person-oriented approach in research on developmental psychopathology

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Abstract
There is a growing acceptance of a holistic, interactionistic view in which the individual is seen as an organized whole, functioning and developing as a totality. This view emphasizes the importance of patterns of operating factors. Within this framework, a standard variable-oriented approach, focusing on the variable as the main theoretical and analytical unit, has limitations. A person-oriented approach would often be preferable, where the main theoretical and analytical unit is the specific pattern of operating factors. Such an approach is presented here, focusing on individual development and psychopathology. A brief theoretical and methodological overview is given and a classification approach is emphasized. Empirical examples concerning the longitudinal study of adjustment problems illustrate a number of issues believed to be important to development and psychopathology: problem gravitation, the significance of single variables and of patterns, the developmental study of syndromes (=typical patterns), and the detection of "white spots" in development.

Introduction

There is a growing acceptance of a holistic, interactionistic view in which the individual is seen as an organized whole, functioning and developing as a totality. The totality is formed by interactions among the elements involved; each aspect of the various structures and processes (behavior, plans, values, goals, biological factors, environment, etc.) takes on meaning from the role it plays in the total functioning of the individual. The research paradigm that most naturally relates to this holistic view of individual development perceives development in terms of complex dynamic systems, as is done in an interactionistic paradigm. For overviews in this area the reader is referred to Cairns, Elder, and Costello (1996); Cicchetti and Schneider–Rosen (1986); Ford and Lerner (1992); Magnusson and Allen (1983); Magnusson (1993); and Magnusson and Stattin (in press).

The holistic–dynamic system view is relevant in all studies of individual development, regardless of the level at which the system is operating. It applies to the cellular level, the cognitive system, the behavior system, and so on. It also expands the boundaries of the individual and includes the environment as well as interacting individuals. In studies of individual development, a holistic view should constitute the theoretical frame of reference for the formulation of the specific problem, the choice of research strategy and methodology, and the interpretation of results. Of course, this does not mean that all aspects of an individual's functioning can or should be investigated in one and the same study. To draw a parallel to the natural sciences: The fact that specific studies in, for example, nuclear physics and astrophysics are planned and interpreted with reference to the same general model of nature does not imply that each study includes the whole universe. A

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common general theoretical framework does, however, facilitate communication between different researchers and the accumulation of knowledge. In the same vein, a common general holistic, interactionistic view—considering the functioning and development of (sub)-systems of individuals as complex processes and using a common terminology—is necessary for effective communication among researchers from different subdisciplines in psychology and neighboring sciences and for the accumulation of knowledge (Magnusson, 1996).

A holistic interactionistic view of individual development has gained momentum from the following three sources:

1. *Recent developments in the life sciences concerned with explaining biological processes and their interactions with behavioral, mental, and social factors* (e.g., Damasio & Damasio, 1996; Rose, 1995). New findings in these areas have helped both to fill the "black box" in stimulus–response models with substantive content and to close the gap between behavioral explanations based on mental, biological, and environmental factors, respectively. To give some examples: Kagan (1992) points out that the strong renewed interest in research on temperament is fueled by new findings in neuroscience. Cairns and Cairns (1994) studied the socialization process from a holistic perspective. Lockman and Thelen (1993) studied motor development using a broad perspective that included both biological and psychological factors.

2. *The recent infusion into psychology of methods and models for nonlinear dynamic systems taken from the natural sciences*, including chaos theory (Devaney, 1989; Gleick, 1987; Prigogine & Stengers, 1985), catastrophe theory (Stewart & Peregoy, 1983; Zeeman, 1976), and general systems theory (Bertalanffy, 1968; Miller, 1978). For overviews of applications within psychology, see Barton (1994), Cicchetti and Tucker (1994), and Smith and Thelen (1993). These approaches have made important contributions to theory construction and empirical research concerning the study of complex systems in meteorology, biology, chemistry, neurology, ecology, etc. (e.g., Hall, 1991). An example of an interesting study in psychology following such an approach is Freeman's (1991) work concerning the physiology of perception in rats, demonstrating that they remember smell as a temporal–spatial *pattern* of the propagation of the stimulus wave for each smell.

3. *The revival of longitudinal research*. Some of the most comprehensive longitudinal programs have been planned and implemented with reference to a holistic view (Cairns & Cairns, 1994; Magnusson, 1988). Only with a longitudinal approach is it possible to obtain information that is more generally applicable to the study of causal mechanisms in the process of individual development (Bergman & Magnusson, 1990; Cairns, Elder & Costello, 1996; Ford & Lerner, 1992). Access to comprehensive longitudinal information makes it feasible to implement a holistic interactionistic paradigm in actual research.

A variable-oriented approach

For a long time in research on individual development, the main conceptual and analytical unit has been the variable (Thomae, 1988; Wohlwill, 1973): most research has been *variable oriented.* Besides the practice of performing the statistical analyses with variables as the main units, there has been a tendency to formulate theories in terms of variables and hypothetical constructs. The results are then interpreted in terms of a mapping of the observed relations, etc., among the variables to the relations among hypothetical constructs as indicated by the theory. However, from an interactionistic perspective and if the purpose is to analyze the structures and processes involved in individual system functioning, this variable-oriented approach to individual development has limitations, as pointed out by, for instance, Cairns (1983) and Magnusson (1985, 1995). To summarize the criticism of the variable-oriented approach in a single sentence: The modeling/description of variables over individuals can be very difficult to translate into properties characterizing single individuals because the information provided by the statistical method is variable oriented, not individual oriented.

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A person-oriented approach

In a holistic–interactionistic framework it is natural in many situations to replace the variable orientation with a person-oriented approach in which the central object of interest is information about the person as a *Gestalt.* Operationally, this focus often involves studying individuals on the basis of their patterns of individual characteristics that are relevant for the problem under consideration. As pointed out above, such patterns can occur at different levels and a given study can, of course, only deal with one or a few levels. It is sometimes objected that even the person-oriented approach is variable oriented because, for instance, in many of its applications, variables are used to construct profiles of individuals' scores which are then used in the statistical analysis. However, variables included in such an analysis have no meaning in themselves. They are considered only as components of the pattern under analysis and interpreted in relation to all the other variables considered simultaneously; the relevant aspect is the *profile* of scores (see also Kagan, in this issue).

The purpose of this article is to present a person-oriented approach and contrast it to a standard variable-oriented approach. We believe that a person-oriented approach may be well suited to the study of important problems in the field of developmental psychopathology.

Theoretical Underpinning of a Person-Oriented Approach

It is useful to conceptualize individual development as a process characterized by states that change in continuous time. A *state* is the specific information configuration characterizing the system under study at a specific time. The following five assumptions about the basic properties of this process can then be made (revised from Bergman & Magnusson, 1991; and Magnusson, in press):

1. The process is partly specific to individuals.
2. The process is complex and is conceptualized as involving many factors that interact at various levels which may be mutually related in a complicated manner.
3. There is a meaningful coherence and structure (a) in individual growth and (b) in differences between individuals' process characteristics. The lawfulness of the processes, within functionally organized structures, is reflected in the development and functioning of all subsystems as well as in the functioning of the organized totality. Assumptions (a) and (b) are similar to those made by Magnusson (1988) when characterizing an interactionistic approach to psychology.
4. Processes occur in a lawful way within structures that are organized and function as *patterns* of operating factors, where each factor derives its meaning from its relations to the others.
5. Although there is, theoretically, an infinite variety of differences with regard to process characteristics and observed states at a detailed level, at a more global level there will often be a small number of more frequently observed patterns ("common types"). The assumption applies both intraindividually (viewed over time for the same person) and interindividually (for different individuals at the same time or over time).

A special feature of evolving biological systems is their capability for self-organization. This is a characteristic of open systems and refers to a process by which new structures and patterns emerge "spontaneously," even from chaos (Barton, 1994; Thelen, 1989). In ontogeny, self-organization is a guiding principle and the operating factors organize themselves to maximize the functioning of each subsystem in relation to the whole system. At a higher level, subsystems organize themselves to fulfill their function in the totality. Being organized in such a way has survival value and leads to perpetuation. Jacob (1989) says "Finality in the living world thus originates from the idea of organism, because the parts have to produce each other, because they have to associate to form the whole, because, as Kant said 'living beings must be "self-organized" ' " (op. cit., p. 62).

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This principle of system evolution has also been demonstrated in many human biological systems like the brain, the coronary system and so on and can be applied to, for instance, the development of the sensory and cognitive systems (Carlson, Earls, & Todd, 1988; Cicchetti & Tucker, 1994). This line of reasoning gives some support to assumptions 4 and 5 above.

The assumption of emerging types is also suggested by more direct analogies to system theoretic thinking—normally only a small number of system constructions and states are in some sense optimal and lead to a stable behavior of the system. For instance, biological systems often present distinct types (e.g., of species, ecotypes, see Colinvaux, 1980). In psychology a similar point has been made by Block (1971, p. 110), talking about "'system designs' with more enduring properties," and by Gangestad and Snyder (1985), arguing for the existence of distinct types, each sharing a common source of influence. To summarize: Viewing individuals in terms of complex dynamic systems, we would expect certain states to be more frequent than others, corresponding to such optimal patterns, and it seems natural to explain and investigate such systems using a pattern-oriented approach.

Theoretical formulations and some methodological solutions according to a person-oriented perspective have been pursued by Bergman and Magnusson (1983, 1991), Gustafsson and Magnusson (1991), Magnusson and Allen (1983), Magnusson (1988), Magnusson and Bergman (1988), and Magnusson and Stattin (in press). The plea to consider the information about a person as an indivisible whole and not just as variables to be analyzed separately is, of course, by no means new; see, for instance, Allport (1937), Block (1971), Cairns (1979), Lerner (1984), and Lewin (1935). In fact, the issue is related to the 19th century debate about the dangers of atomism (e.g., Dewey, 1896; James, 1890).

Although a variable-oriented approach, focusing on relations between variables, obviously can be relevant for studying evolving complex systems, its standard application in psychology neglects the special significance of the parts to the whole. Moreover, this approach usually builds on linear relationships studied across individuals. It should be obvious that such an approach is not compatible with the assumptions made above, except in special cases, and perhaps at an initial stage to help find operating factors. This shortcoming is exemplified by the fact that in many variable-oriented analyses (e.g., structural equation modeling) the correlation matrix or the variance–covariance matrix often becomes the raw data to be analyzed and "explained." As a result, all patterns in data which are not reflected in this matrix are disregarded, a simplification and disregard of higher order interactions that can be misleading; see Bergman (1988, in press) for illustrations.

Fundamental to understanding individual development is the detailed study of the single individual's development (intraindividual change), followed by a careful generalization based on an integration of studies of many such single cases. One approach to studying intraindividual variability is the *p* technique; the case for using this technique in a developmental context is presented by Nesselroade and Featherman (1991). Techniques that focus on intraindividual development can be very useful but in practice the intensive information of a time-series type necessary for a developmental analysis can be difficult to obtain with such an approach. Because our focus is nomothetic (searching for general laws) we will concentrate instead on methods that more directly focus interindividual similarities and differences.

Person-Oriented Methods for Studying Individual Development

Measurement issues

Linear transformations. In our opinion, issues of measurement have been given insufficient attention when studying individual development in a multivariate sense. For instance, with many variable-based methods, the results are not contingent on the use of a particular type of scaling of a variable—as long as the scales are linearly related. In other words: The results are invariant to linear transformations of the variables. Examples are the frequent

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use of correlation techniques and many applications of structural equation modeling. This implies, for instance, that the results are not affected by whether the variables have different means or variances or whether a particular variable has different means or variances at different points in time.

While this invariance to linear transformations may sometimes be desirable, the limitations on the generalizability of the results should be spelled out. To give an example central to the issues in this article: If adjustment problems indicating possible psychopathology are studied using such an "invariance approach," one has to assume that it is of no importance for the study that some adjustment problems are more, or less, common in the sample than others and/or that the same adjustment problem is more, or less, common at different ages. For instance, assume that children's problems with not liking school are pertinent in a context in which we are also interested in other adjustment problems. For a Swedish sample we showed that at age 10 it was rare for children to express a strong dislike of school (which would indicate an adjustment problem in this respect) but that other adjustment problems, for instance, hyperactivity, were much less rare (Bergman & Magnusson, 1984). If all scores had been converted to z scores, then small and insignificant differences in answers to different questions about how they liked school (e.g. the difference between "positive" and "fairly positive") would have been blown up by the z transformation because the standard deviation of that variable was very low. Differences that probably have no psychological significance and could easily have been created by response sets or errors of measurement would have been given the same weight as large, meaningful differences in certain other variables.

Multivariate scaling. In certain situations the assumption of linear invariance may be inappropriate. Instead, a multivariate scaling of all the variables may be preferred so that values compared between variables and times of measurement retain more meaning than is accomplished with standardized scores computed separately for each variable and measurement occasion. In such a case, many standard statistical methods of analysis are not applicable because they make no use of this extra meaning; the results are equivalent to those that would be obtained by using, for instance, z scores.

This issue of multivariate scaling in relation to the measurement and classification of profiles of adjustment problems is discussed by Bergman and Magnusson (1991). For their purpose they constructed what they called a *quasiabsolute scaling procedure* applied to all variables at all measurement occasions. Without aiming to provide absolute prevalences of the adjustment problems (hence "quasi"), the intention was to obtain profiles of adjustment problems that contained relevant information about how different variables and measurement occasions related to each other with regard to prevalences of specific problems as measured by a comparable tally for all variables. In their quasiabsolute scaling, raw information about each adjustment problem (often from more than one data source) was transformed into a 4-step scale with the following approximate meaning of each scale value: 0 = *no problem,* 1 = *tendency to problem,* 2 = *presence of problem,* and 3 = *pronounced problem.* Discrimination only at the negative end of the adjustment spectrum was aimed for. The procedure by which the quasiabsolute scaling was done involves both a subjective component, using independent raters, to assign an appropriate weight to each type of raw information, and a mechanical, objective set of rules based on these weights for computing the quasiabsolute scores based on the raw information. One might say that in this way a psychological–psychopathological scale is created from various kinds of raw data.

Measuring profile dissimilarity between individuals. In many cases when a person-oriented approach is applied one needs to compare the profiles of scores in the variables under study for each pair of individuals and compute some coefficient of profile (dis)similarity (e.g., as a basis for a classification analysis using cluster analysis). Different ways of measuring (dis)similarities between profiles

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are discussed by Cronbach and Gleser (1953) and Budescu (1980); two common coefficients are (a) the average squared Euclidean distance, taking both profile form and level into account, and (b) the correlation coefficient with the pair of persons as the two variables, taking only profile form into account. It is important to note that neither coefficient is invariant nor proportional to linear transformations of the variables. Simple scaling operations can change the monotone ordering according to size of the (dis)similarity coefficients and, hence, affect what clusters the analysis produces.

In the case when the scales of all the variables are arbitrary and have no absolute interpretation, it is normally best to transform them into, for instance, z scores at each age separately before computing the (dis)similarity coefficients. Without such a transformation, the results are liable to be totally misleading regardless of whether one uses the average squared Euclidean distance or the correlation coefficient between subject pairs. In certain cases, however, the scales do have a more absolute meaning, as discussed above, with, for instance, differences in standard deviations between different variables or ages containing important information. A z transformation may then not be called for, since in this way standard deviation differences are obliterated.

Handling missing data. By definition, a person-oriented analysis involves the simultaneous analysis of all variables in the pattern. Not infrequently, a substantial proportion of the sample may have incomplete data for one or several variables in the profile. This can be a tricky problem because the analysis usually requires complete data in all variables, so that subjects with missing data have to be deleted. If a large number of subjects have just one or a few missing values, this option is less attractive. Complete data are then bought at the price of losing many subjects and possibly creating a drop-out bias, a problem that cannot be ignored when analyzing data in the field of psychopathology (Bergman & Magnusson, 1990; Cox, Rutter, Yule, & Quinton, 1977). The best solution might be to "guess" missing values for subjects with almost complete data, a procedure called *imputation.* For this purpose a number of sophisticated methods are available, usually based on linear models (for an overview, see Pierzchala, 1990). However, in a pattern-oriented setting it seems natural to use a twin approach. A missing value for a subject is then replaced by the value in that variable of a twin subject with complete data (Bergman & El-Khouri, 1992). The twin subject is the one that is most similar to the subject with the missing value with regard to the variables in which the latter has valid values; the measure of similarity could, for instance, be the average squared Euclidean distance. It should be emphasized that what is created using imputation is, of course, a temporary file for a specific analysis. The *data* are what they were before the imputation.

Overview of methods

An overview of common pattern-based methods for studying individual development from an interindividual perspective is presented in Figure 1. The acronyms of the methods to be discussed in later sections are given at the appropriate place. A basic distinction is made between model-based and descriptive methods, although the borderline is not always that clear. An example of a model-based method with latent variables is latent transition analysis (LTA), which was developed within the framework of latent class analysis for analysis of categorical data (Collins & Wugalter, 1992). Parameters are estimated describing latent statuses and their evolution over time and the model's fit to data can be tested. An example of a model-based method without latent variables is loglinear modeling (Bishop, Feinberg, & Holland, 1975), where the logarithms of the cell frequencies are modeled according to the "effects" of belonging to specific categories in the different variables. Here, too, the model's fit to data can be tested. Examples of tailoring this method to the study of change are given by, for instance, Clogg, Eliason, and Grego (1990). Although model-based methods are highly useful in certain situations they will not be elaborated in this presentation.

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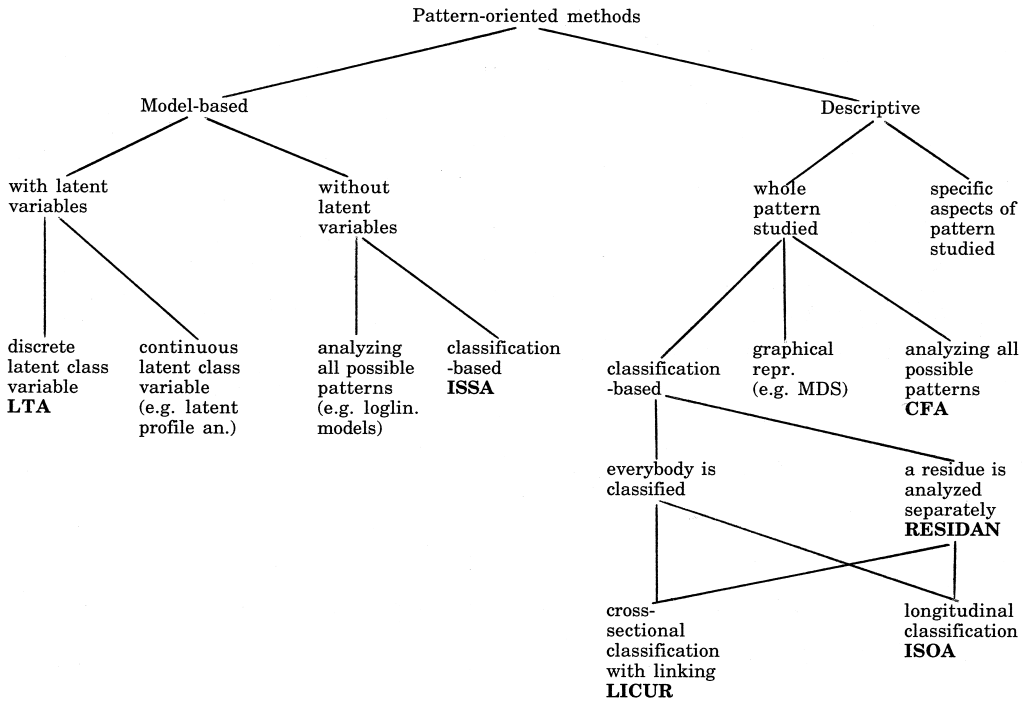


Figure 1. Overview of common pattern-based methods for studying individual development from an interindividual perspective. Acronyms in bold type refer to specific methods discussed in this article. Adapted from Bergman (in press).

Graphical representations of similarities between profiles can sometimes be quite useful in developmental research, for instance based on multidimensional scaling (Wood, 1990). However, such illustrative methods will not be discussed since normally they are most suitable for describing a fairly small number of subjects, whereas the interest here is on the study of interindividual differences in moderate to large samples of persons.

The focus here is on methods which are basic, flexible, and involve a minimum of assumptions about the properties of the data; classification-based methods will be emphasized for studying the development of individuals' patterns of scores in the variables under study. A crucial distinction is then in which of two ways the developmental process is classified:

1. A longitudinal pattern is formed for each individual, including his/her pattern of scores in the variables on all measurement occasions, and longitudinal types are identified directly in the classification. Ideally, this means that full account is taken of each individual's specific pattern of change.
2. At each age a classification is made and the results of the different classifications are linked, usually pairwise (the time i classification is linked to the time $i + 1$ classification). The individuals' class membership over time is then studied.

Methods pertaining to both these two approaches will be discussed. For a more extensive overview, see Bergman (in press). However, first a brief review of classification and cluster analysis is necessary.

Classification and cluster analysis

Classification in psychology and psychiatry. The typologies in early psychopathology and abnormal psychology are but one application within psychology/psychiatry of a basic human tendency to impose structure on perceived phenomena (for a historic overview, see Misiak & Sexton, 1966; for a review of

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cluster analysis in psychiatry, see Skinner & Blashfield, 1982). Classification in psychiatry has always had a stronger standing than in psychology, since diagnostic classification is pervasive in medicine. During this century, classification of individuals has become less prominent as a main research tool in psychology. One reason for this is the enormous expansion of powerful methods for variable-oriented analysis and hypothesis testing in both experimental and nonexperimental settings. However, as discussed in the introduction, the limited capacity of such methods for handling complex interactions and difficulties in translating results from variable-oriented research into statements about individuals, not variables, have lead to an interest in methods that focus on individual value patterns or structures rather than on variables. Classification can be used for this purpose.

Cluster analysis. Within the framework of cluster analysis, a wide variety of methods is available for classifying objects on the basis of their (dis)similarities. We will concentrate here on methods based on comparisons of individuals' profiles of scores but, of course, other ways of obtaining (dis)similarities are possible, for instance by using raters. Some major types of cluster analysis are hierarchical methods (agglomerative or divisive), partitioning methods, and methods that allow overlap between clusters. Each such major category of methods covers a variety of specific methods and algorithms. The most appropriate method of cluster analysis will, of course, also depend on the data set at hand and the specific problem under study. Methods allowing overlap between clusters are potentially attractive but may entail various interpretational problems and will not be further pursued here (Wiener–Ehrlich, 1981). Evaluations of the sensitivity of different clustering algorithms to error perturbation and of the ability to recover a known structure suggest that, as expected, no method is generally superior. However, Ward's (1963) hierarchical minimum variance method, average linkage (sometimes called group average, UPGMA), and *k*-means relocation based on a sound initial classification are reported to function well (Milligan, 1980, 1981a; Morey, Blashfield, & Skinner, 1983). Recently, promising methods based on so-called Beta-flexible clustering have been proposed (Belbin, Faith, & Milligan, 1992). Ward's method and *k*-means relocation are included in the cluster analysis procedure suggested below.

The residue concept. It has long been recognized that the results of cluster analysis may be disturbed by multivariate outliers and it has been suggested that in some situations it might be useful to have less than 100% coverage, that is, not to classify everybody (Edelbrock, 1979). For instance, results with Ward's method appear to be sensitive to the effects of outliers (Milligan, 1980). In addition to technical explanations for this, theoretical reasons have been suggested by Bergman (1988), who points out that, due to extreme environmental conditions and particular genotypes, there is often a small number of "unique" individuals who should not be forced into a cluster. He indicates a semiobjective procedure, RESIDAN, for the a priori identification and separate analysis of what he calls a residue of unclassified. In this procedure, subjects similar to at most *k* other subjects (*k* is usually 0) are identified and assigned to a residue that is not classified with the rest of the sample. Usually, the residue will contain 1–3% of the sample and the subjects belong there either because errors of measurement give them a rare profile of scores or because they are truly (almost) unique. In a subsequent residue analysis, information is obtained about rare or nonexistent patterns which may be of theoretical significance.

Clusters and latent classes. Of course, cluster analysis is not the only method for making a classification. As briefly mentioned earlier, model-based classification using latent class methods could be highly useful in certain situations. For instance, Meehl (1992) is critical of cluster analysis, which in his view is commonly used to sort subjects so as to obtain groups that are as homogeneous as possible without necessarily identifying "natural" clusters, which he calls "taxa." Latent class proce-

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dures should be used that take into account properties of taxa and are efficient in identifying them. He indicates a number of procedures based on what he calls a "system of coherent cut kinetics" (Meehl & Yonce, 1992).

Longitudinal classification analysis

Focusing on *longitudinal patterns* is in theory an attractive approach since such patterns are basic in the description of individual pattern change. The complete longitudinal patterns are sometimes subjected to cluster analysis directly; in other instances an ordination strategy is used first to reduce the number of dimensions by means of, for instance, principal components analysis and the factor scores are then cluster analyzed (e.g., Mumford & Owens, 1984).

One could argue that longitudinal classification is preferable to a snapshots and linking study (discussed in the next section) since the former approach is closer to the individuals' processes of change. In practice, however, the genuinely longitudinal approach can run into problems. For instance, when longitudinal cluster analysis is applied and data from all measurement occasions are included in the profile of scores, the result in many cases is very heterogeneous clusters that are hard to interpret. Especially in cases with many measurement occasions, because subjects were similar at the other measurement occasions, one may have to accept their being classified as belonging to the same developmental cluster, even though their outcome or startup is different.

If only profile form is in focus, a direct longitudinal classification might work better than otherwise since there is then less strain on the classification system (less information has to be summarized by the cluster membership variable). An example of the potential of a longitudinal classification strategy in this situation is offered by Block's (1971) study of longitudinal personality types. For a further discussion of this issue, the reader is referred to Bergman (in press).

In the context of studying individuals as dynamic systems in an interactionistic paradigm, Bergman (1995a) stressed the usefulness of the concept of the i state, which he defined as a specific subject's profile of scores at a specific point in time. From a dynamic system perspective, two types of longitudinal pattern analysis are being developed:

1. I-State Sequence Analysis (ISSA), in which an a priori taxonomy of theoretically expected common types of individuals' developmental i-state sequences is used to structure the data set and then, within each set, a search is made for typical developmental sequences (Bergman, 1995a).
2. I-States as Objects Analysis (ISOA), in which each i-state is considered as a "subindividual" and then subjected to classification analysis (Bergman, 1995b).

Under certain assumptions these methods can be more powerful and extract more information than conventional methods, especially when small samples and many measurement occasions are involved. However, ISSA and ISOA share the important limiting assumption that it is possible to measure the (dis)similarity between i states pertaining to different measurement occasions. Hence, studies covering time periods involving dramatic developmental changes and where the measured variables cannot be assumed to measure "the same thing" at different measurement occasions are not suited for this type of analysis.

Cross-sectional pattern analysis followed by linking over time

There are various methods for cross-sectional pattern analysis followed by linking over time and the choice should be made to suit the specific case. However, there is also a value in having a sort of standard method that is useful in a variety of situations and can serve for reference or comparison. In cases where profiles of scores based on interval scaled data are to be analyzed and cluster analysis is judged appropriate as the method for obtaining the classifications, Bergman (in press) has developed a procedure, LICUR, for cross-sectional classification after removal of a residue, followed by linking of results between mea-

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surement occasions. It is suitable in situations where both the form and the level of the profile are of relevance and when it is considered important to obtain clusters that are reasonably homogeneous. A brief outline of LICUR is given below:

1. First the RESIDAN approach is used at each measurement occasion to remove a residue which is analyzed separately.
2. Then a cluster analysis is undertaken at each measurement occasion, using Ward's hierarchical cluster analysis method, and an optimal number of clusters is decided upon. Four criteria are used for this decision.
3. When the hierarchical property of the cluster solution is important, each cross-sectional analysis stops here. But when there is a strong interest in obtaining as homogeneous clusters as possible, the Ward cluster solutions are used as start solutions in *k*-means relocation cluster analyses where objects are relocated to maximize the explained error sum of squares and, hence, minimize cluster heterogeneity.
4. Finally, the results of the cluster analyses are linked by cross-tabulating adjoining classifications and testing for significant types and antitypes of cluster membership combinations, preferably by using exact cellwise tests (Bergman & El-Khouri, 1987). Often the linking of results from adjoining ages is sufficient.

LICUR can be viewed as a robust and basic method that is applicable in a wide variety of settings, for instance when different variables are measured at the different measurement occasions and during periods of dramatic developmental shifts.

Identifying a set of typical classes

Sometimes the primary aim is not a classification of (almost) all subjects but rather the identification of homogeneous subgroups of subjects ("dense points" in a multivariate space) believed to indicate system states that are in some way optimal. The logic here is the notion that most but by no means all subjects have entered a stable "functioning" system state with a characteristic value pattern and that the number of such states is limited. Other states are transient and less commonly observed. Hence, frequent typical patterns should indicate such optimal states. This can be accomplished within a cluster analytic framework, for instance using LICUR, and then at the RESIDAN stage require that, to be retained in the analysis, each subject has several "twins." There are also different procedures for finding "dense points" (for instance the procedure DENSE in the SLEIPNER package, see below, or procedures within the CLUSTAN package, see below). Another approach to a similar goal involves using CFA, as described below.

Studying all possible patterns using configural frequency analysis

For each of the two main approaches presented above (direct longitudinal analysis or cross-sectional analysis followed by linking), *configural frequency analysis* (CFA), originally suggested by Gustav Lienert (see: Krauth & Lienert, 1982; Zubin, 1937) could be used. This is a set of methods for studying all possible value patterns. In order to have a manageable number of value patterns to be examined, the variables have to be discrete, often dichotomized or trichotomized. As with most good ideas, the basic principle is simple and not new (see e.g., Zubin, 1937). Lienert and coworkers have developed CFA in a number of ways; for a basic introduction the reader is referred to Krauth and Lienert (1982) and for a more recent overview to von Eye (1990a). The CFA rationale has also been applied in longitudinal analyses by, for instance, Lienert and zur Oeveste (1985) and von Eye (1990b), and for linking cross-sectional results by, for instance, Lienert and Bergman (1985). In the following, only the basic rationale is presented.

Consider three dichotomous variables each taking the values 1 or 0. Eight different configurations then exist: 000, 001, 010, 100,

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011, 101, 110, 111. For each configuration the observed frequency is compared to the corresponding expected frequency under some null hypothesis of no relationships in data. The simplest null hypothesis is one of complete independence. An expected frequency is then obtained by multiplying the sample size by all marginal proportions for the values in the specific pattern. An observed frequency is significantly more frequent than the expected one at level *a* if, under the null hypothesis, the probability of observing a frequency as large as or larger than the one observed is less than or equal to *a* (1-tailed test). This is called a *type.* An observed frequency which is significantly smaller than the expected one is called an *antitype.* The binomial distribution can be used to calculate these probabilities with the probability parameter equal to the expected frequency for the specific pattern divided by the sample size and the number of trials equal to the sample size. A simple approximation that roughly follows the standard normal distribution is to divide the difference between an observed and an expected value by the square root of the expected value.

The generalization is obvious to some other number of categories in the variables and to more than three variables. Within the CFA paradigm, methods have been developed for handling a large variety of situations, including repeated measurement designs (von Eye, 1990b; von Eye, Spiel, & Wood, in press). To give a few simple examples: By a special cross-tabulation procedure, all configurations at one age can be related to all configurations at another age. Sometimes it is useful instead to categorize change directly, for instance into positive and negative change, and then subject the categorized change variables to a CFA. However, one has to be careful with disturbances caused by errors of measurement since the reliability of change scores tends to be low (Bergman, 1972; Harris, 1963).

Clearly, CFA bears many resemblances to other techniques for analyzing higher order contingency tables like, for instance, log-linear modeling. Compared to that technique, CFA is simpler, more explorative, and can even be used in cases with cells containing zeros. Ignoring the special features of CFA with regard to design of configurations and measurement, it can be viewed as a special type of analysis of cell residuals within a more conventional method.

The idea of types in a psychiatric setting was elaborated by Krauth (1985), who points to the importance of identifying combinations of variable values that emerge above chance level. His line of reasoning relates to the discussion above about optimal systems states and designs as being more frequent than other states and designs. The concept of antitype also deserves attention. It can be of great interest to identify configurations that occur more rarely than expected by chance, for instance uncommon developmental paths. Such results can often be related to theoretical predictions that this is or is not the case.

Analyzing specific properties of patterns

Instead of considering the complete value patterns in a pattern analysis, it is possible to focus on specific properties of the patterns. Two such analyses will be briefly mentioned here:

1. For some problems the most important aspects to study are the maximum and minimum scores of the subject's profile of scores. The variables taking the maximum and the minimum value, respectively, may be considered as the profile's cardinal features, with the other scores providing the background. Of course, this assumes that the different variables are scaled in a commensurable way. The categorization of the profiles of scores into the different possible maximum–minimum combinations and the frequency of the different combinations may convey important information about the individuals' profile status. Stability and change in individuals' maximum–minimum variable combinations may tell us essential things about the most characteristic features of pattern development.

2. A basic aspect of an individual's profile of scores is whether it is even or uneven, that is, profile scatter. This can be studied in different ways; one obvious measure of profile scatter is the variance around the mean of the scores in all variables constituting the profile. The scaling of the variables is important here.

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It must be done in a commensurable way that allows interindividual comparisons with the same meaning for all variables. Profile scatter can then be informative and in a single measure summarize an important pattern property relating to the organization of the factors under study.

For a more extensive presentation, with an example from a study of the development of intelligence and attainment, the reader is referred to Bergman (in press).

Some computer programs for carrying out pattern analyses

Many of the analyses presented above can be accomplished with the major statistical packages, with some juggling. The most extensive package for cluster analysis is CLUSTAN (Wishart, 1987). All analyses, including imputation, except ISSA and ISOA, can be conveniently accomplished by SLEIPNER, a new package developed especially for pattern-oriented analyses (Bergman & El-Khouri, 1995). For ISSA and ISOA, a preliminary program, TIMEDOG, is available from the first author.

Some Empirical Illustrations of a Person-Oriented Approach

In the following, empirical illustrations of a person-oriented approach are given in some areas believed to be of relevance for developmental psychopathology. The idea is to identify an important concept within a person-oriented approach, indicate its relevance to the field of developmental psychopathology, carry out a person-oriented analysis and, finally, discuss the results in relation to a conventional variable-oriented approach. For comparative purposes, sometimes conventional variable-oriented analyses are also undertaken. A strong effort has been made to keep technical complications to a minimum and use simple analyses to bring out the main principles as clearly as possible.

Problem gravitation of adjustment problems

Principle. Consider the evolution of childrens' patterns of externalizing adjustment problems. The complex dynamic system that regulates this process must allow for a large number of forces affecting the expression of adjustment problems, for instance:

1. Negative reactions from teachers, parents, and/or peers to a high level of expression of an externalizing problem and especially to an increased level of expression.
2. Positive reactions, often in the form of an absence of negative reactions, to a low level of expression and especially to a positive change.
3. Possible alienation of a deviant child from a "normal" peer group and its norms, etc., and identification with an outsider group (Cairns & Cairns, 1994; Olofsson, 1972).
4. Increased tension as a consequence of 1 above and its interaction with the temperament and physiology of the child. For instance, Kagan (1994) has pointed to the possible protective effect of inhibition against certain types of externalizing problems. Inhibited children more easily feel anxious and "bad" when engaged in norm breaking behavior and this may have a deterrent effect on such behavior.
5. Interactions and two-way causality. For instance, increased aggression can lead to trouble with classmates and increasing problems with peer relations, which in turn may lead to frustration and alienation, further increasing aggression and maladjustment to school, causing, for instance, truancy.

Considering the tensions usually created by increased levels of adjustment problems it seems reasonable to assume that in many cases such problems subside or, if severe enough and hooked into other problems, push the child's dynamic system into a stable state of multiple maladjustment to which large sectors of the child's environment are "maladjusted" and congruent (e.g., entering a peer group of delinquent children). Hence, when children grow older it can be hypothesized that more often than not, those that are char-

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acterized by single externalizing problems either grow out of them or develop multiple problems. The stabilization over time of many dynamic systems, as well as the well-known decreased plasticity in development with age, also suggest that in initially well-adjusted children the emergence of problems *de novo* at higher ages should be less frequent than at lower ages. Taken together, the above leads to a hypothesis of *problem gravitation* with regard to the evolution of patterns of externalizing adjustment problems:

> With age there is a tendency for externalizing problem patterns characterized by just a single problem or a few mild problems to become less frequent in relation to the well-adjusted patterns and the more severe multiproblem patterns. Either the child outgrows mild problems or these become worse. New problems for initially well-adjusted children emerge at higher age less frequently than at lower ages.

Empirical example. To illustrate this principle, data were taken from the longitudinal program Individual development and adaptation (IDA; Magnusson, 1988). Six externalizing problems were studied for boys at ages 10 and 13, each problem being measured on a quasi-absolute scale from 0–3 with 0 = *no problem,* 1 = *tendency to problem,* 2 = *problem,* and 3 = *pronounced problem.* The logic behind this scaling was discussed in an earlier section. The following problems were included:

- Aggression,
- Motor Restlessness,
- Lack of Concentration,
- Low School Motivation,
- Poor Peer Relations,
- Low School Achievement.

A literature review suggested that each of these problems is relevant to the study of problem behavior and that together they give a reasonably broad picture of "extrinsic problems" as defined by Bergman and Magnusson (1983). For a more detailed description of the variables the reader is referred to Bergman and Magnusson (1991).

Table 1. *Percentage of boys with adjustment problem for each adjustment problem at ages 10 and 13*

Adjustment Problems	Age 10	Age 13
Aggression	14.4	16.1
Motor Restlessness	21.3	21.8
Lack of Concentration	19.9	20.3
Low School Motivation	11.3	15.2
Poor Peer Relations	12.8	8.6
Low School Achievement	14.0	13.2

Note: With a problem means problem codes 2 or 3. The means are based on the cross-sectional samples (n = 517 at age 10 and n = 540 at age 13 for most variables). Using the longitudinal sample, similar results are obtained.

Consider first the percentages of boys characterized by exhibiting each kind of problem at the two ages. These figures are given in Table 1 for boys having a clear or a pronounced problem (codes 2 or 3).

Table 1 shows that the age differences are small except for Low School Motivation, which became more common at age 13 than at age 10, and Poor Peer Relations, which became less common at the higher age. Let us now look for the phenomenon of problem gravitation. For these data, classifications of the children into clusters according to the patterning of the six adjustment problems at each age are reported by Bergman and Magnusson (1991). The following percentages of children were obtained as belonging to the no problems cluster, single problem clusters, and multiproblem clusters: 32, 44, 24 (age 10); and 46, 32, and 22 (age 13). These percentages indicate problem gravitation: In relation to "single problems," "multiple problems" and especially "no problems" have become more common at the higher age. However, there is a complication in that a cluster mean profile does not allow a completely clear interpretation with regard to the number of problems. For this purpose, a cross-tabulation was performed of the number of problems at the two ages; the results are given in Table 2.

Table 2 also supports the occurrence of problem gravitation. For instance, at age 13 it

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Table 2. *Growth of number of adjustment problems between ages 10 and 13*

	Adjustment Problems at Age 13					
	0	1	2–3	4–6	All	Percent of Total
Adjustment problems at age 10						
0	71	24	17	7	119	27.4
1	49	29	27	15	120	27.6
2–3	20	20	34	32	106	24.4
4–6	6	8	26	50	90	20.7
All	146	81	104	104	435	
Percent of total	33.6	18.6	23.9	23.9		100.0

Values are frequencies of boys with different combinations of number of problems.
Note: With adjustment problems means all value codes except zero.

is more common to be characterized by four to six adjustment problems than by one adjustment problem, while at age 10 the opposite is true. The four to six problems—one problem ratio at age 13 is 1.28, while the corresponding figure at age 10 is 0.75. In Table 2 problem code "1" is also counted as a problem. If only "2" and "3" are counted as problems, the same age difference is found in the multiproblem–single problem ratio (0.48 at age 13 and 0.24 at age 10). Looking at the individual stabilities over time, it is also seen that this stability is lowest for having one or a few problems.

Conclusion. It would appear that the concept of problem gravitation naturally emanates from a person-oriented perspective. It may be relevant also for areas other than the development of adjustment problems. As an empirical phenomenon, it may lie hidden in many data sets, not disclosed by ordinary variable-oriented analyses and perhaps obscured by standardization of variables or other scaling properties of the data. Once the concept is on the table it can, or course, be studied with specially designed methods that may be called variable oriented, as indicated by the analysis presented in Table 2 above. For a more detailed application of this notion of problem gravitation in the field of antisocial behavior the reader is referred to Stattin and Magnusson (in press).

The significance of single variables and the significance of patterns

Pairwise relationships. Consider the relation between boys' externalizing adjustment problems in late childhood and severe adult adjustment problems. Let us assume that we are willing to accept the six externalizing problems measured at age 13 and presented above as giving a sufficient coverage of childhood problems. Let us for the present purpose also accept that information from official records concerning the repeated presence, presence once, or absence in registers of criminality and alcohol abuse and presence/absence in registers for psychiatric care give a useful, albeit restricted, account of severe adult problems. Such information about adult problems between the ages 18–24 is available in the IDA program and is described in more detail in Magnusson (1988). From a variable-oriented perspective the first analysis of such a data set might involve computing the longitudinal correlations between the childhood problems and the adult problems; these results are presented in Table 3. Since the variables were mainly categorical, contingency coefficients were computed as measures of correlation.

It is seen from Table 3 that significant but not high correlations exist between all childhood problems and Criminality and Alcohol Abuse. They are somewhat higher for Motor Restlessness and Lack of Concentration than

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Table 3. *Pairwise relationships (contingency coefficients) between extrinsic problems at age 13 and adult adjustment problems*

Adjustment Problem at Age 13	Adult Adjustment Problem		
	Criminality	Psychiatric Care	Alcohol Abuse
Aggression	.25***	.09	.22***
Motor Restlessness	.28***	.08	.27***
Lack of Concentration	.28***	.12	.25***
Low School Motivation	.24***	.11*	.27***
Poor Peer Relations	.14*	.09	.14*
Low School Achievement	.22***	.08	.20***

Note: χ^2 test is significant at the *5%, **1%, and ***0.1% levels. To avoid too small expected frequencies, the value codes 2 and 3 were merged for the six extrinsic problems measured at age 13.

for the other variables and a very similar pattern of relationships is seen for both Criminality and Alcohol Abuse. What does this say about the importance of a single childhood adjustment problem for adult adjustment problems? Not much. Since there are substantial correlations between the childhood problems (Magnusson, Dunér, & Zetterblom, 1975) it might possibly be the case that one or more of them is of no importance in itself for adult adjustment problems; it only looks that way because such a problem is an indicator of another, more important problem: the eternal question of a possible spurious correlation. Such issues can be studied by making a more elaborate correlation analysis. However, in the following the question of spurious correlation will be discussed in a person-oriented framework.

Pairwise relationships and multiproblem patterns. The issue of the relationship of one independent variable to the dependent variable, taking the other independent variables into account, can be approached from a pattern-oriented perspective. Is it the case that the relationship to adult maladjustment of an adjustment problem in childhood is dependent on the latter being an indicator of a multiple problems syndrome in childhood which we know is strongly related to adult maladjustment and which may explain the presence of the adult adjustment problem? By "explain" we mean that a number of typical childhood multiproblem patterns are strongly connected to adult adjustment problems but that other typical patterns, characterized by single problems, are not. Hence, if the children with the typical multiproblem patterns were removed, no relationship would remain between a childhood problem and adult maladjustment. To shed some light on this question for the variables Aggression and Motor Restlessness, the relationships of these two variables at age 13 to Criminality and Alcohol Abuse at adult age were studied, first for the whole sample and then for the sample after removal of boys belonging to any of three severe multiproblem clusters obtained in a cluster analysis of the six extrinsic problems at age 13 (the clusters are presented in Figure 2 below). Before performing this analysis, the results of which are presented in Table 4, the variables were dichotomized.

As shown in Table 4, Motor Restlessness, but not Aggression, retains a significant relation (although in an attenuated form) to the two adult problems even when boys with severe multiproblems are removed from the sample. Hence, Aggression may possibly be of importance for the adult problems studied here only as an indicator of multiple problems, not in itself. For a detailed discussion of antisocial problems in relation to single problems versus patterns of problems, the reader is referred to Stattin and Magnusson (1996).

As indicated above, there are ways of con-

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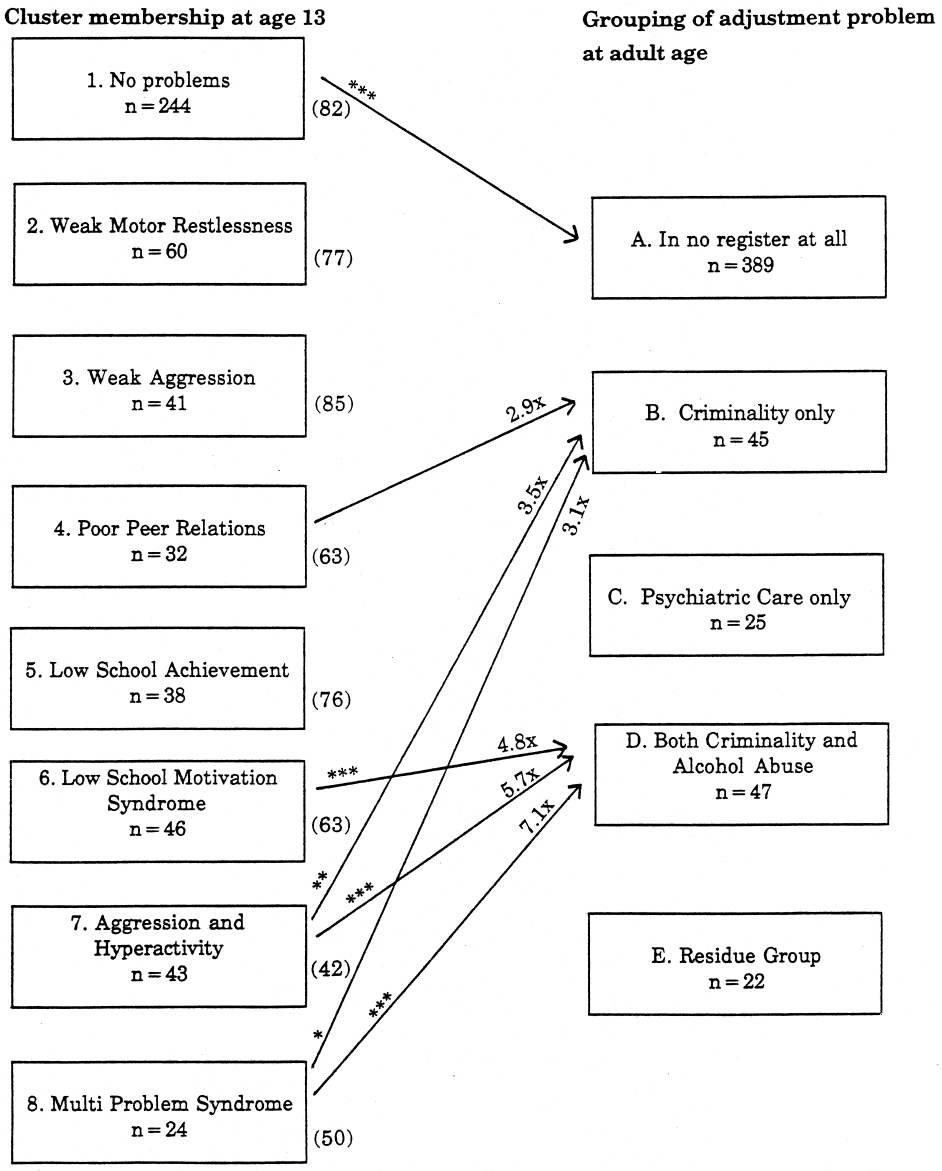


Figure 2. Significant longitudinal streams between age 13 and adult age. Figures on arrows indicate how many times more frequent the pattern combination is from what is expected from the development of the No Problems cluster. Figures within parentheses indicate how many percent of the cluster that are found in the normal group at adult age. Only significant streams are presented and an exact 1-tailed hypergeometric test was used. *$p < .05$, **$p < .01$, and ***$p < .001$.

trolling for the "influence" of one variable in the presence of others, using correlation techniques, for instance, by computing partial correlations between each childhood adjustment problem and adult adjustment problem after partialing out the other childhood problems. Sometimes such an approach can be used but it tends to lead to interpretational problems, as discussed by Magnusson, Andersson, and Törestad, (1993).

Robins (1966), in her classical study "Deviant Children Grown Up," looked at, among other things, the relationship between antisocial symptoms in childhood and diagnosis of

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Table 4. *Relation between Aggression or Motor Restlessness at age 13 and Criminality or Alcohol Abuse at age 18–23: Observed frequencies*

	Age 18–23					
	Criminality			Alcohol Abuse		
Age 13	No	Yes		No	Yes	
All men ($n = 538$)						
Aggression						
No	383	69	$\chi^2 = 32.5$	405	47	$\chi^2 = 19.3$
Yes	50	36	$p < .001$	62	24	$p < .001$
Motor Restlessness						
No	363	57	$\chi^2 = 43.1$	385	35	$\chi^2 = 39.5$
Yes	70	48	$p < .001$	82	36	$p < .001$
Reduced group ($n = 467$)[a]						
Aggression						
No	373	67	$\chi^2 = 0.2$	395	45	$\chi^2 = 0.0$
Yes	22	5	n.s.	24	3	n.s.
Motor Restlessness						
No	357	55	$\chi^2 = 11.5$	378	34	$\chi^2 = 15.6$
Yes	38	17	$p < .01$	41	14	$p < .001$

Note: The significance of a relationship was tested using a χ^2 with 1 *df* corrected for continuity. For Criminality and Alcohol Abuse Yes means registered at least once and for Aggression and Motor Restlessness Yes means problem code 2 or 3.
[a]Men after removal of those belonging to a severe multiproblem cluster at age 13.

sociopathic personality as adult. She stressed the importance of the number of antisocial symptoms a child exhibited for the prediction of later sociopathic personality and pointed to the fact that the predictive significance of a specific problem might lie in it being an indicator of multiple antisocial problems, an argument similar to the one made here. She found this to be only partly true; some symptoms apparently had a power "of their own" in predicting sociopathic personality. However, focusing on prediction, she did not study the connections between specific *patterns* of childhood behavior and outcomes, emphasizing instead the *number* of symptoms. Our main concern is these connections between patterns.

A possibility which has to be considered is that even in adults an adjustment problem may be related back in time only because it is an indicator of other adult problems that are "genuinely" related to the childhood problems. Again, this might be possible to "solve" by applying increasingly complex variable-based statistical analyses. A more straightforward alternative in this situation is to undertake a person-oriented analysis and obtain information about how typical childhood problem patterns relate to typical adult problem patterns. Such an approach is presented in the next section, based on the data presented above. An example of a pattern-oriented approach in a related context is given in a study by Rönkä and Pulkkinen (1995), focusing on the accumulation of problems in social functioning in young adulthood.

Relating syndromes of adjustment problems between late childhood and early adulthood

When trying to understand the relationships between adjustment problems in childhood and adulthood it was argued above that relating syndromes (=typical patterns) of adjustment problems between ages would give information about how syndromes evolve that would not be obtainable with an ordinary variable-oriented approach. The results of such a person-oriented analysis are given below, based on the data presented in the previous section. First, however, the cross-sectional typical patterns are described.

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Table 5. *Significant cross-sectional patterns of data from official records at age 18–23*

Criminality	Psychiatric Care	Alcohol Abuse	Observed Frequency	Expected Frequency	
0	0	0	504	442.4	Type
1	0	1	22	7.2	Type
1	1	2	11	0.6	Type
2	0	2	12	1.8	Type
2	1	2	4	0.2	Type
0	0	1	18	33.9	Antitype
0	0	2	4	32.5	Antitype
1	0	0	63	93.7	Antitype
2	0	0	8	23.8	Antitype

Note: Only patterns significant at the 5% level after Bonferroni correction are listed (corresponding to a nominal significance level of 0.0028). 0 = *not present*, 1 = *present once*, and 2 = *present more than once in a register at adult age* (except for Psychiatric Care where 1 = *present in a register*).

Clusters of childhood patterns of problems. The typical patterns of externalizing problems in late childhood are represented by eight clusters, with the means in the six problems for each cluster indicating the typical profile of scores for the boys belonging to that cluster. These results have been presented elsewhere (Bergman & Magnusson, 1991) and are briefly summarized by the verbal labels given in Figure 2.

Categories of adult adjustment problems. Because the data at adult age did not consist of approximately interval-scaled variables, a cluster analysis was not performed on them. Instead, another type of classification was undertaken, the results of which are presented below. But first a configural frequency analysis was carried out on the different possible configurations (=value combinations in the three variables) at adult age. Three possible values in each of Criminality and Alcohol Abuse and two in Psychiatric Care gave a total of $3 \times 3 \times 2 = 18$ configurations to study. The results of the CFA are presented in Table 5.

As shown in Table 5, there is a strong tendency (a) for problems not to occur at all or (b) for two or more to occur together. Many such patterns are significant types in the CFA. The most frequent combination of scores in the three problem indicators is having no problem at all. It is also a significant type. All other types include registration for both Criminality and Alcohol Abuse. Although Criminality as the only problem is an antitype, it is still rather frequent, characterizing 71 subjects, due to the high frequency of registration for Criminality. Also Psychiatric Care was not infrequent as a single problem, characterizing 25 subjects. Criminality alone and Alcohol Abuse alone are strong antitypes, occurring much less frequently than expected by chance. Based on this information, adult adjustment problems could be classified into five categories: No problems, Criminality only, Psychiatric Care only, Criminality and Alcohol Abuse, and a mixed group (those that do not fit into these categories).

Childhood patterns related to adult patterns. The childhood classification into eight clusters according to the six externalizing problems and the adult classification into five categories according to the three variables Criminality, Alcohol Abuse, and Psychiatric Care were cross-tabulated as 8 clusters $\times$ 5 categories. The significant relationships found in the tabulation are presented in Figure 2.

Figure 2 shows that four strong types occur. First, it is more common than expected by chance to belong to the "well-adjusted" group at both ages. Second, being in any of the three multiproblem clusters at age 13 is strongly connected to being in the group characterized by both Criminality and Alcohol Abuse at adult age. The risk of this is 5–7

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times higher than for the boys in the well-adjusted cluster. There are also some additional tendencies to longitudinal streams involving mainly the two most severe multiproblem clusters and the Criminality only category but they are not truly significant after adjusting for the fact that a large number of significance tests were made.

It is interesting to note the *absence* of significant longitudinal streams between the clusters Weak Motor Restlessness and Weak Aggression on the one hand and any of the adult groups indicating adjustment problems on the other hand. There is not even a tendency in this direction, as reflected by the fact that the percentages of boys in these two clusters that end up in the "well-adjusted" group at adult age is about the same as for those boys that start out in the "well-adjusted" cluster.

Conclusion. Seen in perspective, an overall picture emerges: At each age severe problems tend to occur together. Boys with multiple childhood problems have a much higher risk than other boys of exhibiting both criminal behavior and alcohol problems as adults, perhaps also psychiatric problems. Single adjustment problems in childhood do not usually have strong manifestations and are not related to adult problems. Alcohol problems in adulthood rarely occur alone, while psychiatric problems occurring alone are not related to patterns of childhood externalizing problems. The conclusion is inescapable: Problems tend to occur together in syndromes. It is the severe problem syndromes in late childhood and adulthood that link up; the rest is secondary. Hence, attention should be focused on such syndromes characterizing individuals rather than on variables viewed separately.

Finding the "white spots"

Principle. Regardless of whether the approach to studying development is variable oriented or person oriented, the focus is on finding things that go together and to explain the developmental paths that occur. From a person-oriented perspective it has been pointed out by Lienert and zur Oeveste (1985), in the context of their concept of antitype, that what does *not* occur is also instructive. There must be an explanation for why certain configurations occur less often than expected by chance. In another context, Bergman (1988) pointed out, when discussing the concept of a residue, that unique cases tell us about what, for some reason, is rare and that finding out the reason for this may be of theoretical relevance. It is also possible to hypothesize value patterns that that theory predicts shall not occur and test this hypothesis using the RESIDAN approach. In a variable-oriented context, Kagan (1996) has pointed to what can be learned by studying the extreme cases. They may differ from the other cases not only quantitatively but also qualitatively.

At the heart of all the above approaches is a belief that a certain class of complex dynamic systems characterizing a sample of individuals is inherently constrained by the kind of states that (almost) cannot occur and that these states are of importance to know for understanding the systems, sometimes even more important than finding typical developmental sequences. What cannot occur sets boundaries to what can occur and both aspects have to be accounted for in any sound theoretical explanation of a phenomenon. This reasoning may be particularly relevant to the study of psychopathology since it is at the boundaries of what can occur that "normal" development becomes deviant.

Detecting "white spots" using configural frequency analysis. As a simple illustration of the quest for white spots, consider the data set presented above concerning patterns of externalizing adjustment problems at age 13 and in addition information about the scores in an identical set of variables for the same sample measured at age 10. CFA applied at each age separately on dichotomized data for the six problems showed that the following two strong antitypes occurred at both age 10 and age 13:

1. Lack of Concentration and no other problems (observed frequencies 5 and 13, expected frequencies 26.4 and 30.2, at ages 10 and 13, respectively);

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2. Aggression and Lack of Concentration and no other problems (observed frequencies 1 and 2, expected frequencies 9.8 and 14.2, at age 10 and 13, respectively).

Apparently, Lack of Concentration rarely occurs alone, and hardly ever together with only Aggression. Is this because concentration difficulties (almost) always cause or are caused by other adjustment problems? Or is it because concentration difficulties are a powerful indicator of the state of some underlying mechanism that generates other externalizing problems? More information about these CFA analyses is given in Bergman and Magnusson (1991).

Applying this CFA strategy of searching for antitypes to adult adjustment data shows (Table 5) that Alcohol Abuse as a pronounced single problem is a strong antitype (observed frequency 4, expected 32.5). That pronounced alcohol problems rarely occur alone may indicate that they are either a powerful cause of other problems or an almost inevitable consequence of them. Or, as discussed for concentration difficulties, they may indicate the state of an underlying causal mechanism. If the last interpretation is true, can this mechanism and the putative one for Lack of Concentration be the same?

Residue analysis. This analysis concerns the data set used in the CFA analysis based on the age 10 and age 13 data. At each age a residue of almost unique subjects was removed from the sample for a separate analysis. The residues comprised nine and seven subjects at ages 10 and 13, respectively (a small additional number of subjects were removed in the relocation phase of the analyses, see Bergman & Magnusson, 1991, but these subjects are not discussed here). The residue subjects are presented in Table 6. Although all the indicators had very high reliabilities (above 0.90), the possibility cannot be ruled out that in some cases the observed residue patterns were caused by errors of measurement.

As, by definition, residue subjects do not resemble other subjects, the results in Table 6 are difficult to summarize. However, all the residue subjects were characterized by multiproblems, with strong expressions of some but not all four conduct problems and the presence of one or both of the two remaining problems (i.e., Poor Peer Relations and Low Achievement). This was true at both ages except for one subject, who was extremely high in all problems except Poor Peer Relations at age 13. The results indicate that most multiproblem patterns that did not characterize the multiproblem clusters were strongly atypical.

From theoretical considerations it was hypothesized that strong aggression combined with notably low intelligence/proficiency in the school subjects would entail overwhelming risks of generalized maladjustment. The child would receive strong negative feedback almost continuously, which would be bound to create more problems. Therefore it was hypothesized that the value pattern "3" in both Aggression and Low Achievement, accompanied by no other problems, could hardly occur. Hence, in a RESIDAN analysis this pattern of scores as an "artificial subject" was added to the sample after the residue had been removed and a test was made of whether it came out as the single residue case. This happened at both age 10 and 13; the chance of this occurring under a random model is on each occasion about 2%.

That the residue analysis and the CFA analysis applied to the same data yield partly divergent results is only to be expected in the light of their different focuses. CFA finds antitypes that are significantly less common than expected by chance but may still occur, while the residue analysis finds almost unique cases, irrespective of whether this is only to be expected due to low marginal frequencies of the value codes of the specific pattern.

Discussion

A person-oriented approach and a variable approach

A person-oriented *theoretical* approach to the study of individual development should not be confused with a *methodological* approach using pattern analysis. Although, in many cases, a holistic orientation makes it natural to

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Table 6. *Value patterns for members in original residue*

	Variable					
	Aggression	Motor Restlessness	Lack of Concentration	Low School Motivation	Poor Peer Relations	Low School Achievement
Age 10	1	3	3	2	3	0
$n = 9$	0	0	3	3	0	3
	0	0	0	2	2	3
	3	0	1	1	1	3
	2	1	3	1	0	3
	3	1	2	3	3	0
	3	1	3	3	3	0
	1	1	3	3	3	2
	1	1	3	2	3	1
Age 13	0	0	3	1	3	2
$n = 7$	3	1	0	0	3	0
	2	1	1	0	3	2
	3	1	3	2	3	2
	3	3	2	0	3	0
	3	3	3	3	1	3
	1	3	3	2	0	3

use pattern-based methods, standard variable-based methods with the variable as the main analytical unit may also be appropriate, all depending on the specific purpose. The variable is also a versatile tool: results from a pattern analysis can sometimes be used to construct new variables (for instance, the presence or absence of a specific typical pattern is transformed into a dichotomous variable).

Notwithstanding these comments, it is probably fair to say that the use of standard variable-based methods also for person-oriented research in development has been overemphasized, as exemplified by the attention given to this approach in a recent review concerning personality development in a social context (Hartup & van Lieshout, 1995). Moreover, in their discussion of methods for analyzing patterns in this context, these authors have a narrow perspective, concentrating on studies of ipsative stability, that is, the relative rank ordering of different behavioral characteristics displayed by a person across repeated measurements. An approach like the one presented in this article, where individuals are classified according to their patterns of relevant personality characteristics, is hardly mentioned, even though such an approach is a main road to obtaining results that are directly person oriented. Broadly speaking, a pattern approach is a way of restoring the person to personality and developmental psychopathology, the person concealed in the correlation matrix produced by standard methods (cf. Carlson, 1971). The concept of problem gravitation presented above exemplifies this point. Although, in the empirical illustration, the different adjustment problems were roughly equally common at the two ages, hidden behind this variable-oriented result is the finding that the typical individual patterns of problems changed with age. Individuals with single problems became less common with age and individuals with either no or many problems became more common, as hypothesized by the problem gravitation hypothesis.

Sometimes reality may not be continuous, operating instead to produce more or less discrete types. In other words, only certain configurations of system states are in some way optimal and become stable and frequently observed. This issue was discussed in the introduction. It could be argued that, from this perspective and within a person-oriented framework, methods for pattern-based analysis like the ones presented here may be more appropriate than standard variable-based methods that treat the variable, not the pattern, as the main analytical unit. The number of pattern methods discussed here has, of course,

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been limited to prevent the presentation from becoming too technical. Quite justifiably, a researcher proficient in the application of a specific variable-based method might feel that this would have done better in our illustrative comparisons of pattern methods and variable methods and that the results presented here should not be generalized too far, at least not to his/her area of research. In this we agree—the appropriateness of a methodological approach is always dependent on the problem in hand (Bergman, Magnusson, & Eklund, 1991). But we still believe that in a variety of situations, pattern-based methods provide a more direct way of considering interaction structures than variable-based methods. In a thorough consideration of interactions, an approach that focuses on variables tends to become immensely complex. Cronbach (1975) even likened this to entering a hall of mirrors.

Classification and related methods in the study of development

A major methodological approach in a person-oriented framework is classification using cluster analysis. In a developmental setting, an approach was indicated which entailed cross-sectional cluster analysis followed by linking of results between each pair of adjacent measurement occasions. This proved useful in many settings and a specific procedure, LICUR, was briefly presented. It has been argued that results from cluster analysis are sensitive to small methodological differences and sampling variation. As discussed in Bergman (in press), Bergman and Magnusson (1987), and Milligan (1981), this is an exaggeration; inconsistent results often reflect an unsuitable clustering procedure. Important matters to consider to obtain trustworthy results from a cluster analysis are (a) that the variable profile under study adequately summarizes the pertinent information *Gestalt*; (b) that the values in the different variables are commensurable and the similarity between two subjects' profiles is adequately measured; (c) the choice of a sound clustering algorithm; (d) that only variables with a reasonably high reliability are included and, if it is important to find homogeneous clusters, only a limited number of variables are included in the profile; (e) a readiness to retreat, if necessary, from classifying everybody. For a further discussion of these issues the reader is referred to Bergman (in press).

As discussed in the methods section, direct analysis of longitudinal patterns is a potentially attractive approach but may pose problems that result in heterogeneous classifications. Weighting problems also have to be considered; they may be introduced by different periods of time between measurements if more than two measurement occasions are involved. To further complicate matters, time is not always best conceived as linear in relation to chronological age; see, for instance, Stattin and Magnusson (1990) for an illustration of the importance of biological age. Useful new methods in the area of longitudinal classification may be ISSA and ISOA, described earlier, for analyzing longitudinal sequences based on the concept of the i state (Bergman, 1995a, 1995b).

Classification is a major approach to the identification of typical developmental patterns. However, as discussed in previous sections, other approaches to this goal can be highly relevant. Important developmental types can be identified by searching for "dense points" (clumps) in the multidimensional space without aiming for a complete classification. To give one example: Suppose a highly extreme group with regard to some psychopathology-related aspect has been identified and one wants to find typical patterns of scores in a number of explanatory factors that are strongly associated with membership of this extreme group. One might then reason that since we are dealing with a very extreme group that is homogeneous in many respects, it is conceivable that just one or a few typical patterns of scores in the explanatory factors will account for the emergence of a majority of such extreme cases. Hence, one could start by identifying the largest homogeneous class of subjects with regard to the scores in the explanatory factors and tentatively interpret it as pointing to a typical pattern (a "dense point in n-dimensional space") of major importance in the process of generating the behaviors constituting the psychopath-

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ology-related aspect under study. No complete classification is aimed at; although a substantial proportion of the subjects belonging to the extreme group are believed to have this typical pattern in the explanatory factors, it is also believed that other subjects may have other patterns, for instance due to very special environmental circumstances or to errors of measurement. Attempts to disentangle these subgroups and make the classification complete would require a much larger sample than is usually obtainable when studying extreme groups.

The above mentioned typical pattern is an example of what Meehl (1992) would call a "taxon"; a "natural cluster." A taxon should be viewed as a group that really "is out there" and not just a product of some method of classification. The concept is not clear-cut but it would stand for, for instance, a group that is separated from other groups and which in a number of variables exhibits a typical pattern of scores that arose from a specific cause. It could also simply mean a group of individuals identified as belonging together by procedures known to be valid and which is in some sense psychologically meaningful. It is not always necessary for such a "natural" cluster to be homogeneous with regard to the configuration of scores in the variables used to describe the group but one usually strives for a classification that has this property. The importance of homogeneity would depend on which of the following purposes are emphasized: (a) identifying the typical patterns of the "natural" clusters (it is often the cluster means that contain the relevant information; cluster homogeneity is less important); (b) identifying the relative frequencies in the population of the different "natural" clusters (cluster homogeneity may be important to increase the chances of obtaining reasonably correct frequencies); (c) using cluster membership as a variable in further analysis (cluster homogeneity is important since low homogeneity might indicate an increased risk of misclassification of individuals).

Types and typology

Few concepts mean such different things to different researchers as "type" and "typology." The concepts go far beyond the realm of classification and often imply something that is fixed or innate as opposed to something that is dynamic or changing (for a discourse on this topic, see Valsiner's (1984) discussion about typological and variational modes of thinking). It is important to note that we do not subscribe to this interpretation of a typical pattern or cluster as fixed. We are strongly opposed to a revival of the old typological thinking in which persons are seen as belonging to unalterable, permanent classes. While it is true that persons characterized by a specific pattern of scores in the variables under study must exhibit a certain stability in this respect for the pattern to be detectable, so that one might talk of a "typical pattern" or "type," this does not mean that the typical pattern is unchangeable. In fact, its developmental connections and transformations into other typical patterns are the core issue in a developmental study of psychopathology in a person-oriented framework.

Finding the "white spots"

An interesting approach, complementing the search for typical patterns, involves the detection of white spots, patterns that occur seldom or not at all. This can be done cross sectionally, as exemplified here, or developmentally, looking for pathways of pattern development that for some reason are closed. Different ways of doing this cross sectionally were presented in the methods section and illustrated empirically (searching for antitypes, identification of a residue, etc.). Within the confines of phase space (i.e., what theoretically can be observed), it is the combination of patterns that occur often and those that occur seldom or not at all which describes the empirical world. In spite of its obvious relevance for theory testing, a search is seldom made for the boundaries of areas containing nonoccurrent developmental patterns. Yet theoretical predictions about white spots can often be made which would be quite simple to test. A few voices have urged research along these lines. For instance, boundary conditions were discussed by Lewin (1933, p. 598) in terms of "region of freedom of movement" and Val-

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siner (1984) pointed out that the observed behavioral variability of a person constitutes only a fraction of the possible range of variability and discussed the phenomenon from an epistemological viewpoint.

Some comments on measurement

The measurement of the adjustment problems presented in the empirical illustrations above was done with quasiabsolute scaling. As discussed in the measurement section, it was judged important to obtain a *multivariate* measurement, reflecting both varying prevalences of different problems and varying prevalences for the same problem over time. This issue of achieving comparable measurements tends to be dodged or is sometimes unsuccessfully circumvented by computing standardized scores.

Another important measurement issue, especially in the field of psychopathology, is the dimensionality of the indicators of adjustment and whether they should measure the whole spectrum of adjustment. In the empirical illustrations of adjustment problems in this article we decided to discriminate only between degrees of *negative* adjustment. There was otherwise a risk of at least certain scales no longer being unidimensional. For instance, the other extreme to "very aggressive" is "total absence of aggression," and it is doubtful whether that constitutes less of an aggression "problem" than, for instance, "moderate aggression." Some degree of aggression may be desirable for good adjustment. For a further discussion of these issues the reader is referred to Bergman and Magnusson (1991).

Studying complex dynamic systems

Work on theoretical models for complex dynamic systems in the natural sciences has led to the development of powerful methods for a more realistic analysis of such systems. These methods include nonlinear mathematics, data simulation methods, the study of patterns, chaos theory, and catastrophe theory. Our acronym for such methods is NOLIDS. It is important that the behavioral sciences make full use of these new tools. Appropriately applied, NOLIDS have implications also for theory and empirical research in the developmental field (Barton, 1994; Wallacher & Novac, 1994). There is also a growing interest in applying such methods and models in the study of individual development (e.g., Smith & Thelen, 1993). It is, of course, important to be very careful when transposing methods used in the natural sciences for the study of human development from a behavioral science perspective. Essential differences exist, especially concerning higher mental functions. At that level, a key characteristic of the process of individual functioning is *intentionality,* which is linked to emotions and values. For a successful application of NOLIDS, such distinctive features must be taken into account.

It is something of a paradox that systems concerning living things, although often more complex than systems concerning dead matter, in many cases are less chaotic and more clearly organized. This may have to do with the fact that biological systems function and develop in a process that includes two opposed forces: maturation, experience, and environmental impact working for change and an inherent principle of resisting change. The concept of homeostasis has been replaced by the concept of allostasis (Schulkin, McEwen, & Gold, 1994). A biological system achieves stability partly through change and defends itself against harmful change, which might lead to malfunction or destruction of the system. For example, in brain function and development, events leading to a detrimental chaotic attractor are suppressed and only functional changes are accepted.

To reiterate: in many respects the processes involved in individual development as studied in the behavioral sciences differ from those studied in the natural sciences using NOLIDS. However, there is one central proposition that unquestionably is fundamental also to the study of individual development, namely that a complex dynamic system cannot be fully understood by summing results pertaining to single aspects viewed in isolation from other simultaneously operating aspects. The totality cannot be understood just by studying the parts one by one. The old credo from gestalt psychology holds: The to-

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tality is more than the sum of its parts. From this perspective, a person-oriented approach is intimately related to the new venture in the natural sciences. This resemblance tends to be greater for hierarchical person-oriented methods in relation to models of biological systems since nature tends to organize systems hierarchically (Koestler, 1978). Statistical methods of, for instance, estimation, have also begun to be applied to problems in the field of nonlinear dynamic systems (e.g., Berliner, 1992; Chatterjee & Yilmaz, 1992). At the interface of the variable-oriented, the person-oriented and the NOLIDS approaches, possibilities arise for new exciting methods to emerge. As regards methods for conducting a person-oriented approach, we think there has been a dearth of methodological work in this area. Person-oriented methods are comparatively underdeveloped and large gains in analytical power are to be expected if a strong effort is made to support methodological development in this area.

The importance of careful observation and description

The methods discussed and illustrated here are not model based—no formal comprehensive models are being tested. However, the methods do allow for hypothesis testing, though not at a global model level. Without denying the obvious power of formulating and testing comprehensive statistical models, it is worth advocating the usefulness of a more descriptive approach in which only limited testing is undertaken. In the initial stages in a complex field, careful open-minded observation is paramount. Guidance about what to look for, according to existing theories, is, of course, important, but theories prematurely transformed into statistical models of data can become blinkers. If the model window opens at the wrong place, the interesting things may be missed. This point has been made again and again by, among others, Cronbach (1975), Greenwald et al. (1986), and Magnusson (1992). When applying a person-oriented approach in a complex developmental setting one is often at this initial stage. As such a field matures, a possible sequence of analyses could be (a) preliminary simple variable-based analyses to identify operating factors and lay the foundation for the formulation of relevant patterns, (b) descriptive pattern-based analyses, and (c) model-based pattern analyses for testing person-oriented theories.

Prediction and the person-oriented approach

Sometimes it is claimed that the ability to predict behavior should be the principal tally for measuring the usefulness of a theory and that the main goal is to predict and control behavior (e.g., Watson, 1913). It is instructive to discuss this issue in the context of the empirical examples given in this article concerning the study of patterns of adjustment problems from childhood to adulthood. In the light of the kind of results obtained by Robins (1966), which were briefly summarized in the presentation of the empirical example, the following argument against a pattern approach is sometimes put forward: The prediction of adult maladjustment can be (almost) maximized by following the simple law "the more problems in childhood, the more maladjusted in adulthood." This means that it suffices to use some kind of sum score of the number of problems or, at most, a number of relevant predictors in a linear model. Prediction is not appreciably improved by considering more complex models. Occam's razor should then be used, with the inference that the study of connections between specific patterns of childhood problems and adult problems, as depicted in Figure 2, is superfluous and unnecessarily complicated.

Let us assume for the moment that within a certain area the law stated above is true and that prediction is not improved by applying a pattern approach (whatever we may mean by "prediction" in this latter case). The relevance of the conclusion based on Occam's razor then stands and falls with the assumption that prediction is the goal. However, from a holistic, interactionistic perspective this outlook is much too narrow, as discussed by, for instance, Magnusson (1985), who pointed out that to be able to predict a phenomenon is neither a sufficient nor a necessary condition for understanding it. For instance, meteorologists

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have a fairly good understanding of the factors that regulate the weather and the dynamic systems involved. Yet, predictions of the weather a month ahead are quite unreliable. With simple examples it can also be shown that powerful pattern relations may exist over time even though all pairwise correlations are zero between all single variables and between time 1 and time 2 indexes of variables, see for instance Bergman (1988, in press). Should these interactions be ignored just because linear prediction cannot be demonstrated? To sum up this argument: We have pointed in this article to typical patterns of adjustment problems in childhood that are connected to typical patterns of problems in adulthood. The value of such results cannot be measured by some prediction coefficient pertaining to a linear model alien to a pattern approach. That would be like evaluating the recreational value of the trees in a park by applying a formula for computing the dollar value of the trees as timber.

Some final comments

By definition, "psychopathology" is "not normal." Put differently, psychopathology is a collection of states of the dynamic systems describing psychiatric health development that are not very common in the general population (but do sometimes occur). From this one can make two surmises: the first is that often such states will be "recognized" by the individual's dynamic system as being nonoptimal and therefore should be expected to be transient and not stable. Hence, changing symptomatology with time is often the rule and should be studied intensively. The discrimination of this situation from the one described below is a primary task.

The second surmise is that states indicating a specific typical pattern of psychopathology that exhibit individual stability must have powerful factors to throw the individuals "off track" in such a consistent way. There are probably only a few constellations of operating factors that can accomplish this for a specific syndrome and only a limited number of syndromes that exhibit long-term stability. They should be possible to identify. For this purpose, as discussed above, studying both typical patterns (for instance, using classification analysis, analyzing "dense points") and white spots seems highly relevant in the field of developmental psychopathology. The focus on patterns of operating factors underlines the importance of studying multiple domains of variables in psychopathology, as advocated by Cicchetti (1993).

Writing this article and reviewing the evidence for a person-oriented approach, we have become increasingly convinced of the validity and power of this approach for many important questions concerning development and psychopathology. It is true that the methods considered here for carrying out a person-oriented approach do not have the features of sophisticated variable-based methods for comprehensive model testing and handling of errors of measurement. It is also true that a person-oriented approach using today's methods may place higher demands on sample size and quality of measurement than is usually the case with a variable-oriented approach. But in many situations a person-oriented approach is closer to a realistic view of the development of individuals' complex dynamic systems than is a standard variable-oriented approach. We must then look for the key where it happens to be, even if the light is poor there and better somewhere else. We also believe that the infusion of NOLIDS concepts and methods into the person-oriented approach will provide us with much needed new tools for this pursuit.

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