

Models for Hierarchical Structures in Differential Psychology

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This paper provides descriptions and applications of models for investigating hierarchical structures in differential psychology. These models are sub-classified into common-source, person-situation and state-trait models according to the characteristic restrictions of the relationships between manifest variables and combinations of manifest and first-order latent variables. The models include one level of manifest variables and two or more levels of latent variables. It is the advantage of this framework that a few characteristic models can be adapted to a large number of structures by minor modifications. Cross-sectional and longitudinal approaches are suggested for investigating different aspects of the person-situation issue. While the cross-sectional approach is concerned with behavior in different situations, the longitudinal approach deals with behavior observed at different occasions. Structural equation modeling provides the framework for the formal representation of these models. Some models are applied for investigating the structure of social optimism. For a sample of $N=462$ participants it is demonstrated that the model including three first-order latent variables and one second-order latent variable provides an appropriate representation of the data.

Keywords: *confirmatory factor analysis; hierarchical structure; interindividual differences; person-situation debate; latent state-trait theory*

The paper deals with the investigation of hierarchical structures. Confirmatory factor analysis within the framework of structural equation modeling provides a methodological tool for the representation and investigation of structures on the level of latent variables (e.g., Bentler, 1976; Bentler & Weeks, 1980; Marsh & Hocevar, 1985). It is a rather general tool since it allows the researcher to assign different meanings to the components of the models. Different assumptions concerning different components even

enable the distinction between different types of models. In the following we distinguish between “common-source models”, “person-situation models” and “state-trait models”. Figure 1 provides a graphical representation of this typology.

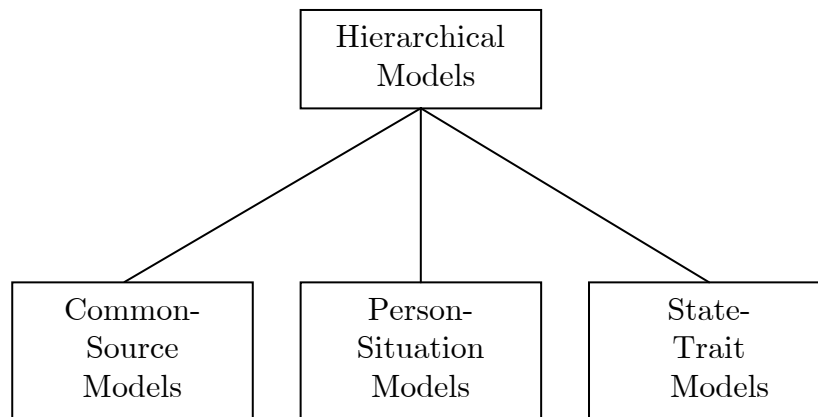


Figure 1. Typology of hierarchical models.

Common-source models comprise two or more levels of person variables which are usually abilities or traits, and they include the assumption that the general abilities or traits exert influence on the specific abilities or traits which relate to behavior. There are several models of cognitive ability which are hierarchical, as for example the models provided by Carroll (1993) and Vernon (1965). Furthermore, several hierarchical models of temperament were proposed, as for example the models presented by Eysenck (1947) and Guilford (1975). Moreover, ability and trait models usually assume that there is no direct access to abilities or traits whereas behavior is directly observable. This assumption requires the distinction between manifest and latent levels. Since confirmatory factor analysis is able to analyze the relationship between manifest and latent variables, it is especially well suited for the investigation of such structures. The questions which usually guide the investigation are the following: *Is the model which represents the structure appropriate with respect to the data? Which of two or more alternative models representing the structure is the best one? Can the model be cross-validated?*

A more specific field of application is the person-situation issue which dominated the scientific debate within differential psychology for a long time during the 20th century. In the beginning of this debate there were two major perspectives: The person and situation perspective. The person perspective rests on the assumption of behavioral consistency both across situations and across time (e.g., Epstein, 1977), i.e., the tendency to behave always in the same way. This perspective is contrasted with the situation per-

spective. The situation perspective assumes that behavior depends on the situation (e.g., Mischel, 1968). The proponents of this perspective argue that consistency is due to the perception of the situation and that similar situations lead to the same response (Cantor & Mischel, 1979; Fiske, 1974). This perspective suggests high correlations between specific behaviors in similar situations. Learning theory provides the theoretical basis for the expectation of such correlations. Since neither the person nor the situation perspectives could explain the data sufficiently well, a third alternative emerged: the person-in-situation perspective (e.g., Ekehammar, 1974; Endler, 1982). The proponents of this perspective argue that both person and situation are important. They demonstrated by means of analysis of variance that neither person variables nor situation variables nor their interactions are sufficient to explain behavioral variability. When investigating the person-situation issue by means of confirmatory factor analysis either person models, situation models or *person-in-situation models* are considered. When applying these models an answer to the following research question is expected: *Is the person-in-situation model or one of the sub-models, the situation or person models, most appropriate for representing the data?*

If the cross-sectional approach presented in the previous paragraph with respect to the person-situation issue is replaced by the longitudinal approach, i.e., measures obtained at different points in time, there is the opportunity for an increase of consistency since the replacement of situations by occasions excludes variation due to different situations (see Epstein, 1979). The latter approach suggests the distinction between states and traits instead of the distinction between persons and situations. The restriction to repeated measurements opens a new field of research. It enables the investigation of specific psychometric problems resulting from classical test theory. Measuring traits at different occasions reduces the error variance to the variation which occurs as a function of the change from occasion to occasion. As a consequence of this restriction, the classical model of measurement applies and enables the obtaining of estimates of reliability, specificity and consistency. It is the General Latent State-Trait Theory (Steyer, 1989; Steyer, Ferring, & Schmitt, 1992; Steyer & Schmitt, 1990; Steyer, Schmitt, & Eid, 1999) which relates these concepts to the models of confirmatory factor analyses and gives rise to the *state-trait models*. Within this approach the following research questions are of interest: *Which one of the set including the state, trait and state-trait models is most appropriate for representing the structure with respect to the data? What are the estimates of reliability, specificity and consistency?*

Formal Description of Hierarchical Models

In the following, we will discuss hierarchical structures which include two levels of latent variables which may represent traits or abilities. Confirmatory factor analysis enables the investigation of whether data are consistent with a highly constrained a priori model. In presenting hierarchical models it is useful to distinguish between two parts of each model, the measurement model and the structural model (Bollen, 1989). The measurement model which relates the observed variables Y to the latent constructs is given by

$$Y = \Lambda \eta + \varepsilon \quad (1)$$

where Y is the $(p \times 1)$ column vector of indicator variables Y , Λ is the $(p \times q)$ matrix of loadings of p indicator variables Y on q first-order factors η , and ε is the $(p \times 1)$ column vector of measurement errors. It is this equation which brings about the separation of what is considered as the true component of measurement from the error component of measurement. The true component includes all the parts of the latent structure.

If the endogenous latent variables η (first-order factors) are related to exogenous latent variables ξ (second-order factors), the structural model can be expressed by

$$\eta = \Gamma \xi + \zeta \quad (2)$$

where η is the $(q \times 1)$ column vector of first-order factors η , Γ is the $(q \times m)$ matrix of loadings of q first-order factors η on m second-order factors ξ , and ζ is the $(q \times 1)$ column vector of disturbance terms. Apparently, this equation enables the decomposition of the true component which corresponds to the latent endogenous variables into a sub-component assigned to the latent exogenous variables and an additional sub-component which is not explained by the model. The part of the latent endogenous variables represents the first level and the part of the latent exogenous variables the second level of the hierarchy if the model includes two levels.

Substitution of Equation 2 into Equation 1 shows that the observed variables of vector Y comprise three components:

$$Y = \Lambda \Gamma \xi + \Lambda \zeta + \varepsilon \quad (3)$$

where Y is the $(p \times 1)$ column vector of indicator variables Y , Λ is the $(p \times q)$ matrix of loadings of p indicator variables Y on q first-order factors η , Γ is the $(q \times m)$ matrix of loadings of q first-order factors η on m second-order factors ξ , ζ is the $(q \times 1)$ column vector of disturbance terms, and ϵ is the $(p \times 1)$ column vector of measurement errors. It can be shown that all the models of interest, i.e., the common-source models, the person-situation models and the state-trait models, are different types of the hierarchical model and can be expressed by Equations 1 - 3. They are only special cases of the hierarchical model, which result from the type of research question, the type of data under investigation, and the interpretation of the variables.

The common-source model is given by the following specification of Equation 2: the first component of η refers to a single *common latent trait variable* ξ which is common to all latent trait variables η . This variable ξ reflects the person component of measurement, i.e., interindividual differences that are stable across situations and occasions. The second component of η is considered as the *unique component* ζ . This component is also ascribed to the person, i.e., a specific component that is independent of the common latent trait variable ξ and stable across measurement occasions.

The person-situation and state-trait models take into account that the measurement takes place in a specific situation. In this case the first component ξ is *common to all variables across occasions or situations of the same type*. The component ξ reflects the person-component of measurement, i.e., interindividual differences that are stable across the points of measurement or situations. The component ζ reflects the situational and/or interactional component of the measurement. The combined influences of the variables ξ and ζ constitute the so-called *latent state variables* η (see Equation 2). These variables represent overall reliable interindividual differences due to the person component *and* the situational and/or interactional component.

The variance decomposition corresponding to Equation 3 is given by Equation (4):

$$\Sigma = \Lambda\Gamma\Phi\Gamma'\Lambda' + \Lambda\Psi\Lambda' + \Theta_{\epsilon}, \quad (4)$$

where Σ is the $(p \times p)$ model-implied covariance matrix of the indicator variables Y , Φ is the $(m \times m)$ covariance matrix of the latent variables ξ , Ψ is the $(q \times q)$ covariance matrix of the residual variables ζ , and Θ_{ϵ} is the $(p \times p)$ covariance matrix of error variables ϵ . The first two terms on the right side of Equation 4 specify the systematic variance components, and the third term specifies the error variance.

There are certain statistical assumptions which must be met in confirmatory factor analyses. It is assumed that the expected values of manifest variables, latent variables, and error variables are zero [$E(Y) = E(\eta) = E(\xi) = E(\epsilon) = 0$], that error variables ϵ are independent and uncorrelated with latent variables ξ and residuals ζ [$E(\epsilon\xi') = E(\epsilon\zeta') = 0$], and that ζ variables are uncorrelated with latent variables ξ [$E(\zeta\xi') = 0$]. For latent state-trait models the error components of each variable measured repeatedly on different measurement occasions may covary and, therefore, may give rise to method factors.

In constructing a hierarchical model according to these equations, it is necessary to specify the matrices and vectors of the models appropriately. The appropriateness of the specifications is in the responsibility of the researcher.

Common-Source Models

Common-source models are hierarchical models which are characterized by a minimum of restrictions guiding the assignment of manifest variables to latent variables. Common-source models assume that the first-order latent variables are the common sources of the corresponding manifest variables and that the second-order latent variables are the common sources of the corresponding first-order latent variables. Common-source models should possess as many levels as the structure which is represented. The most basic common-source model includes one level of manifest variables and two levels of first- and second-order latent variables. Figure 2 provides such a basic model.

In a common-source model each unit of the higher level is associated at least with two units of the lower level. The arrows which originate in an oval and are directed downwards symbolize the influence of the higher-level trait on lower-level traits whereas the arrows which are directed upwards symbolize that there are remainders which are independent of trait influence. The level of manifest variables can include various measures, as for example observations, ratings, the responses to questionnaire items or the responses to achievement test items. Sometimes even test scores serve as manifest variables. The first latent level comprises specific traits or abilities, as for example the retrieval of information ability or test anxiety. Rather general abilities or traits can be found on the second level, as for example Spearman's (1904) *g* factor representing intelligence or Spielberger's (1979) trait anxiety. Although models with more than two latent levels can be constructed, the two-level model is the most common case.

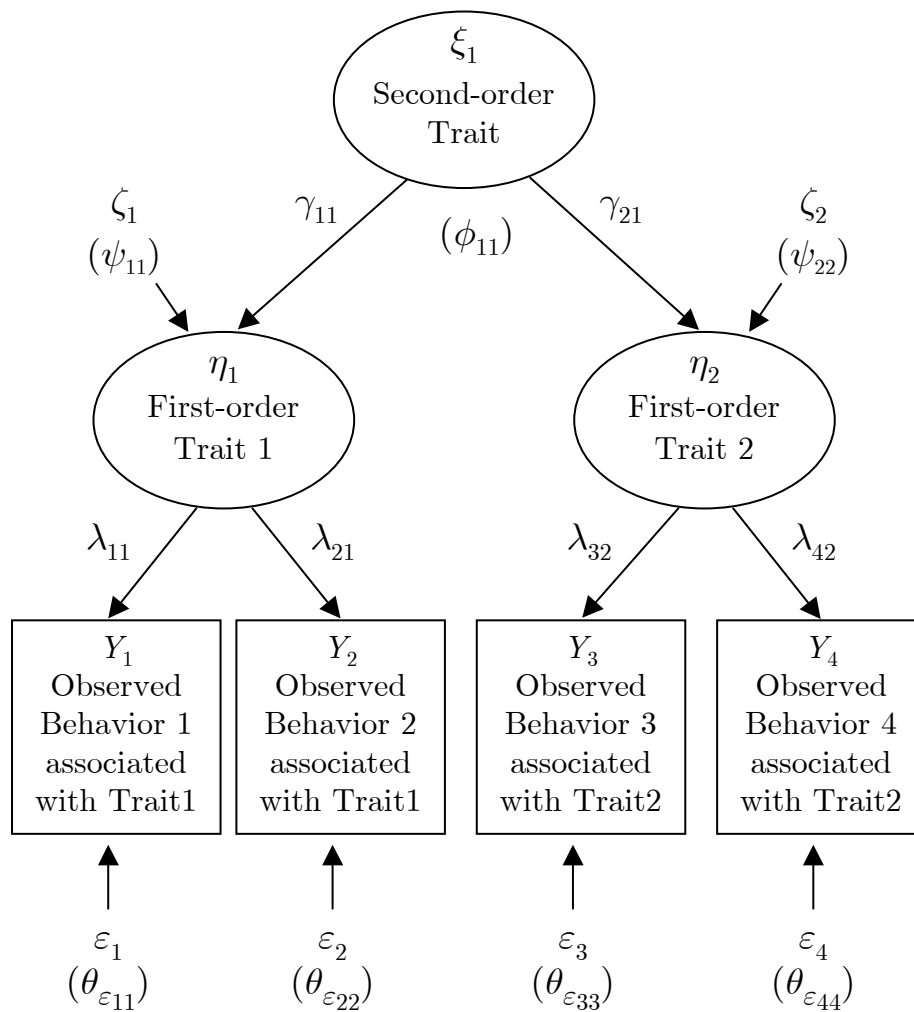


Figure 2. Common-source model for four measures of specific behaviors, two first-order latent traits and one second-order latent trait (parameters in brackets indicate variances).

As has been pointed out by Jöreskog (1993), it is important to distinguish between three approaches of structural equation models: the strictly confirmatory approach (CM), the alternative models approach (AM), and the model generating approach (MG). In the CM approach, a model is tested using a structural equation model to determine if the pattern of variances and covariances is consistent with the model specified by the researcher. In the AM approach, several alternative models are tested while in the MG approach, the first model for a given data set must be modified several times until a good or acceptable model fit is reached. Common-source models are frequently applied in order to check whether a model represents the data appropriately (CM) or which one of several alternative models is the most appropriate one (AM). The first approach requires the evaluation of the model fit of the specified model whereas the sec-

ond approach demands the comparison of fit indices of nested or non-nested models. There is an obvious relationship between these approaches and the initially presented questions which guide the application of such models.

Person-Situation Models: A Cross-Sectional Approach

Person-situation models are hierarchical models which are characterized by the additional assumption that the first-order latent variables are restricted to specific behavior or behavioral tendencies while the corresponding manifest variables refer to behavior in different situations. There is no systematic temporal relationship between the various situations which are considered in applying person-situation models. It is only assumed that the observations concerning the various situations occur in temporal proximity. Because of the assumed temporal proximity person-situation models are considered as representing the cross-sectional approach.

The person-in-situation model takes the observation into consideration that there is often a considerable degree of correlation between various behavioral tendencies. Therefore, the person-in-situation model includes an additional trait which is assigned the role of second-level latent variable. The formal representation of the person-in-situation model exactly corresponds to the formal representation of the hierarchical model because it makes no difference whether four different behaviors or two different behaviors observed in two situations each are assigned to the four manifest variables. In order to provide an illustration, greeting behavior is considered. Many people tend to shake hands when coming close to a friend but prefer to greet by waving when the distance is quite large. These are two different behavioral tendencies which depend on the situation. Since the two behavioral tendencies, shaking hands and waving, are usually correlated, it is additionally necessary to consider a trait ξ which can explain this correlation. A trait which serves well for this purpose is friendliness. A person who is very friendly usually tends to shake hands very often and also to wave if there is an opportunity. Friendliness is assigned the role the common latent trait ξ and the behavioral tendencies the role of η which include unique components ζ .

Figure 3 provides a graphical representation of the person-in-situation model. This model suggests that the trait exerts a direct influence on the specific behavioral tendencies and an indirect one on specific behavior. This is indicated by the arrows directed downwards except of the arrows associated with ζ . The other arrows symbolize the error

components. It needs to be added that the situations 1 and 1* and also 2 and 2* are usually not the same. If they were the same, two rather similar behaviors would be assumed to occur in the same situation. For example, it is rather unlikely that people shake hands and wave at the same time.

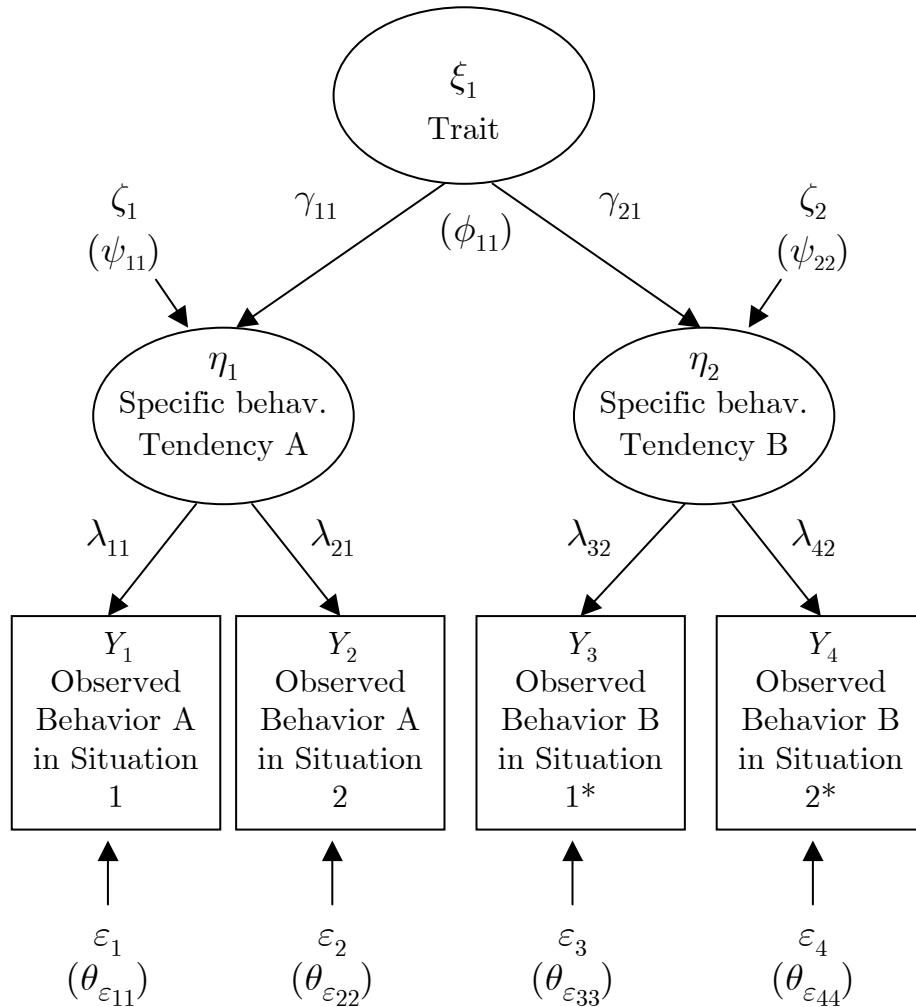


Figure 3. Person-in-situation model for measures associated with different situations.

There are two other models which need to be considered besides the person-in-situation model with respect to the person-situation issue: the model representing the person perspective and the model representing the situation perspective. These additional models are termed person and situation models, respectively. There are two reasons for considering person and situation models besides the person-in-situation model: Firstly, the person-in-situation model is the least parsimonious model when compared with the other models. The person and situation models possess one latent level only. Secondly, there is the theoretical reason which demands the comparison of models corresponding to the three perspectives associated with the person-situation issue. The mani-

fest level and the first-order latent level of the person-in-situation model closely correspond to the situation model and the second and third levels to the person model. The situation model accounts for the correlations between the observations and the person model for the correlations between the behavioral tendencies. Although the person-in-situation model combines all the perspectives, it does not provide the opportunity for comparing the complete models with the sub-models with respect to the data at hand. It is necessary to consider all the models and to compare them with each other.

The person model is not hierarchical since it includes one latent level only. It assumes that there is one trait which exerts a considerable influence on all the behaviors represented by the manifest variables. This means that the person model can be represented by the measurement model equation:

$$Y = \Lambda \eta_{(\text{trait of first level})} + \varepsilon, \quad (5)$$

where $\eta_{(\text{trait of first level})}$ is the first-order factor. This means that η receives the role which is assigned to ξ as common latent trait in the person-in-situation model.

Figure 4 depicts a basic version of this model. The trait relates to four measures of behavior. They can differ considerably as long as there is reason to assume that they are indicators of the same trait. For example, they can differ according to the occasion, to the situation, to the behavioral aspect and to the measurement instrument which was applied. The trait is usually not assumed to determine behavior completely so that behavior can not be predicted exactly. Instead, it is assumed that the trait is one source of influence besides other sources causing random error. In order to provide an illustration, the example provided for the person-in-situation model is modified appropriately. Applying the person model to this example means that the assumption of specific behavioral tendencies is rejected. Instead, it is assumed that there is only one source which is common to all the manifest variables Y and also to every subset of them.

The situation model pertaining to the situation perspective is also not hierarchical. It rests on the assumption that specific stimuli elicit specific behavioral responses. Since specific stimuli are frequently associated with specific situations, behavior usually differs from situation to situation. As a consequence, the situation perspective suggests the replacement of the assumption of a trait as general source of behavior by the assumption of specific sources giving rise to characteristic behavior in specific situations. Accordingly, the situation model assumes that there are sets of similar situations associ-

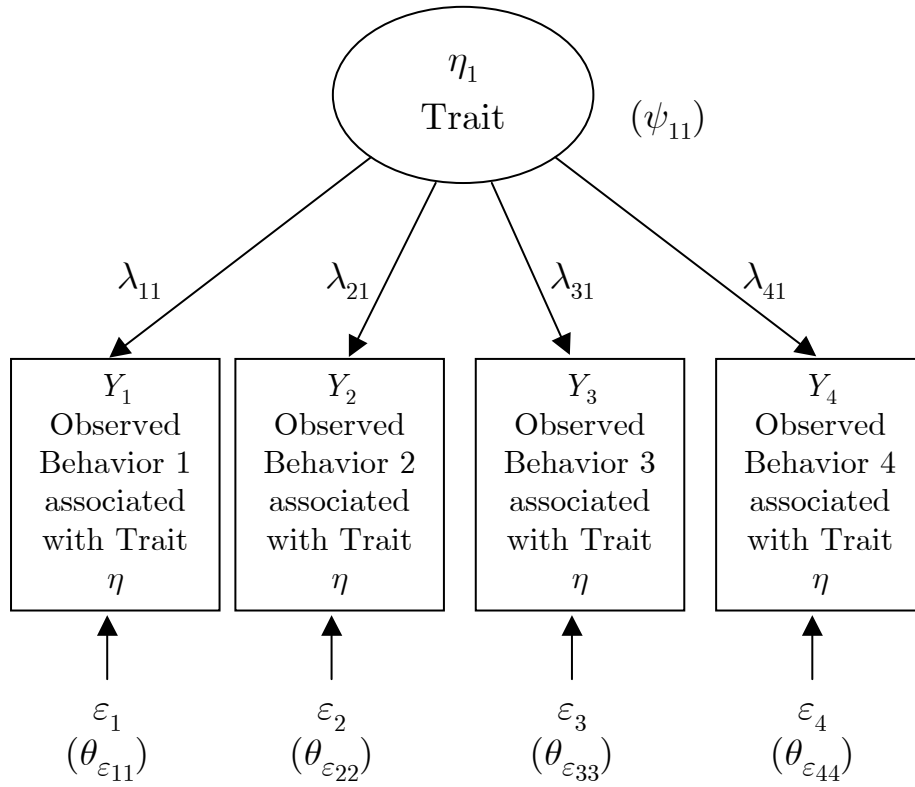


Figure 4. Person model with four measures of specific behavior.

ated with specific behavioral tendencies. The situation model also requires the formal representation by the measurement model equation only:

$$Y = \Lambda \eta_{(\text{behavioral tendencies of first level})} + \epsilon, \quad (6)$$

where $\eta_{(\text{behavioral tendencies of first level})}$ represents the latent variable of the behavioral tendencies. A graphical representation of this situation model is given in Figure 5. Each specific behavioral tendency relates to behavior observed in different situations belonging to the same type of situation. This is indicated by two arrows directed downwards per specific behavioral tendency. In the figure only two specific behavioral tendencies which are selected from a multitude of behavioral tendencies are presented. The errors which are directed upwards indicate that the association between occasion and situation is not assumed to be perfect. In restricting the example provided for the person-in-situation model to the part including the behavioral tendencies an appropriate example is obtainable.

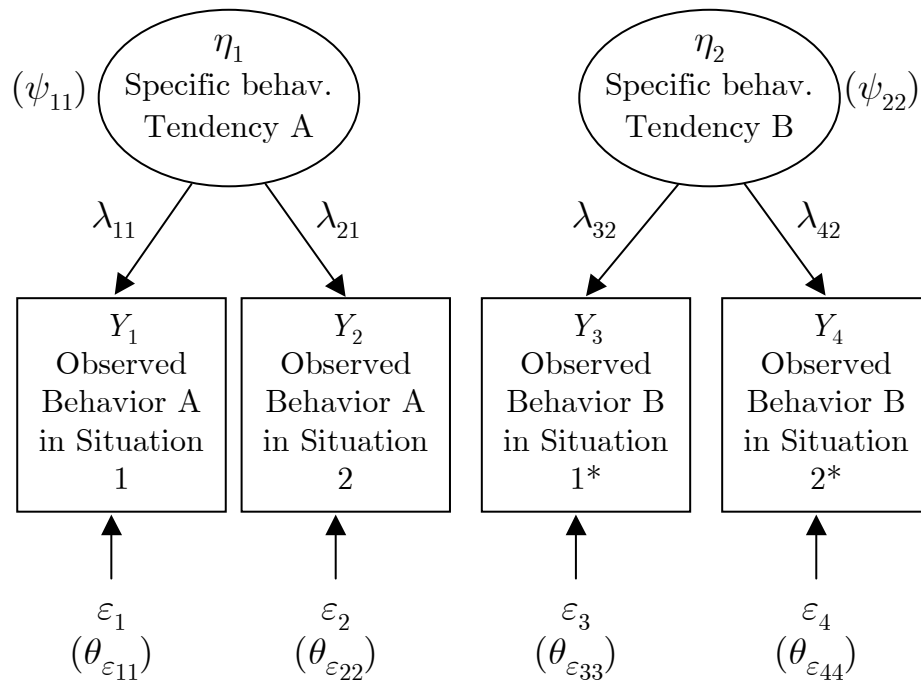


Figure 5. Situation model for measures associated with different situations.

For comparing these models a systematic strategy should be selected: At first, the relationships between the models must be considered. The person model and the situation model are non-nested (see Bollen, 1989, p. 291) so that they cannot be compared by means of the chi-square difference test, but by AIC values. Only if the situation model proves more appropriate than the person model which is the most parsimonious model, the person-in-situation model should be considered. A direct comparison between the situation model and the person-in-situation model is not possible since equation 2 demonstrates that the second level is only a decomposition of what is explained on the first level. Therefore, it is necessary to consider the gamma coefficients of the links relating the latent variables of different levels to each other. Significance of these coefficients means that there is an important contribution of the second-level latent variable.

State-Trait Models: A Longitudinal Approach

State-trait models are also hierarchical models which are characterized by the additional assumption that the first-order latent variables represent states and that the corresponding manifest variables are only allowed to differ according to occasion. This means there is a considerable restriction to potential manifest variables. Since only repeated measures hold with respect to this restriction, state-trait models represent the so-called longitudinal approach.

The General Latent State-Trait Theory (Steyer, 1989; Steyer et al., 1992; Steyer & Schmitt, 1990; Steyer et al., 1999) provides the theoretical basis for investigating the state-trait issue within the framework of structural equation modeling. Latent State-Trait models take into account that psychological measurement always take place in a specific situation. According to Latent State-Trait Theory the manifest variable is not only affected by stable systematic influences ξ induced by person-characteristics or traits, but also by systematic though unstable influences η induced by the situation present at the occasion of testing. The state-trait models decompose the true score of Classical Test Theory (Lord & Novick, 1968) by means of structural equation modeling into components ascribed to latent states, latent traits and latent residuals. This decomposition is the prerequisite for obtaining estimates of reliability, consistency and specificity.

The state-trait model includes the latent states η_1, \dots, η_q , the latent trait ξ and the latent residuals ζ_1, \dots, ζ_q . An example of this model is given by Figure 6. This example includes one trait, two states and four manifest variables.

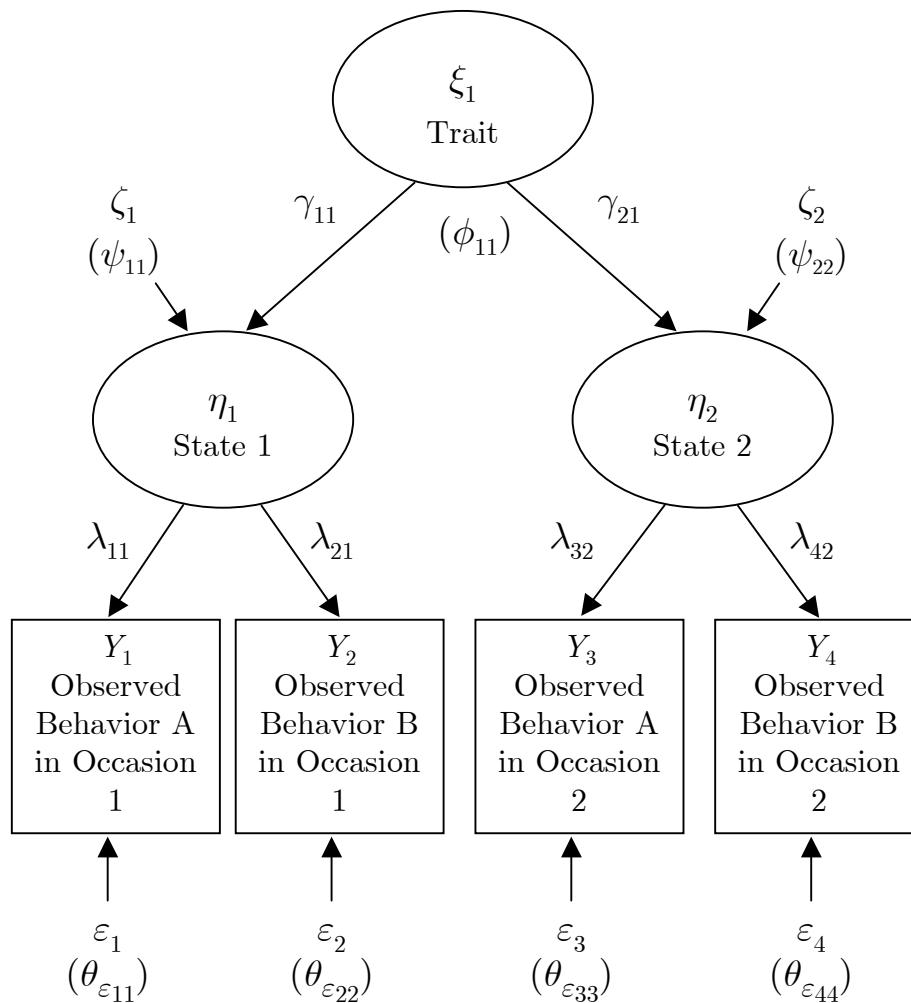


Figure 6. Latent state-trait model for behavior A and B on occasions 1 and 2.

It is important to notice that the manifest variables assigned to the same state only differ according to the behavior (A or B) which is measured. In contrast, the states only differ according to the occasion in which the measurement took place from each other. Furthermore, it should be noted that this model can be formally represented by the same equations as the common-source models and the person-situation models.

Accordingly, there is a close correspondence between trait, state and state-trait models on the one hand and person, situation and person-in-situation models on the other hand. The main difference is the model of measurement (see Alwin & Jackson, 1980) which is selected. There are the factor analytic and true score models. The true-score model is further subdivided into the congeneric, tau-equivalent and parallel-measures models. The various models of measurement differ according to their restrictions. The person, situation and person-in-situation models include the congeneric model of measurement whereas the authors of General Latent State-Trait Theory selected the parallel-measures model of measurement for investigating their examples in order to achieve results which satisfy the requirements of Classical Test Theory (e.g., Deinzer, et al., 1995; Schmitt, 2000; Steyer et al., 1992). Because of the close correspondence of these models with the person, situation and person-in-situation models we do not provide further details.

An Example: The Investigation of the Structure of Social Optimism

The concept of social optimism was proposed as generalized expectancy of a positive outcome concerning social and environmental issues (Schweizer & Schneider, 1997). Social optimism was expected to reflect the reactions to all the negative information with which people have been confronted over the last decades. For the assessment of social optimism a scale was constructed which addressed a great number of social and environmental issues (Schweizer, Schneider, & Beck-Seyffer, 2001). Although all the items of this scale showed appropriate part-whole correlations and loadings on a common factor, the exploratory investigation of the structural properties of the items revealed that one factor is insufficient for an appropriate representation of all the correlations. In contrast, three factors proved to be sufficient for this purpose. They were termed optimism concerning economic affairs, optimism concerning controllability of violence, and optimism concerning predicted disasters. The three factors suggest the existence of three

different types of responses associated with different types of stimuli. These responses are assumed to be due to specific behavioral tendencies represented by η . Therefore, the scale for the assessment of social optimism provides an interesting candidate for illustrating the construction and investigation of person-situation models.

Participants

The sample included the data of 462 adults (41 percent males and 59 percent females). The mean age of the sample was 29.68 years of age ($SD = 12.37$). This sample is described in more detail by Schweizer et al. (2001).

Measurement Instrument

Social optimism was assessed by means of the Social Optimism Scale (SOS), a part of the Personal Optimism and Social Optimism Questionnaire POSO (Schweizer et al., 2001). The SOS scale comprises 24 items. The items address the following issues: abuse of energy and mineral resources, environmental pollution, lack of consideration for such problems, security of old age pension, drug abuse, immigration problems, violence, crime, economic development, reduction of the quality of live, perspectives for the next generation, and welfare. There were two items per issue, one item included a positive statement and the other one a negative statement. Furthermore, there were four response alternatives (“correct”, “almost correct”, “partly correct”, “incorrect”). For didactic reasons the number of items selected for this demonstration was restricted to 18.

Hypothesis

The results of the previous studies give rise to the expectation that the person-in-situation model provides the best representation of the data. This means: the model including a second-order latent variable representing social optimism and three first-order latent variables representing optimism concerning economic affairs, optimism concerning controllability of violence, and optimism concerning predicted disasters represents the structure of the data appropriately.

Statistical Analyses

The pairs of items of addressing the same issue were averaged in order to have one score per issue. This means issues were considered in constructing models instead of items. Before averaging, each item which included a negative statement was recoded in

order to assure that the numbers assigned to the response alternatives have the same meaning. Then the covariances between the nine manifest variables were computed.

We used confirmatory factor analysis (CFA) to test hypotheses related to the structure of Social Optimism. All analyses were based on the covariance structures using the ML estimation procedure of the LISREL (version 8.5) program (Jöreskog & Sörbom, 1996).

The fit of each model was evaluated by examining model chi-squares and degrees of freedom, goodness-of-fit index (*GFI*; Jöreskog & Sörbom, 1989), root mean square error of approximation (*RMSEA*; Steiger, 1990), normed comparative fit index (*CFI*; Bentler, 1990), and nonnormed fit index (*NNFI*; Bentler & Bonett, 1980), and Akaike Information Criterion (*AIC*; Akaike, 1987). Good model fit was judged by $\chi^2/df < 2.0$, $RMSEA < .05$ (Browne & Cudeck, 1993, p. 144), $GFI > .95$, $AGFI > .90$ and CFI , $NNFI > .97$, and model $AIC < AIC$ for the alternative model (for interpretation details see Schermelleh-Engel, Moosbrugger & Müller, 2003).

Results Concerning the Person-in-Situation Model

As we can see, the data can be explained sufficiently by the common-source model with one second-order trait (social optimism, ξ_1) and three first-order traits (EAO, η_1 ; CVO, η_2 ; PDO, η_3), each measured by three manifest variables. The data fit the model well with $\chi^2(24, N = 462) = 35.73$, $RMSEA = .03$, $GFI = .98$, $AGFI = .97$, $CFI = .99$, and $NNFI = .99$. Figure 7 provides a graphical representation of this model with all estimated parameters.

The λ coefficients which indicate the relationships between the manifest and latent trait variables (first-level traits) vary between .46 and .90. The reliability of the indicator variables ($1 - \theta_e$) varies between .81 for Y_4 and .31 for Y_7 . The γ coefficients of the links which relate the second-order latent trait to the first-order latent variables are considerable: The γ coefficients indicate that Social Optimism predicts 100 percent of Optimism concerning Predicted Disasters, 65 percent of Optimism concerning Economic Affairs, and 42 percent of Optimism concerning Controllability of Violence. The variances (ψ) of the latent residuals (ζ) denote the unique components of the first-order latent variables. The largest unique variance is indicated for Optimism concerning Controllability of Violence with 58 percent of the variance of the latent variable. This means that the first-order latent variables are to a high degree determined by the second-order latent variable.

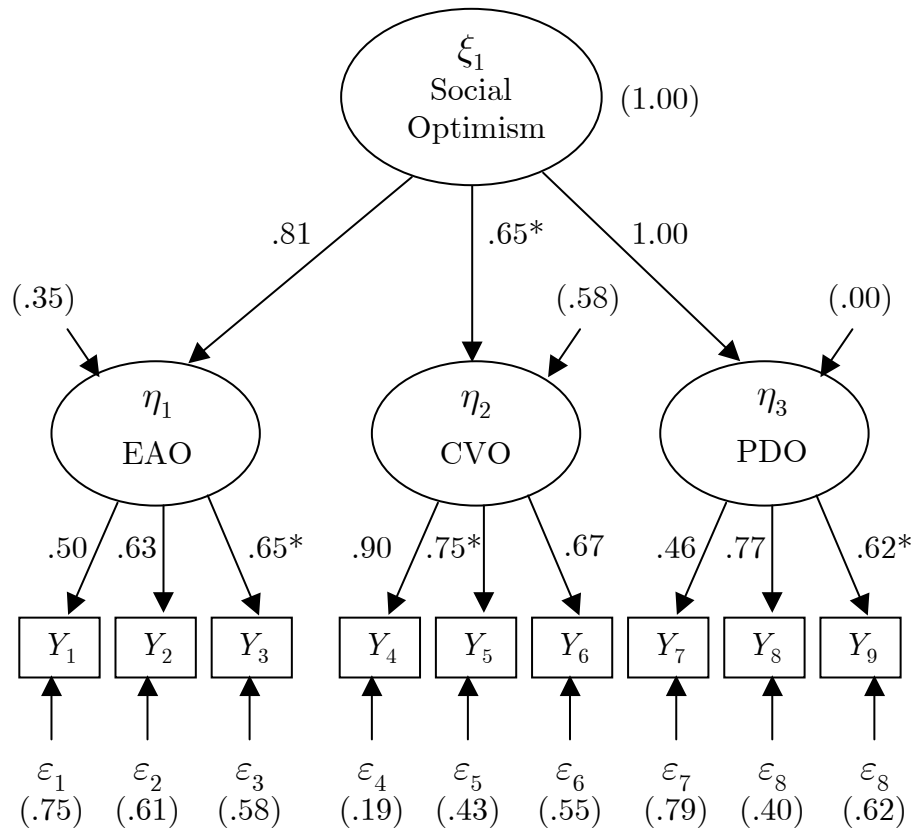


Figure 7. Second-order CFA parameter estimates of the model for social optimism, three first-level traits, optimism concerning economic affairs (EAO), optimism concerning controllability of violence (CVO), optimism concerning predicted disasters (PDO) and nine manifest variables (completely standardized solution; values in brackets indicate variances; * indicates the reference variables fixed to one in the unstandardized solution).

Results Concerning all Models

The investigation of the optimism data (Schweizer et al., 2001) with respect to the person, situation and person-in-situation models led to the fit statistics which are given in Table 1.

The fit indices presented in the first row indicate that the person model was inappropriate. There is not even one index that suggests that the model fits the data (for a detailed interpretation of fit indices see Schermelleh-Engel et al., 2003). This means that the person model is not appropriate for representing the data. The fit indices of the situation model are presented in the second row.

Table 1

Fit Statistics of the Person Model, the Situation Model, and the Person-in-Situation Model

Model	χ^2	<i>df</i>	<i>RMSEA</i>	<i>CI</i> ^a	<i>GFI</i>	<i>CFI</i>	<i>NNFI</i>	<i>AIC</i>
Person model	316.10	27	.15	.14 ; .17	.87	.89	.85	352.10
Situation model	35.73	24	.03	.00 ; .05	.98	.99	.99	77.70
Person-in-situation model ^b	35.73	24	.03	.00 ; .05	.98	.99	.99	77.70

^a Limits of confidence interval. ^b These results correspond to the results presented for the common-source model.

The fit of this model improved substantially compared to the person model. Model fit may now be interpreted as a good fit to the data as indicated by a smaller *AIC* value (77.70 compared to 352.10), $\chi^2/df < 2$, *RMSEA* < .05, *GFI* > .95, and *CFI* and *NNFI* > .97. This means that the situation model is quite appropriate for representing the data. However, the correlations between the situation factors were considerable with significant coefficients of .53, .56, and .62 (standardized solution). Therefore, it was reasonable to consider the person-in-situation model additionally.

In the person-in-situation model the latent state variables are not only correlated but explained by a general trait capturing variance common to all situations. The difference between the two models is that in the situation model the latent situation factors are only correlated, while in the person-in-situation model the covariances between the three situation factors are explained by a single trait or second-order variable. The fit indices of the person-in-situation model are given in the third row, and it is obvious that the values are exactly the same as the values obtained for the situation model.

The reason for this equivalence is that both models are statistically identical. Since there are only three latent situation (first-order) variables in the person-in-situation model, the higher-order model is only just identified with 6 parameters to be estimated. A model test of the higher-order structure would require to have four or more latent situation variables. Since the γ coefficients - the loadings of the first-order on the sec-

ond-order variables - are significant and the magnitude of these effects is quite substantial, a single latent trait (and not two or more traits) explains the covariances between the situation factors in the person-in-situation model. Therefore, from a theoretical point of view the person-in-situation model is the best representation of the structure of the optimism data.

Discussion

Hierarchical confirmatory factor analysis possesses a considerable potential for investigating models representing a large number of different structures, which can be obtained by slightly modified model specifications. Such structures characterize theories which primarily originate from differential psychology but also from developmental psychology, social psychology or the applied psychological sciences. Within these fields confirmatory factor analysis is applied with different aims in mind. One typical aim is the investigation of the appropriateness of the formal representation of structure. Another aim is the comparison of the complete model with sub-models in order to find the most parsimonious representation of the structures. Such comparisons are necessary in investigating person-situation models and state-trait models. There are further aims which have not been addressed in this paper so far. There is the comparison of models representing different structures. In the course of developing theory comparisons can provide valuable information by ruling out inappropriate alternatives. The investigation of invariance is another aim which motivates the application of confirmatory factor analysis. These aims are important in the context of a large number of issues which deserve investigation.

In order to have an illustration, the person-situation models were applied to data obtained by means of an optimism questionnaire. The data provided the opportunity to consider one common trait, three specific behavioral tendencies or a hierarchical combination of one second-order trait and three first-order specific behavioral tendencies alternatively. It was the model including two latent-levels which best represented the data. Obviously, social optimism shows a hierarchical structure. There is the general behavioral tendency to respond in a characteristic way to all the optimism items. But this tendency is not strong enough to completely dominate behavior. There are three more specific behavioral tendencies which also exert influence on behavior. The explanation of the responses to the optimism items requires the consideration of all the behavioral tendencies in order to be appropriate.

In comparing the models included in the classes initially presented it becomes obvious that some of the specific models are actually the same. Furthermore, there are differences due to different interpretations. In the common-source and person models the responses to the questionnaire items are considered as observations of behavioral acts “associated with the trait” and in the situation-in-trait and situation models as observations of behavioral acts “associated with a specific situation type”. Moreover, in the common-source and person models the first-order latent variables were considered as traits and in the person-in-situation and situation models as specific behavioral tendencies. The approach of the person-situation models suggest the comparison of person, situation and person-in-situation models. In contrast, such a comparison is not suggested by the approach of the common-source model.

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