Situational dependence of emotions and coping strategies in children with asthma. A three-mode component analysis

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Situational Dependence of Emotions and Coping Strategies in Children with Asthma: A Three-Mode Analysis

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Abstract

In a study to evaluate the influence of asthma on the daily functioning of children in primary school, 119 children with asthma were confronted with 8 situations, and they were asked to indicate how they would react in these situations on 9 scales consisting of 4 emotions plus 5 coping strategies. The $8\times(4+5)\times119$ situations by scales by children data set was analysed with three-mode principal component analysis to investigate the situational dependence of the children's judgements and the individual differences in such judgements. Apart from the substantive motivation, this paper also aims to illustrate how three-way rating scales of an individual differences stimulus (situation) – response (emotions and strategies) format can be analysed with three-mode methods.

1. Introduction

In pediatric literature, children's coping strategies have been studied with respect to self-management of asthma (Bernard-Boddin et al., 1995). Although knowledge of disease-related stress is valuable, research also is necessary on children's ways of handling everyday stress, which should provide a deeper understanding of asthmatic children's coping repertoire as well. Moreover, Boekaerts argued that existing inventories to measure coping do not take into account the cognitions and emotions that are part of the stressful episode, simply because these questionnaires are not sensitive to context (Boekaerts, 1996; Boekaerts and Röder, 1999). Boekaerts and her colleagues defended the view that individuals make a mental representation of a stressor and the coping goal they use to deal with the stressor. This mental representation varies with the context in which the stressor occurs. The Stress and Coping Questionnaire for Children (School and Asthma version) that was used in this study registers the child's perception of the frequency of occurrence of the stressor, the intensity of various emotions, and the coping strategies that children consider using in the situation. For its construction, three questionnaires measuring coping in children were used, the Dutch Student Stress and Coping Inventory (see Röder, 2000, pp. 253–255, for the English version), the Kidcope (Spirito, Stark, & Williams, 1988), and the Self-Report Coping Scale (Causey and Dubow, 1992).

2. Method

2.1. Subjects

The sample consisted of 119 children with asthma, who were recruited through general practitioners and an asthma nurse (N= 95). In addition, an advertisement led to the inclusion of an additional 24 families. The sample consisted of 63 boys (53%) and 56 (47%) girls, with a mean age of 10.2 years (SD=1.7), ranging from 8 through 14 years. Ninety-six children (81%) were in grades 3 through 6. The rest of the children attended secondary school.

2.2. Instrumentation

The most important characteristic of the questionnaire is that stress and coping are measured as domain-specific constructs, meaning that children's emotional responses and coping strategies are registered in response to specific stressful events, both asthma-related and school-related. These responses and strategies were measured for three common stressors and one disease-related stressor. The common situational stressors consisted of *Problems with school work*, *Rejection by peers*, and *Conflict with authority*. The situation *Shortness of breath* was the disease-related stressor, mirroring the Asthma Coping Questionnaire for Adults (Maes et al., 1987). Each situational stressor was covered by two descriptions. Problems with schoolwork consisted of *Failure in the classroom* and *Too much school work*. Rejection by peers consisted of *Being bullied at school* and *Not allowed to join in play at school*. Conflict with authority consisted of *Being constrained by the teacher* and *Being constrained by parents*. Shortness of breath consisted of *Being short of breath in the classroom* and *Being short of breath at home*. As an operational check the frequency of occurrence of these stressors during the last few months was rated on four-point Likert-scales, but these frequencies do not play a role in the present study.

Descriptions of each situation started with four questions about children's emotional responses. Emotional responses were operationalised in terms of the intensity of the emotions *Anger*, *Anxiety*, and *Sadness*. A question that referred to a general feeling of being upset was added, called *Annoyance*. Children rated their answers on four-point Likert scales: (1) not at all, (2) somewhat, (3) rather, (4) very much.

Five coping strategies were chosen on the basis of their salience in child research: *Approach coping*, *Avoidance coping*, *Seeking social support*, *Use of aggression*, and *Crying* (see Röder, 2000, p. 104). Coping items for asthma were based on two studies, in which children's responses to shortness of breath were described (Kolhman et al., 1991; Ryan-Wenger and Walsh, 1994). In order to ensure comparability of coping strategies across the various stressors, items were worded as similarly as possible in the descriptions of each situation. For each stressful situation the children were asked whether they (1) almost never, (2) sometimes, (3) often, or (4) almost always, used the described coping behaviour.

2.3. Procedure

A meeting for the children with asthma was organised in each city or village where the families lived. When it was not possible for children to come to such meetings, an appointment was made for a home visit. A research assistant read aloud the questions to the children in Grades 3 and 4, in order to control as much as possible for any differences in reading comprehension. However, the children filled in the answer to that question themselves, in order to insure self-report.

2.4. Analysis methods

The data in this study thus consisted of scores of the 119 children with asthma on nine scales consisting of four emotions (Annoyed, Sad, Afraid, Angry) and five coping strategies (Approach coping, Avoidant coping, Seeking support, Aggression, Crying) measured in eight situations (Something does not succeed, Not allowed to participate, Something is disallowed by the teacher, Being bullied, Problems with school work, Something is disallowed by the mother, Shortness of breath in class, Shortness of breath at home). The data can therefore be arranged in a 9 by 8 by 119 three-dimensional data block.

In this paper, we will treat the data as so-called multiway rating data (see

Kroonenberg, 2008, Chapter 14). This implies that we assume each child makes a judgement of the strength of the association between a scale and a situation and assigns a number between 1 and 4. As the interest is in the relationships between situations and scales and individual differences between children in their perceptions of the relationship, all scales for all children were centred so that the averages of all scales for all children were removed. Moreover, also the average scores a child gave to the situations were removed because we were not interested whether some children gave a higher mean score across all scales for a situation but in the way they ordered the scales around the situation mean. Effectively, the scores were thus double-centred and the resulting score contains exclusively the scales–situations interaction for each child.

To understand the nature of what is being analysed, it is useful to look at the data as if they came from a three-way analysis of variance design with a single observation per cell (x_{ijk}). This analysis-of-variance model has the form

$$x_{ijk} = \mu + \alpha_i + \beta_j + \gamma_k + \alpha\beta_{ij} + \alpha\gamma_{ik} + \beta\gamma_{jk} + \alpha\beta\gamma_{ijk}, \tag{1}$$

where the single-subscripted terms are the main effects, the double-subscripted terms the two-way interactions and the final term the three-way interaction. The effect of the double centring applied to the data before the three-mode component analysis, is that all terms are removed except the situation–scale interaction and the three-way interaction, i.e.

$$x_{ijk} = \alpha\beta_{ij} + \alpha\beta\gamma_{ijk}. \tag{2}$$

The first term indicates the situation–scale interaction averaged over all children and thus expresses their consensus with respect to the relationship between situations and scales. The second terms indicates the individual differences between the children in judging the relationships between the scales and the situations. The sums of squares of these interactions are 538 and 1892, or 22% and 78%, respectively, showing that the three-way interaction is about 3.5 times as large as the two-way interaction. By far the larger part of the three-way interaction will, however, not contain systematic information but only random error. One should therefore not expect to have large explained variances for the analyses to be reported. What the proposed analysis will do is separate as much systematic information as possible from a large amount of noise.

One could decide to analyse the two remaining interactions independently. A drawback of this is that it is difficult to establish the relations between the results of the two analyses. The other possibility is to analyse the interactions together and this is the course followed in this paper. In particular, the centred scores were analysed with three-mode principal component analysis (Tucker, 1966; Kroonenberg, 2008). The basic outcomes of such an analysis are three sets of components, one set for situations, $\mathbf{A}$, one set for scales $\mathbf{B}$, and one set for the children $\mathbf{C}$ plus a weight matrix, called the core array, $\mathcal{G} = \mathbf{G}_1, \ldots, \mathbf{G}_R$. For each component r of the children, $\mathbf{G}_r$ indicates the strengths of links between the scale and situation components, much in the same way as eigenvalues indicate the strength of the components for the subjects and variables in ordinary or two-mode principal component analysis.

More formally, Tucker's three-mode principal component model approximates each child's data, $\mathbf{X}_k$, as

$$\mathbf{X}_k = \sum_r c_{kr}\mathbf{\Delta}_r + \mathbf{E}_k = \sum_r c_{kr}\left(\mathbf{A}\mathbf{G}_r\mathbf{B}'\right) + \mathbf{E}_k, \tag{3}$$

where $\mathbf{E}_k$ indicates the lack of fit of the model to the data of child k. From the formulation it can be seen that for each child component r the expression between

brackets, $\mathbf{\Delta}_r = \mathbf{A}\mathbf{G}_r\mathbf{B}'$, looks like an ordinary principal component analysis where the matrix $\mathbf{G}_r$ parallels the matrix with the square roots of the eigenvalues. The complete name for $\mathbf{\Delta}_r$ would be the "situation–scale configuration matrix for the rth component of the child mode", as they contain the relationships between the situations and scales corresponding to the rth child component. For convenience sake, they will be referred to as the *situation–scale configuration matrices*. It is these configurations which will supply us with the major answers to our research questions.

One of the major differences with ordinary principal component analysis is that the matrix $\mathbf{G}_r$ is not necessarily square nor diagonal. The nondiagonality implies that each component of the scales, $\mathbf{b}_q, (1, \ldots, Q)$ can have a link with each component of the situations $\mathbf{a}_p, (1, \ldots, P)$. Furthermore, we see that each child weighs the situation–scale configuration $\mathbf{\Delta}_r$ with a coefficient c_{kr}, so that for children with a large positive c_{kr} the situation–scale configuration is large, and for children with a small positive c_{kr} the configuration is small, while it is irrelevant for children with a near-zero value for c_{kr}. Negative values on the component mean that the relationships between the scales and situations are reversed.

Because our prime interest is focussed on the strategies and emotions children use in different situations, and whether there are individual differences in this respect, the results will presented with plots for each situation–scale configuration matrix $\mathbf{\Delta}_r$. Such plots are called *joint biplots* because they display the situations and scales jointly and have the properties of standard biplots (see Kroonenberg, 1994, 2008, Chapter 11, for technical details of joint biplots and references to biplots in general). As it turned out, the joint biplot for $\mathbf{\Delta}_1$ describes the general consensus between the children about what they do in which situation, because virtually all children's weights c_{k1} on the first child component have the same signs. However, the weights vary in size so that this situation–scale configuration has a different quantitative importance or size for the children. The joint biplot for $\mathbf{\Delta}_2$ describes their qualitative individual differences because their c_{k2} are different both in sizes and signs. In an attempt to explain these individual differences the component coefficients c_{kr} of the children were correlated with available background variables.

3. Results

The fit of all three-mode PCA models which had a complexity less or equal to the $3 \times 3 \times 3$ model was examined via an deviance plot (Figure 1). The five models on the convex hull shown in the figure are candidates for further inspection. The Ceulemans and Kiers (2006) *st*-criterion suggests a $3 \times 3 \times 1$ model (24% explained variability) as the convex hull at that point has the smallest angle (ca. 140^o), but such a model does only allow for quantitative individual differences as virtually all c_{k1} are positive. The positiveness can be seen by projecting all child points on the first axis in Figure 2. To be able to look in more detail at individual differences, it was decided to report a model with 3 situation components, 3 emotion-strategy components and 2 child components, but note that the convex hull at that point has an angle which is larger (ca. 180^o) than that for the simpler model. The $3 \times 3 \times 2$ model explained 29% of the combined two-way situations–emotions & strategies interaction and three-way interaction. This shows that the three-way interaction contained systematic information as the explained variability is more than the 22% variability of the two-way interaction on its own. The more so because the two-way interaction also contains a certain amount of random error.

3.1. Children's scores

The 29% explained variability of the $3 \times 3 \times 2$ model can be split into contributions of each of the child components, 24% and 5% respectively. To evaluate

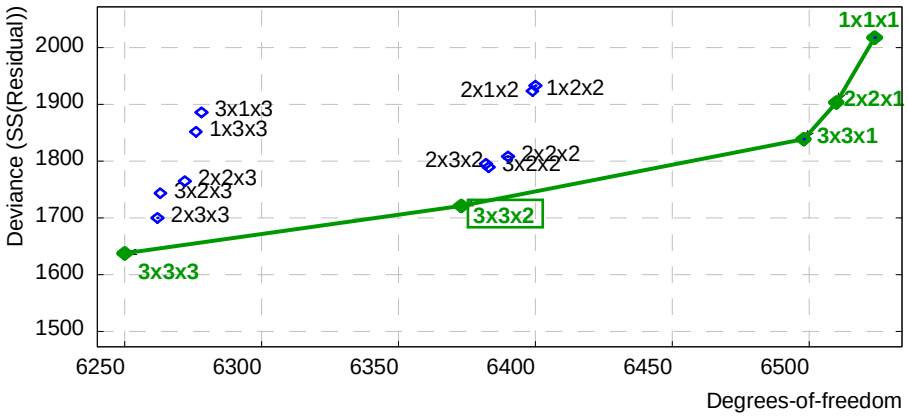

Fig. 1 Deviance plot showing the residual sums of squares versus the degrees of freedom of all Tucker3 models with complexity equal are lower than the 3×3×3 model. The models on the convex hull are connected and the preferred 3×3×2 model is boxed.

the child scores they have been plotted in Figure 2. There are only a few children (such as 5, 13, 33, and 75) who have scores of nearly zero on the first component, indicating that the consensus view contained in the situation–scale configuration is not shared by them. The second component shows the differences between the children, the nature of which will be discussed below.

In three-mode principal component analysis it is possible to partition the fitted sums of squares for the entire model into a separate part for each of the children, in the same way this done in the "communalities" in standard PCA. The fit values differ vastly, their range is from 59% to 3%, compared to an overall fit of 29%. Clearly, the ill-fitting children contribute considerably to the low fit to the interactions.

Additional information about the children, such as the educational level of their parents, the severity of their asthma symptoms, and other background variables were available. For a subset of children ($N = 71$) also their reading and arithmetic scores were present. Unfortunately, of the background variables the only significant and sizeable correlation was between educational level of the parents and the second child component: $r = .27; p = .012$.

3.2. Consensus solution and quantitative individual differences

The easiest way to compute the coordinates for the joint plot is to perform a singular value decomposition on the matrix and use a symmetric scaling for the components. More precisely

$$\mathbf{\Delta}_r \;=\; \mathbf{U}_r\mathbf{\Lambda}_r\mathbf{V'}_r, \tag{4}$$

and

$$\mathbf{A}_r = ((I/J))^{1/4}\mathbf{U}_r\mathbf{\Lambda}_r^{1/2} \text{ and } \mathbf{B}_r = (J/I)^{1/4}\mathbf{V}_r\mathbf{\Lambda}_r^{1/2}. \tag{5}$$

Fig. 3 displays the joint biplot for the situation–scale configuration matrix $\mathbf{\Delta}_1$ associated with the first child component. The consensus among the children is that they try to solve their problems with school work (Approach coping of

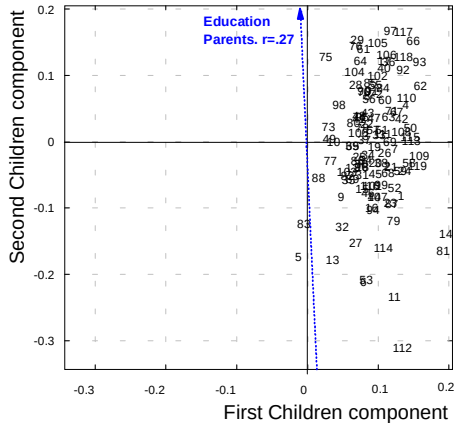

Fig. 2 Component space of child mode. Regression line of best fit (r = .27) for Education parents is included. Note that the axes are presented in normalised coordinates, so that the distances between the points are not accurately displayed in the figure.

Problem with school work (1)), they run away from conflicts with their mothers and teachers (Avoidant coping of Conflicts with authority (3)), they react with anger and aggression in conflicts with their peers (Angry and Aggression with Rejection by peers (4)), and finally with respect to their asthma they seek support from their social network (Social support, Afraid, Annoyed with Shortness of breath (2)).

3.3. Qualitative individual differences in judgements

Fig. 4 displays the joint biplot for the situation–scale configuration matrix $\mathbf{\Delta}_2$ associated with the second child component. The individual differences patterns associated with this joint biplot moderate the conclusions derived from the first joint biplot. The joint biplot shown applies to children who tend to have better educated parents, while a similar plot but with scales mirrored around the origin shows the patterns for the children who tend to have parent with less education. For instance, the first kind of children tend to seek more social support when rejected by peers, tend to resort more to approach coping strategies when confronted with problems at school, and tend to be more angry and aggressive towards the situations with shortness of breath. On the other hand, the second kind of children tend to get more angry and aggressive when rejected by peers than is already indicated in the consensus solutions, and they tend to resort more to avoidance coping when faced with shortness of breath and problems with school work than the first group. Note that all these patterns can be seen as corrections or specifications with respect to the consensus patterns.

4. Discussion

Children were in general agreement that they would use (1) avoidant coping strategies if things were disallowed by authority, (2) approach coping when they were short of breath or had problems with school work, and (3) that they would get sad, angry, and aggressive if they were rejected by their peers.

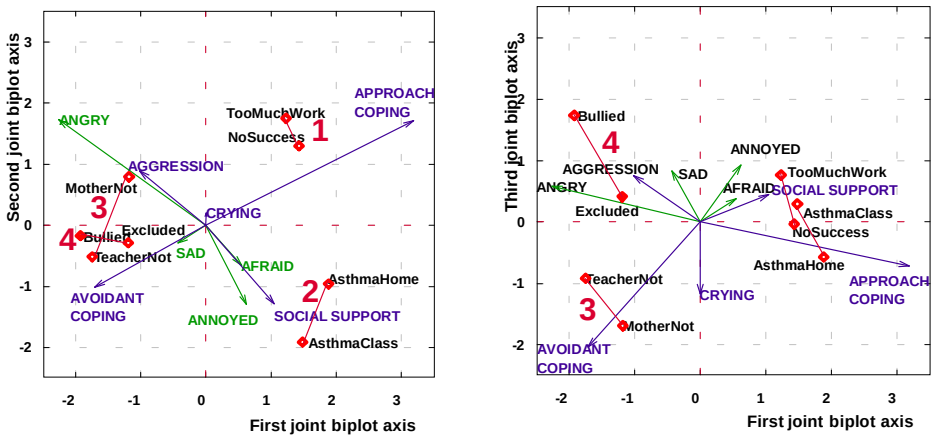

Fig. 3 Joint biplot of Situations and Emotions+Strategies for first Child component (Common Perspective) 1. Problems with school work; 2. Shortness of breath; 3. Conflict with authority; 4. Rejection by peers.

Of the explanatory variables available, only parental education had a, be it weak ($r = .27$), relationship with the individual differences found. In particular, the children who said that they would react with anger and aggression when short of breath, but not when being bullied, tended to have more educated parents. While children, for whom the reverse was true, tended to have less educated parents. In addition, children who tended to have more educated parents said that they would use approach coping rather than avoidant coping when they had problems with school work, but not when being disallowed something by their mothers or teachers. For the other kind of children, the reverse was true. The lack of relationship with the available external background variables which could have explained the different behaviour of the children suggests that in research such as this extensive data on the personality of children might be necessary to explain the observed differences.

The patterns very clearly show that the reaction of children is very much context dependent and that it is a mistake to investigate the reactions of children independent of the context in which they find themselves. This confirmed the contention expressed by Boekaerts (1996); Boekaerts and Röder (1999).

By using three-mode principal component analysis it was possible to unravel the complex relationships between the reactions of children in different situations and it was possible to point to different types of children. Essential in the understanding of the analysis was the use of appropriate plots to visualise the relationships.

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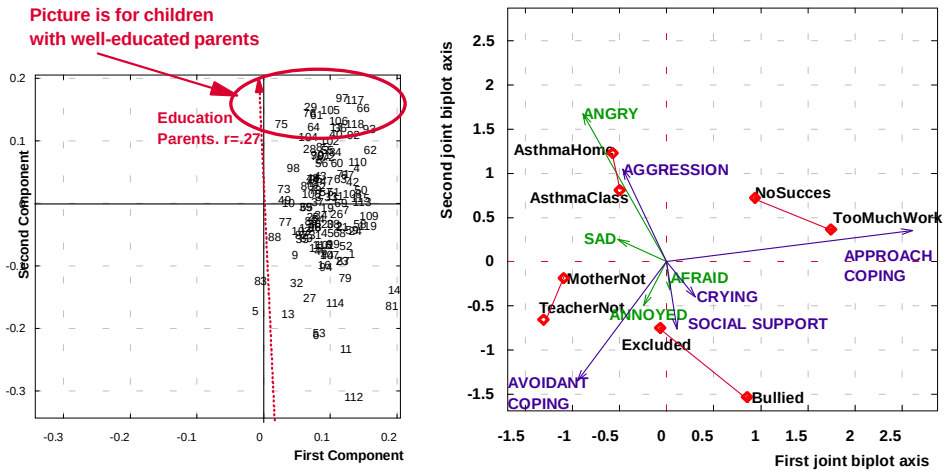

Fig. 4 Joint biplot of Situations and Emotions+Strategies for second Child component (Individual Differences) 1. Problems with school work; 2. Shortness of breath; 3. Conflict with authority; 4. Rejection by peers.

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