# Three-Mode Principal Component Analysis: Theory and Applications

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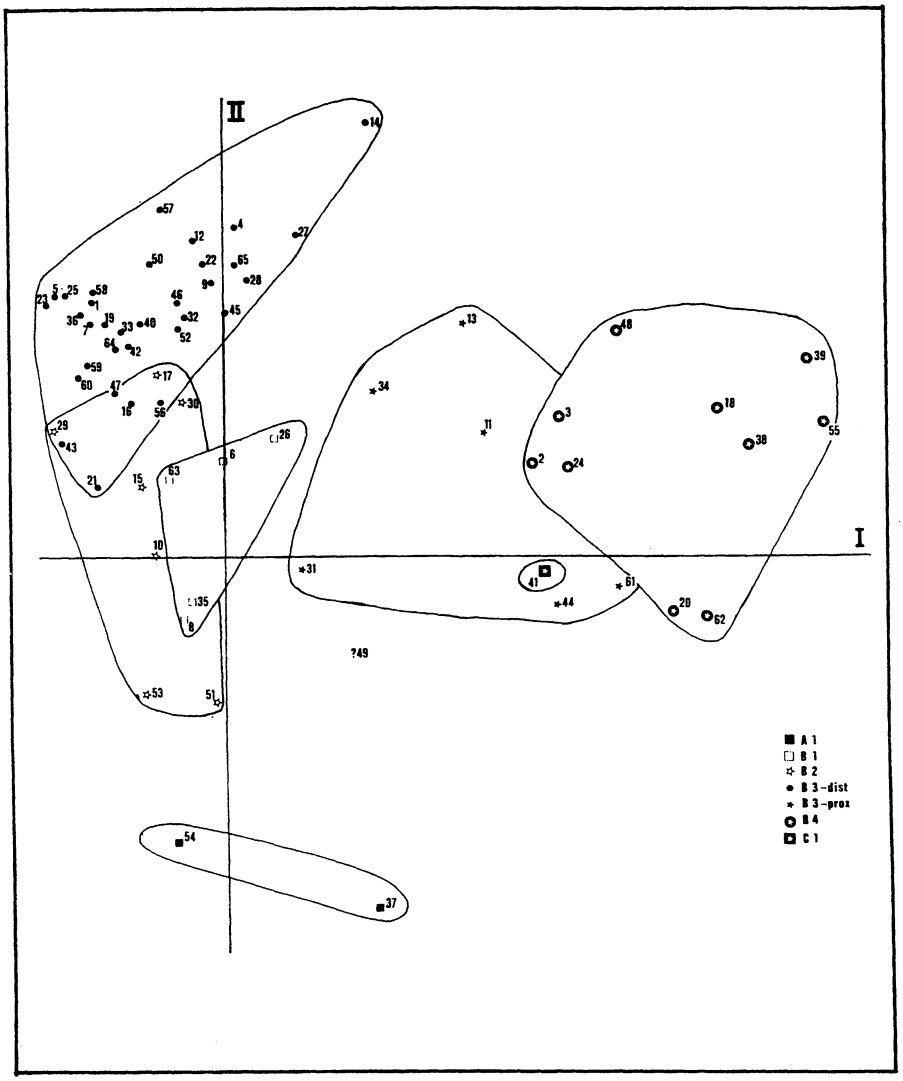
# STANDARD THREE-MODE DATA

# 8

**attachment study**



## 8.1 DESIGN AND DATA DESCRIPTION

In this chapter we present a relatively straightforward analysis of data collected by Goossens (Note 1) on the reactions of two-year old children to a stranger and to their mothers in an unfamiliar environment within the context of a standardized observation procedure called the *Strange Situation (Patterns of Attachment (POA)*, Ainsworth, Blehar, Waters, & Wall, 1978). The practical aspects and theoretical considerations which form the foundation of the strange situation are covered in many publications including the above, as the measurement procedure has become a standard one in developmental psychology. Therefore we will not dwell in detail on the strange situation, but only treat those aspects necessary to an understanding of the data and their analysis.

In the course of the strange situation the child is subjected to increasingly stressful circumstances (i.e. arrival of a stranger, leaving of the mother, being left alone) in order to elicit 'attachment behaviours'. *Attachment* itself is defined as "the affectional bond or tie that an infant forms between himself and his mother figure - a bond that tends to be enduring and independent of specific situations", and *attachment behaviours* are defined as "the class of behaviours that share the usual or predictable outcome of maintaining a desired degree of proximity to the mother figure" (Ainsworth et al., 1978, p. 302).

As Ainsworth et al. point out (p.33), the sequence of episodes is very powerful both in eliciting the expected behaviours, and in highlighting individual differences. The major purpose of the procedure is to assess the quality of the attachment relationship of a child to its mother-figure. A summary of the procedure is

given in Table 8.1A. The major types of attachment are *secure attachment* (B-children), *anxiously resistant attachment* (C-children), and *anxiously avoidant* attachment (A-children).

Table 8.1 *Attachment study: Description of strange situation, interactive scales, and classification system*

A. *Strange situation*, (*POA*, p.37)

| Episode | Persons | Duration | Brief description of action |
|---|---|---|---|
| 1 | mother, child, observer | 30 secs. | Observer introduces mother and baby to experimental room, then then leaves. |
| 2 | mother, child | 3 min. | Mother is non-participant while child explores; if necessary, play is stimulated after two minutes |
| 3 | stranger, mother, child | 3 min. | Stranger enters. First minute: stranger silent. Second minute: stranger converses with mother. Third minute: stranger approaches child. After three minutes mother leaves unobtrusively. |
| 4 | stranger, child (S4) | 3 min. or less 1) | First separation episode. Stranger's behaviour is geared to that of the child. |
| 5 | mother, child (M5) | 3 min. or more 2) | First reunion episode. Mother greets and/or comforts child, then tries to settle it again in play. Stranger leaves unobtrusively in the meantime. Mother leaves saying "bye bye". |
| 6 | child alone | 3 min. or less 1) | Second separation episode. |
| 7 | stranger, child (S7) | 3 min. or less 1) | Continuation of second separation. Stranger enters and gears behavior to that of the child. |
| 8 | mother, child (M8) | 3 min. | Second reunion episode. Mother enters, greets child, then picks it up. Meanwhile stranger leaves unobtrusively. |

1) Episode is curtailed if the child is unduly distressed.
2) Episode is prolonged if more time is required for the child to become reinvolved in play.

Table 8.1 *(cont'd)*

B. *Interactive scales (POA*, p.53, 54)

- Proximity (or contact) seeking (PROX): a measure for the degree of active initiative a child shows in seeking physical contact with or proximity to an adult.
- Contact maintaining (CM): a measure for the degree of active initiative a child exerts in order to maintain physical contact with a person, once such contact is achieved.
- Resistance (RES): a measure for the degree of angry and/or resistant behaviour to an adult. It is shown by physically rejecting an adult who tries to come into contact or initiate interaction with the child.
- Avoidance (AVOI): a measure for the degree of avoiding proximity and interaction with an adult, for instance by ignoring or looking away.
- Distance interaction (DI): a measure for the degree in which a child interacts with an adult from a distance, for instance, by showing toys and talking.

C. *Ainsworth Classification Categories* (based on *POA*, p. 59-63; Sroufe & Waters, 1977)

Behaviour towards the mother

| | PROX | CM | RES | AVOI | DI | most salient feature | behaviour towards stranger |
|---|---|---|---|---|---|---|---|
| A1 | - | - | - | ++ | - | disinterested | treatment more or |
| A2 | +(+) | - | (+) | ++ | - | mixed feelings | less like mother |
| B1 | (+) | - | - | - | ++ | secure | friendly towards |
| B2 | +(+) | (+) | - | (+) | +(+) | secure | stranger but mo- |
| B3 | ++ | ++ | - | - | -/++ | very secure | ther is clearly |
| B4 | ++ | ++ | (+) | - | - | secure | preferred and sought after |
| C1 | ++ | ++ | ++ | - | - | angry ambivalent | treatment more or |
| C2 | (+) | (+) | ++ | - | (+) | passive | less like mother |

- low; (+) low to moderate;
+ moderate; +(+) moderate to high;
++ high.

*POA: Patterns of attachment*, Ainsworth et al. (1978)

Ainsworth et al. (1978, Ch.3) have developed a more detailed classification system, which is presented in Table 8.1C. The classifications of the children are made by trained judges on the basis of the children's scores on so-called *interactive scales* which range from 1 to 7. The child's behaviour corresponding to each of the seven categories has been explicitly defined, and can be summarized as going from 1 (virtually non-existent) to 7 (very often, very intense). The scores are awarded by trained observers, while viewing videotapes of the strange situation. In the present analysis the following scales were used: *proximity seeking* (PROX), *contact maintaining* (CM), *resistance* (RES), *avoidance* (AVOI), and *distance interaction* (DI) (see Table 8.1B).

The data consisted of observations on *65* two-year old children on the *5* interactive scales during *4* episodes (S4, M5, S7, M8), where S indicates the presence of the stranger and M that of the mother. Details on the data and the reasons for discarding the earlier episodes can be found in Goossens (Note 1). One might argue that a three-mode analysis is not a proper technique for these data, as for instance proximity seeking towards the stranger might not be the same variable as proximity seeking towards the mother. Moreover, the relationships between the scales in the stranger episodes might be different from those in the mother episodes. However, as the basic purpose of the strange situation is to assess children on the basis of their reactions to the entire strange situation, and not to specific parts of it, it seems justified to treat a scale as the same variable regardless of the adult towards whom the behaviour is directed.

Before analysis, the overall scale means were removed, i.e. the scales were centred over all children-episode combinations (j-centring - see section 6.5). No equalization of variances was performed. This decision was based on the consideration that not the overall scoring levels of the children on the interactive scales were of interest, but the individual differences between children. This centring ensures that the meaningful differences in scoring levels between episodes which carry important information are retained. A disadvantage of using the mean values for generalization is that they are sample dependent. For more extensive studies some standard norm for centring the scales should be devised.

## 8.2 ANALYSIS AND FIT

The main analysis reported here is a Tucker3 (T3) analysis with two components each for the first mode (episodes), second mode (interactive scales), and third mode (children). It will be referred to as the *2x2x2-solution*, and will be compared with a *3x3x3-solution* on the same data. At times we will also refer to a Tucker2 (T2) analysis with two components for the first two modes, or the *2x2-solution*.

Table 8.2 shows that with an increasing number of components the fit increases, but that the increase in fit in going from the 2x2x2-solution (fit = .59) to the 3x3x3-solution (fit = .68) involves estimating an additional 93 parameters. At least three-fifth of the variation in the (j-centred) data is accounted for by the three-mode model. Considering the relative difficulty of reliably measuring children's behaviour, and the variability inherent in it, this seems quite satisfatory.

Table 8.2 *Attachment study: Characteristics of the solutions*

| | T3 *2x2x2* | T3 *3x3x3* | T2 *2x2* |
|---|---|---|---|
| Standardized total sum of squares - SS(Total) | 1.00 | 1.00 | 1.00 |
| Approximation of SS(Fit) from separate PCA | | | |
| on mode 1 | .77 | .91 | .77 |
| on mode 2 | .83 | .92 | .83 |
| on mode 3 | .63 | .71 | - |
| Fitted sum of squares from simultaneous estimation - SS(Fit) | .59 | .68 | .67 |
| Residual sum of squares from simultaneous estimation - SS(Res) | .41 | .32 | .33 |
| Improvement in fit compared to initial configuration | .03 | .01 | .001 |
| Parameters to be estimated | 156 | 249 | 278 |

When using the Tucker2 model, i.e. computing only components for episodes and interactive scales, a better overall fit is possible than with the Tucker3 model with the same number of components

(.67 for the 2x2-solution versus .59 for the 2x2x2-solution). But due to leaving the third mode unreduced there are more parameters in the former model (278 versus 156). Comparing the two T3-solutions, it is difficult to decide which is the 'best' solution to look at in detail. No goodness-of-fit tests are available, and, in addition, it seems largely a content-specific problem in how much detail one wants to describe the relations.

## 8.3 CONFIGURATIONS OF THE THREE MODES

The (common) component spaces for each mode are given in Table 8.3A,B,C. In Fig. 8.1 the components for scales and episodes are plotted, and in Fig. 8.2 those for the children. In Fig. 8.1 A,B, but not in Fig. 8.2, the components have been multiplied by the square root of their component weights, so that the plots reflect the relative importance of the axes (see section 6.8).

The general remark can be made that on the whole the choice of a particular solution is not very crucial with respect to interactive scales and episodes. The first two components of both the scale space and the episode space are the same within reasonable bounds (roughly ± .05; the order is preserved in all but two cases).

Table 8.3 *Attachment study: Component spaces*

A. *Episodes* (mode 1)

| nr. | adult | | T3: 2x2x2 | | T3: 3x3x3 | | | T2: 2x2 | |
|---|---|---|---|---|---|---|---|---|---|
| | | | E1 | E2 | E1 | E2 | E3 | E1 | E2 |
| 4 | stranger | S4 | .26 | -.44 | .25 | -.37 | .45 | .26 | -.45 |
| 5 | mother | M5 | .47 | .25 | .52 | .28 | .68 | .48 | .27 |
| 7 | stranger | S7 | .38 | -.77 | .41 | -.80 | -.23 | .44 | -.73 |
| 8 | mother | M8 | .75 | .39 | .71 | .38 | -.53 | .71 | .43 |
| component weight ( $\lambda_p$ ) | | | .37 | .22 | .41 | .21 | .07 | .42 | .25 |

Labels for components: E1, stress of situation
E2, mother versus stranger
E3, early versus late

Table 8.3 *(cont.d)*

B. *Interactive scales* (mode 2)

| Scales | | T3: 2x2x2 | | T3: 3x3x3 | | | T2: 2x2 | |
|---|---|---|---|---|---|---|---|---|
| | | S1 | S2 | S1 | S2 | S3 | S1 | S2 |
| Proximity seeking | PROX | .32 | .69 | .37 | .68 | .04 | .35 | .67 |
| Contact maintaining | CM | .26 | .35 | .26 | .34 | .14 | .28 | .34 |
| Resistance | RES | .33 | -.41 | .30 | -.39 | .85 | .30 | -.39 |
| Avoidance | AVOI | .27 | -.48 | .25 | -.50 | -.46 | .25 | -.53 |
| Distance interaction | DI | -.81 | .07 | -.80 | .12 | .24 | -.80 | .10 |
| component weight ($\mu_q$) | | .37 | .22 | .43 | .24 | .02 | .40 | .27 |

Labels for components: S1, intensity of reaction
S2, security seeking
S3, interest in adult

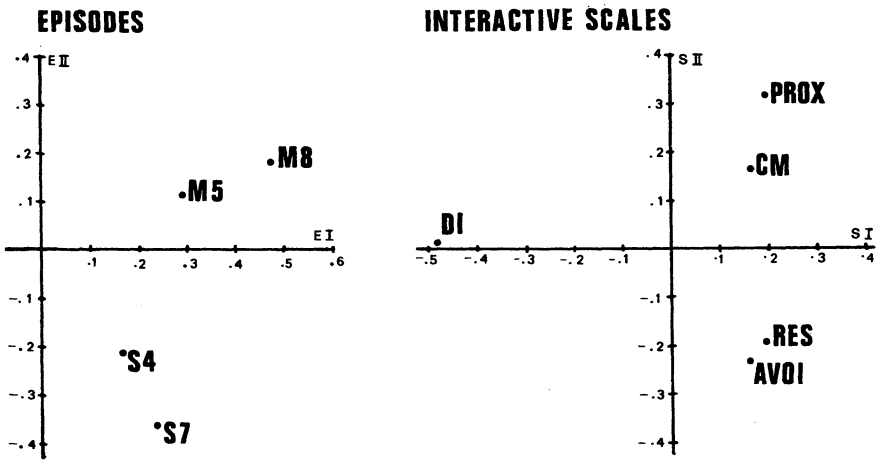



Fig. 8.1 *Attachment study: Component spaces (scaled)*

A point which should be made at the outset of the interpretation is that it is rather difficult to link the details of our results to those in *POA* as the latter refer mainly to one-year olds, and Goossens's study deals with two-year olds. Previous

research (summarized in *POA*) shows that the reaction of older children in the strange situation is different from that of the one-year olds it has been validated for (see also Goossens, Swaan, Tavecchio, Vergeer, & Van IJzendoorn, 1982).

One of the aims of the present analysis is to investigate how individual differences between children can be traced back to their different behaviour in the various episodes, on the basis of the interactive scales. These results will then be compared with the classification (sub)categories resulting from the scoring instructions in *POA* (see Goossens, Note 1). One qualification should be made in advance, as the research project from which these data have been derived is not yet finished. Both the scoring of the data and the results presented here should be seen as a first exploration, not yet as definite. The final version will be published elsewhere at a later date.

*Episodes.* With only four episodes there is really no need to label the axes, but for further reference we will try to name them anyway (see section 6.8). The first axis (E1) reflects the overall variability of the scores in the episodes, and it does not seem unreasonable to associate increasing variability with greater *stress* put onto the child. The second axis (E2) contrasts the behaviour towards the *mother* and that towards a *stranger*. The third axis (E3), finally, contrasts the *early* and *late* episodes, i.e. those episodes before and after episode 6, in which the child has been left alone. If desired two oblique axes could be chosen as well, one for the mother episodes, one for the stranger episodes.

*Interactive scales.* The first axis (S1) reflects the overall variability of the children-episode combinations around the overall scale mean. This variability is approximately equal for PROX, CM, RES and AVOI, and considerably larger for DI. High scores on distance interaction reflect an opposite reaction compared to high scores on the other scales, and the same holds for low scores. This is to be expected as proximity seeking more or less precludes distance interaction and vice versa. The special position of distance interaction has been noted before, and a number of research-

Table 8.3 *(cont'd)*

C. *Children* (mode 3)

| nr. | ACC | C1 | C2 |
|---|---|---|---|
| 55 | B4 | .34 | .08 |
| 39 | B4 | .33 | .12 |
| 38 | B4 | .30 | .07 |
| 18 | B4 | .28 | .09 |
| 62 | B4 | .27 | -.03 |
| 20 | B4 | .25 | -.03 |
| 48 | B4 | .22 | .14 |
| 61 | B4 | .22 | -.02 |
| 24 | B4 | .20 | .05 |
| 3 | B4 | .19 | .08 |
| 44 | B3 | .19 | -.02 |
| 2 | B4 | .18 | .06 |
| 41 | C1 | .18 | -.01 |
| 11 | B3/4 | .15 | .07 |
| 13 | B3 | .14 | .14 |
| 34 | B3 | .08 | .10 |
| 14 | B3 | .08 | .26 |
| 57 | B3 | -.04 | .21 |
| 4 | B3 | .01 | .20 |
| 12 | B3 | -.01 | .19 |
| 27 | B3 | .04 | .19 |
| 22 | B3 | -.01 | .18 |
| 50 | B3 | -.04 | .18 |
| 65 | B3 | .01 | .18 |
| 28 | B3 | .02 | .17 |
| 9 | B3 | -.00 | .17 |
| 25 | B3 | -.09 | .16 |
| 5 | B3 | -.09 | .16 |
| 58 | B3 | -.07 | .16 |
| 46 | B3 | -.03 | .15 |
| 1 | B3 | -.07 | .15 |
| 36 | B3 | -.08 | .14 |
| 23 | B3 | -.10 | .15 |
| 45 | B3 | -.00 | .15 |
| 52 | B3 | -.03 | .14 |
| 32 | B3 | -.02 | .14 |
| 40 | B3 | -.05 | .14 |
| 19 | B3 | -.07 | .14 |
| 7 | B3 | -.07 | .14 |
| 33 | B3 | -.06 | .13 |
| 64 | B3 | -.06 | .13 |
| 42 | B3 | -.05 | .13 |
| 59 | B3 | -.08 | .12 |
| 60 | B3 | -.08 | .11 |
| 17 | B2 | -.04 | .11 |
| 47 | B3 | -.06 | .10 |
| 30 | B2 | -.02 | .09 |
| 56 | B3 | -.04 | .09 |
| 16 | B3 | -.05 | .09 |
| 29 | B2 | -.09 | .08 |
| 43 | B3 | -.09 | .07 |
| 26 | B1 | -.03 | .07 |
| 6 | B1 | -.00 | .06 |
| 63 | B2 | -.03 | .05 |
| 15 | B2 | -.05 | .04 |
| 21 | B3 | -.07 | .04 |
| 10 | B2 | -.04 | .00 |
| 31 | B3 | .04 | -.01 |
| 35 | B1 | -.02 | -.02 |
| 8 | B1 | -.02 | -.04 |
| 49 | ? | .07 | -.06 |
| 53 | B2 | -.04 | -.08 |
| 51 | B2 | -.01 | -.09 |
| 54 | A1 | -.03 | -.17 |
| 37 | A1 | .08 | -.21 |
| component weight ($v_r$) | | .50 | .09 |

Notes:

ACC = Ainsworth's classification category

? = unclassified

B3/4 = B3 or B4

C1 = first child component

C2 = second child component

ers therefore do not include it in their analyses (see e.g. Waters, 1978; Grossmann, Grossman, Huber, & Wartner, 1981). In *POA*, for instance, it is noted that for one-year olds distance interaction is a low-stress behaviour of low intensity, and that it differentiates less among the classification (sub) categories (p.246). Whether this is true for two-year olds is still a matter for investigation. We will come back to this point later. An acceptable label for the first scale component seems to be *intensity* of the reaction.

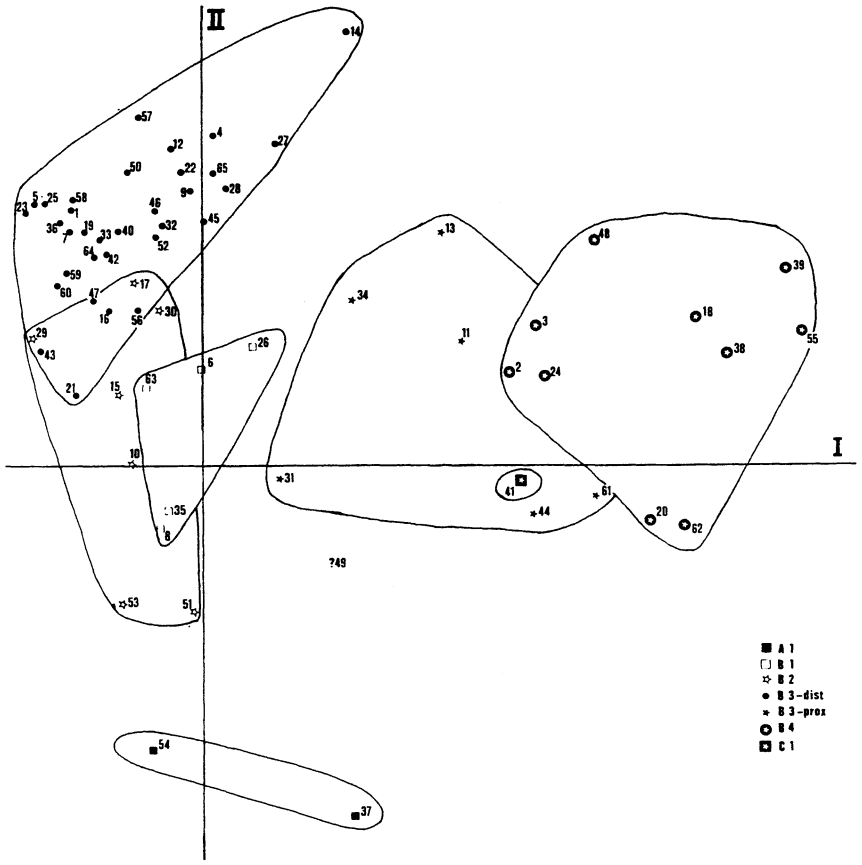



Fig. 8.2 *Attachment study: Child space (unscaled)*

The second component (S2) distinguishes between attachment behaviours, proximity seeking and contact maintaining, and behaviours antithetical to attachment, i.e. avoidance and resistance. It might be labelled as the *security seeking*. We will not discuss the third axis (S3) due to the small amount of variation explained by it (2%), even though it shows a theoretically important contrast between resistance and avoidance. It is, by the way, equally legitimate to define a PROX,CM-axis, and a RES,AVOI-axis by rotating the scale space.

*Children.* Table 8.3C and Fig. 8.2 show the two-dimensional child space for the 2x2x2-solution. The children have been labelled both by a sequence number and their Ainsworth classification subcategory (see Table 8.1C). These classifications are based on the same interactive scales as those in the present analysis. For the scoring, however, it is mainly the behaviour towards the mother which has been taken into account, instead of that towards both the mother and the stranger as in our analysis. The classification instructions are contained in *PAO* (p. 59-62; see also Swaan & Goossens, 1982), and require extensive training. One of the aims of applying three-mode principal component analysis to these data is to assess the adequacy of the scoring instructions. Psychological and medical research, for instance, have shown that people do not necessarily combine multivariate information in a very reliable way (see e.g. Sawyer, 1966; Linschoten, 1964, p.142ff.; Einhorn, 1972).

With respect to these data we will try to answer two questions. The first is whether the classification system is *consistent*, i.e. whether the children who occupy the same region in the child space, have the same Ainsworth classification . The second question is, whether the same scales to the same extent, are responsible for the grouping of the children, as specified in the scoring instructions. The grouping observed in our analysis may be the result of different combinations of scores. In other words, the present analysis is an attempt to validate the classification rules.

Ainsworth et al. (Ch. 6) applied discriminant analysis to check the adequacy of the classification system, but this involves

the interactive scales twice: once to make the classification, and then to evaluate this classification by using the interactive scales as predictors in the discriminant functions. Here we use the interactive scales to group the children and to assess their contribution to this grouping simultaneously, and only after that we check the grouping against the classification. This provides a more adequate check of the appropriateness of the classification procedure.

The first impression from Fig. 8.2 is that on the whole a reasonable separation is possible between the B-subcategories, although on the basis of our analysis alone the divisions could not have been made. In addition, the two A1-children are in their proper places, as their score patterns on the interactive scales should be the mirror-image of the B3-children (see Table 8.1C). Furthermore, the one C1-child does not occupy a separate place. Finally, there are some B3-children seemingly belonging to the B4-children; they have been labelled 'B3-prox' for reasons to be discussed in section 8.7, where we will also try to provide the answers to the above questions. In the meantime we will use the Ainsworth classification to label the children, pretending we have already established its appropriateness.

## 8.4 INTERPRETATION OF THE CORE MATRICES

*Explained variation.* The core matrix indicates the relations between the various components of the three modes. For instance, the element $c_{111}$ (=19.9) of the T3 core matrix (Table 8.4) indicates the strength of the relation between the first components of the three modes, and $c_{221}$ (=13.5) the strength of the relation between the second components of the first and second modes in combination with the first of the third mode. As Table 8.4 shows, 30% of the SS(Total) is accounted for by the combination of the first components of the three modes, another 14% by $c^2_{221}$, and 3% each by $c^2_{121}$, and $c^2_{211}$ (see section 6.9 for an explanation of this interpretation of the core matrix). We see that the differences between the children on the first component (C1) explain half of the fitted variation. This 50% can be partitioned as follows:

Table 8.4 *Attachment study: TUCKALS3 core matrix*

*2x2x2-solution*

(frontal planes)

| child component (C1): B4 versus REST | components of interactive scales S1 intensity of reaction | S2 security seeking | proportion variation explained | |
|---|---|---|---|---|
| components of episode: | | | | |
| stress of situation E1 | 19.9 | 5.8 | .30 .03 | $c_{111}$ $c_{121}$ |
| mother versus stranger E2 | -5.8 | 13.5 | .03 .14+ | $c_{211}$ $c_{221}$ |
| | | | $v_1$ = .50 | |
| child component (C2): B3(dist) versus A1 | | | | |
| stress of situation E1 | -6.7 | 3.0 | .03 .01 | $c_{112}$ $c_{122}$ |
| mother versus stranger E2 | -2.1 | 7.7 | .00 .05+ | $c_{212}$ $c_{222}$ |
| | | | $v_2$ = .09 | |

*3x3x3-solution*

(frontal planes)

C1

| | S1 | S2 | S3 |
|---|---|---|---|
| E1 | 20.1 | 4.5 | .6 |
| E2 | -4.8 | 13.7 | -2.2 |
| E3 | -2.0 | -2.3 | -0.5 |

$v_1$ = .50

C2

| | S1 | S2 | S3 |
|---|---|---|---|
| E1 | -6.5 | 2.8 | 2.6 |
| E2 | -2.0 | 6.8 | 0.1 |
| E3 | -7.1 | -0.3 | 0.6 |

$v_2$ = .12

C3

| | S1 | S2 | S3 |
|---|---|---|---|
| E1 | 1.1 | -6.7 | -2.7 |
| E2 | -1.7 | -0.8 | 0.0 |
| E3 | -4.9 | -1.3 | 0.0 |

$v_3$ = .06

(a) due to $c_{111}$ (30%): intensity of reaction (S1) due to the stress of situation (E1) for B4-children versus REST (C1);

(b) due to $c_{221}$ (14%): security seeking (S2) with the mother versus stranger (E2) for B4-children versus REST (C1);

(c) due to $c_{121}$ ( 3%): security seeking (S2) with stress of situation (E1) for B4-children versus REST (C1);

(d) due to $c_{211}$ ( 3%): intensity of reaction (S1) with mother versus stranger (E2) for B4-children versus REST (C1);

The differences between the children on the second component (C2) contributes the remaining 9% explained variation, which can be broken down as follows

(e) due to $c_{112}$ ( 3%): intensity of reaction (S1) due to the stress of the situation (E1) for B3-dist children versus A1-children (C2);

(f) due to $c_{222}$ ( 5%): level of attachment (S2) with mother - stranger (E2) for B3-dist children versus A1-children (C2);

(g) due to $c_{122}$ ( 1%): security seeking (S2) with stress of the situation (E1) for B3-dist children versus A1-children (C2).

*Three-mode interactions*. The percentages of explained variation only point to the important combinations, but do not indicate the direction of the relationship. This information can be found in the original (i.e. not-squared) core matrix. For the most important element of the core matrix the three-mode interaction between loadings on components is $c_{111}$ (= +19.9). The plus sign indicates that

a. positive loadings on C1, S1 and E1 occur together:
the more B4-like children are, the more intensely they react (= the higher above average their scores are on all scales except DI) in more stressful situations (= M5/S7 and M8);

b. negative loadings on C1 and S1 occur together with positive loadings on E1:
the more negative a child loads on C1 the less intensely it reacts (= scores below average on all scales except DI) in more stressful situations (= M5/S7 and M8).

Or in slightly different terms:

° for B4-children (i.e. with positive loadings on C1) intensity of the reaction (S1) and stress of the situation (E1) are positively related;

° for children with negative loadings on C1 intensity of the reaction and stress of the situation are negatively related.

For the Goossens data the interpretation in terms of scores of idealized quantities (see section 6.9) is that an 'ideal' B4-child reacts intensely in stressful situations ($c_{111}$ = 19.9), seeks much security with its mother-figure ($c_{221}$ = 13.5), seeks moderate security in stressful situations ($c_{121}$ = 5.8), reacts with moderately low intensity to the mother-figure ($c_{211}$ = -5.8), and similarly for the other elements of the core matrix.

*Extended core matrix.* So far we have only looked at the interpretation of the core matrix of the Tucker3 model. As noted in section 6.9 the extended core matrix can be interpreted in essentially the same way as the TUCKALS3 core matrix in terms of the amount of explained variation.

We already noted the near equality of the components for the interactive scales and the episodes in the 2x2-solution and 2x2x2-solution in connection with Table 8.3A,B, consequently interpretations of those spaces are the same as before. The relationships between these components, as embodied in the frontal planes of the T2 core matrix, are given for a few selected children in Table 8.5. Four of the children were chosen because they are relatively close to one of the axes in the child space (i.e. 38, 57, 29, 37), and they can be considered 'idealized individuals' in the sense of e.g. Tucker & Messick (1963).

The frontal planes thus indicate how, for each child, the axes of the common space are related, just as was the case in the Tucker3 model for 'ideal' children. For instance, for child 38 (a B4-child) *intensity of reaction* (S1) and *stress of the situation* (E1) are positively related (see Table 8.5), as are *security seeking* (S2) and the *mother versus stranger* distinction (E2), while the other combinations are immaterial. For child 35, by comparison (a B1-child), none of the relationships seem very relevant (see section 8.7 for a discussion of this phenomenon). Note also that the two A1-children (37 and 54) have very different patterns of relationships, notwithstanding their similar position in the child space (Fig. 8.2).

Roughly one can conclude that children on the first child dimension (C1) weight the *intensity* (E1) - *stress* (S1) combination

Table 8.5 *Attachment study: TUCKALS2 core planes for selected children*

| | B4 (38) | | B3 (57) | | B2 (29) | | B1 (35) | |
|---|---|---|---|---|---|---|---|---|
| | S1 | S2 | S1 | S2 | S1 | S2 | S1 | S2 |
| E1 | 5.7 | 0.9 | -2.1 | -0.7 | -2.4 | -0.2 | -0.2 | -1.0 |
| E2 | -0.5 | 5.1 | -0.7 | 1.4 | 0.4 | -0.6 | 1.1 | 0.1 |
| *) | .30 | .07 | -.04 | .21 | -.09 | .08 | -.02 | -.02 |

| | A1 (54) | | A1 (37) | | C1 (41) | | B2 (51) | |
|---|---|---|---|---|---|---|---|---|
| | S1 | S2 | S1 | S2 | S1 | S2 | S1 | S2 |
| E1 | 0.6 | -2.2 | 3.0 | -3.2 | 3.7 | -.07 | 0.5 | -0.0 |
| E2 | 2.3 | -0.8 | -0.1 | 0.4 | -1.0 | 2.9 | 0.2 | -0.9 |
| *) | -0.3 | -.17 | .08 | -.21 | .18 | -.01 | -.01 | -.09 |

*) T3 component loadings (See Table 8.3C)

Notes: B4 (38): child nr. 38 - Ainsworth classification category B4
S1 (S2): first (second) scale component
E1 (E2): first (second) episode component

and the *mother versus stranger* (E2) - *security seeking* (S2) combination with a ratio similar to the ratio of $c_{111}$ to $c_{221}$ in the T3 analysis, and that the overall size of the elements determines their position on the C1 component: high positive numbers on the diagonal of the TUCKALS2 core plane (e.g. for child 41 and child 38) lead to highly positive loadings on C1, and moderately negative numbers (e.g. for child 29) lead to moderately negative loadings. On the negative side of the second child component (C2) there are children who emphasize the (E1, S1) combination, but not or hardly the (E2, S2) combination (child 37), and on the positive side of C2 (child 57) the situation is reversed, i.e. (E2, S2) is high and (E1, S1) low. This distinction corresponds with the opposite signs in the second frontal plane of the T3 analysis.

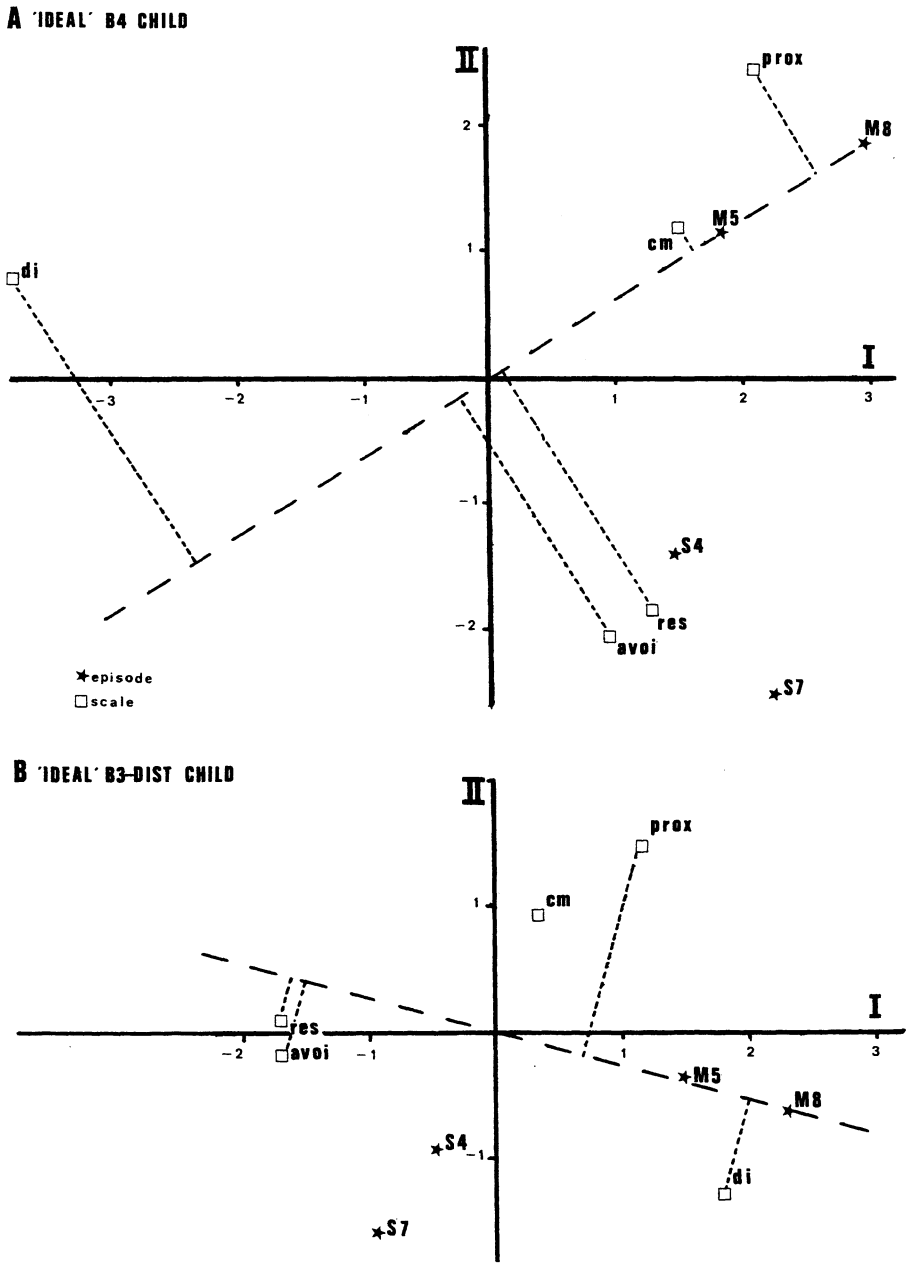



Fig. 8.3 A,B *Attachment study: Joint plots of episodes and interteractive scales.*

## 8.5 JOINT PLOTS

With joint plots (see section 6.10) we can examine in some detail the relationships between the interactive scales and the episodes for each ideal-type child or child component. In Fig. 8.3A,B we present the joint plots for the two child components. The following characterization for the children loading on the positive side of the first component C1, i.e. B4-children, can now be made:

(a) they have high scores on proximity seeking and contact maintaining towards the mother (in episodes M5, M8), and they score about twice as high in M8 as in M5. With a high score we mean relatively to the overall scale means, as we have removed these means for all interactive scales.

(b) they have high scores on resistance and avoidance towards the stranger (in S4 and S7), and nearly twice as high in S7 as in S4.

(c) they show roughly average resistant and avoidant behaviour towards the mother in M5 and M8, even somewhat below average on avoidance. Similarly, proximity seeking and contact maintaining towards the stranger have average values.

(d) the scores on distance interaction do not discriminate between the mother and the stranger, and they are below average. There is less distance interaction in the later episodes.

These interpretations are derived from the fact that the scales can be seen as points and the episodes as vectors or directions in the common space, or vice versa. In this case the former approach is to be preferred because the episodes are fixed, i.e. they are elements of the design. The relative importance of the various scales at any episode can then be assessed from their perpendicular projections on the vectors as is shown for M5 and M8 combined.

For the positive scores on the second child component, i.e. the B3-dist children, the characterization is (see Fig. 8.3B):

(a) low scores on resistance and avoidance towards the mother, coupled with average contact maintaining and proximity seeking. High distance interaction increasing further in M8.

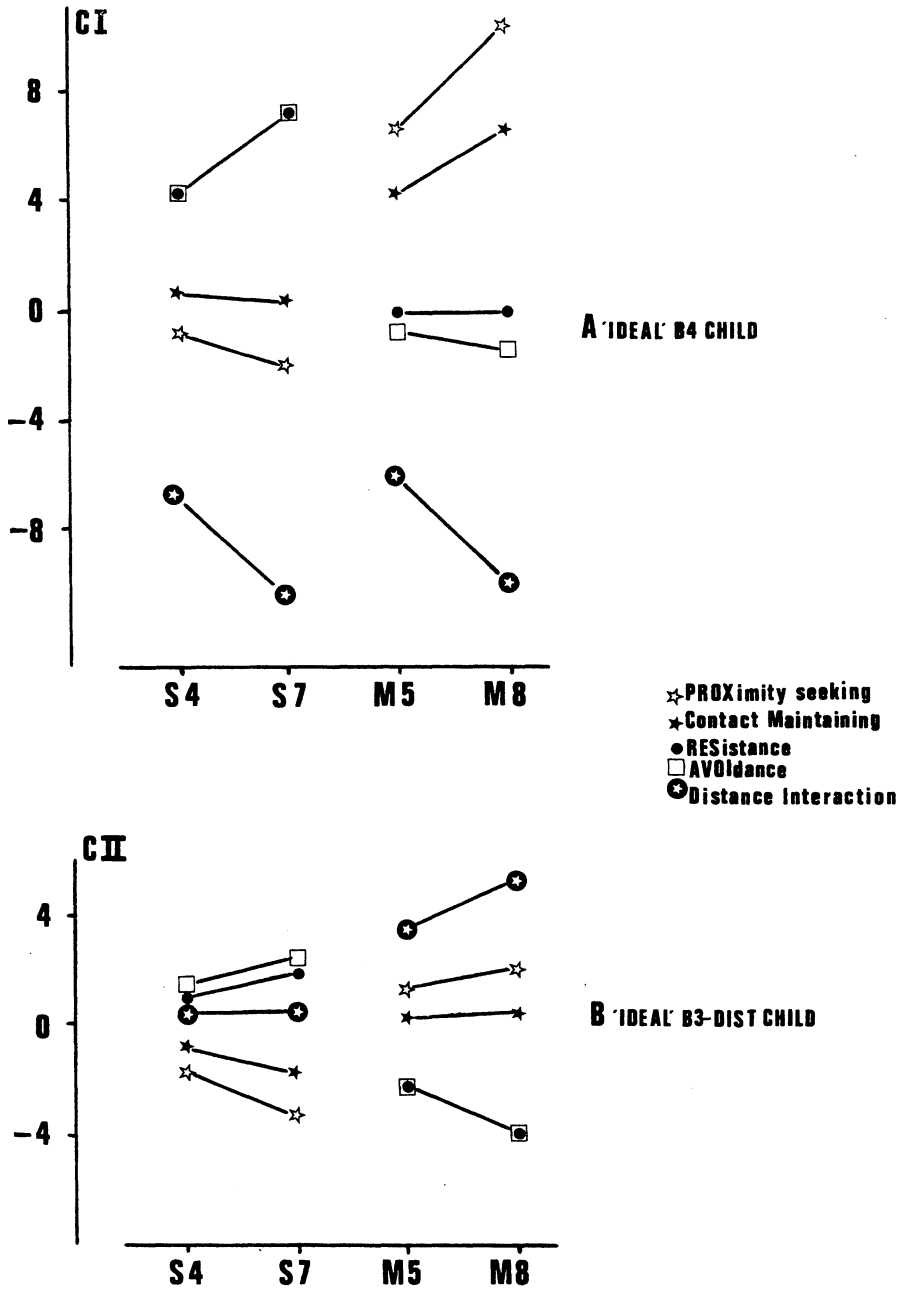



Fig. 8.4 *Attachment study: Component scores for episode-scale combinations.*

(b) low scores on proximity seeking and contact maintaining towards the stranger, with lower scores on proximity seeking. Average resistance, avoidance, and distance interaction with a slight increase in the avoidance measures in S7.

For 37, an A1-child, the mirror image of the above observations is true as he/she lies on the negative side of the second child component (C2). These relationships are displayed in Fig. 8.4, where the component scores are given for the 'ideal' B4-child, and the 'ideal' B3-dist child.

## 8.6 FIT OF THE SCALES, EPISODES, AND CHILDREN

In Table 8.6 the sums of squares for the scales and episodes are shown. From the SS(Total)s for episodes we see that the variability as expressed by the sums of squares increases with the later episodes, as children deviate more from the scale means, or probably show more variation among themselves. With respect to the scales we see that *contact maintaining* has relatively little variability, while *distance interaction* has considerably more. From the residual sums of squares we note that the scales fit more or less equally well, irrespective of their total sum of squares, but that the configurations derived and discussed above are for a large part determined by the last two episodes. The structure described is, therefore, more representative of the later behaviours than the earlier ones. This explains, for instance, why an added third episode component shows an early versus late character; primarily the earlier episodes will then be fitted better.

Fig. 8.5 is the sums-of-squares plot which shows the residual sums of squares versus the fitted sums of squares for the children from the 2x2x2-solution.

A number of features are particularly noteworthy. The B4-children fit well, have large sums of squares, and dominate the solution. Furthermore, there is a large group of B3-children (mainly B3-dist) which have small total sums of squares (thus they score about average on all scales), and most of their variation is fitted well. On the other hand, none of the B1- and B2-children fit very

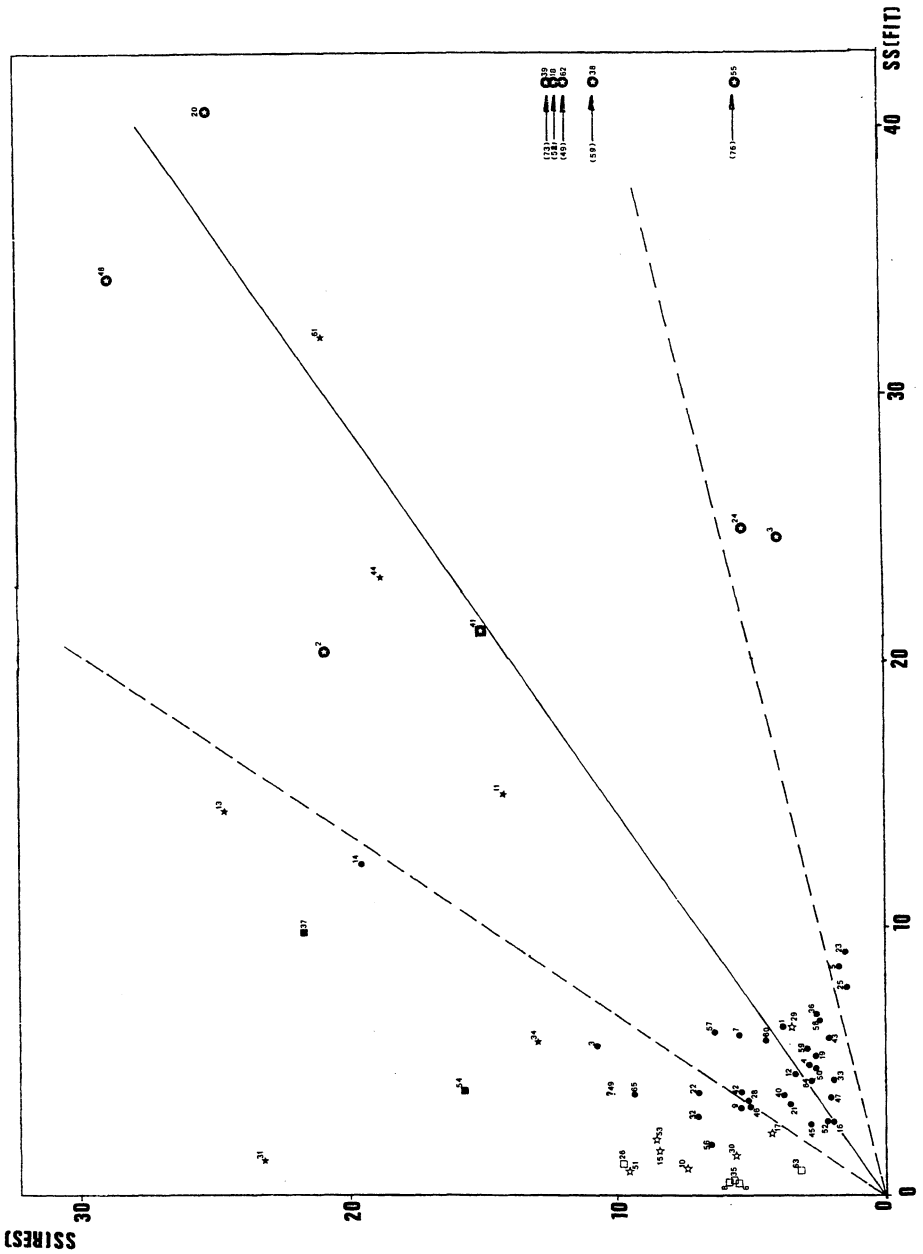



Fig. 8.5 *Attachment study: Sums-of-squares plot for children.*

Table 8.6 *Attachment study: Sums of squares*

A. *Episodes* (mode 1)

| | | *2x2x2-solution* | | | | *3x3x3-solution* | |
|---|---|---|---|---|---|---|---|
| | SS(Total) | SS(Fit) | | SS(Res) | | SS(Res) | |
| episode | stand. | stand. | rel. | stand. | rel. | stand. | rel. |
| S4 | .16 | .07 | .40 | .10 | .60 | .10 | .59 |
| M5 | .21 | .09 | .44 | .12 | .56 | .06 | .27 |
| S7 | .29 | .18 | .63 | .11 | .37 | .09 | .30 |
| M8 | .33 | .24 | .74 | .09 | .26 | .08 | .23 |
| overall | 1.00 | .59 | | .41 | | .32 | |

B. *Interactive scales* (mode 2)

| | | *2x2x2-solution* | | | | *3x3x3-solution* | |
|---|---|---|---|---|---|---|---|
| | SS(Total) | SS(Fit) | | SS(Res) | | SS(Res) | |
| scale | stand. | stand. | rel. | stand. | rel. | stand. | rel. |
| PROX | .23 | .14 | .61 | .09 | .39 | .06 | .27 |
| CM | .10 | .05 | .54 | .05 | .46 | .04 | .41 |
| RES | .15 | .08 | .52 | .07 | .48 | .06 | .41 |
| AVOI | .17 | .08 | .44 | .09 | .56 | .08 | .46 |
| DI | .35 | .24 | .68 | .11 | .32 | .07 | .21 |
| overall | 1.00 | .59 | | .41 | | .32 | |

Notes: stand. = standardized or divided by the overall SS(Total).
rel. = relative sum of squares, which is defined as:

$$\text{relative SS (Res) of episode S4} = \frac{\text{SS(Residual) of episode S4}}{\text{SS (Total) of episode S4}}$$

well into the overall pattern, but we have to remember that there are only few of them. Their total sums of squares are not very large, but their relative residual sums of squares are. Finally, there is a number of children which couple considerable sums of squares with little fit, indicative of either another organization of the scale and episode relationships, or large amounts of random variation. In fact, the two A1-children (37 and 54) belong to this group.

## 8.7 DISCUSSION

Keeping in mind the provisional character of the data, there are some conclusions that can be drawn with respect to the example. In the first place, we note that three-mode principle component analysis has succeeded in showing individual differences between the children, and characterizing the kind and degree of these differences. Furthermore, the analysis presented here supports to a large degree the *consistency* of the classification procedures as described by Ainsworth et al. in *POA*, especially for the B-children. The consistency follows from the grouping of children belonging to the same category. The presence of only two A-children and a single C-child precludes any serious statements about these classification categories, apart from the observation that their position in the child space (Fig. 8.2) agrees with what one would expect.

In section 8.3 we noted the presence of two groups of B3-children. In Fig. 8.2 they were labelled *B3-prox* and *B3-dist*. The classification instructions in *POA* (p. 61) for B3-children (see also Swaan & Goossens, 1982) also suggest that there are two types of B3-children: those who actively seek physical contact with their mothers (B3-prox), and those who seem especially 'secure' in their relationship with their mother, and are content with mere interaction from a distance with and proximity to the mother without seeking to be held (B3-dist). It is possibly due to the greater ability of communicating at a distance on the part of two-year olds that there are more children in the B3-dist than in the B3-prox group in Goossens' sample. For one-year olds the reverse seems to be true (see Goossens, Note 1, for further details).

In Table 8.7 the characterizations of the children (derived from Fig. 8.4), occupying the extremes of the axes in Fig. 8.2 (child space) are presented. Comparing this table with Table 8.1C (reproduced in part here) shows global agreement and disagreement in detail. The most conspicuous differences are related to resistance and distance interaction. The comparison for resistance is probably biased by the absence of extremely resistant (C)-children, and 'high resistance' in Goossens' sample might be average when

compared to the resistant behaviour of C-children. The differences between distal behaviours are, most likely related to the age differences.

Table 8.7 *Attachment study: Comparison of Ainsworth's and TUCKALS classifications*

| | AINSWORTH | | | | | TUCKALS | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | PROX | CM | RES | AVOI | DI | | PROX | CM | RES | AVOI | DI |
| A1 | - | - | - | ++ | - | A1 | o | o | H | H | L |
| | | | | | | B3-dist | o | o | L | L | H |
| B3-prox | ++ | ++ | - | - | - | B3-prox | H | H | o | o | L |
| B4 | ++ | ++ | (+) | - | - | B4 | HH | HH | o | o | LL |

- low +(+) moderate to high
(+) low to moderate
+ moderate ++ high

LL = low H = average to high
L = low to average
o = average HH = high

A number of problems remain. One is the low number of A-children compared to the number found in samples of one-year old children. One of the explanations might be that this is due to less avoidant behaviour of two-year old children. Another, by now more likely explanation is that it is due to a somewhat non-standard scoring procedure for avoidance (see Goossens, Note 1).

A further possible problem are the ill-fitting B1- and B2-children. Two reasons might be put forward in this respect. One is that they have approximately average scores on all scales so that we are trying to fit their individual error, rather than any meaningful variation; otherwise it might be that their way of reacting to the strange situation cannot be fitted very well together with the other children. Their small number might preclude finding a separate dimension for themselves. Clearly these conjectures could and will be further investigated.