Parameter estimation for repeated measures
designs using the SPSS MANOVA program

Charles Lewis*

Summary

Certain problems and confusions may arise when attempting to estimate
parameters in multivariate models for repeated measures data with the help
of SPSS MANOVA. These are described in detail and ways of dealing with them
are suggested.

While SPSS MANOVA, as described in the SPSS UPDATE 7-9 manual
(Hull & Nie, 1981)[1], offers the user an attractive range of possibilities
for carrying out repeated measures analyses of variance, it also includes
some unnecessarily confusing aspects. One of these latter, namely the
options available for specifying model parameters to be estimated,
is the subject of the comments that follow.

* Vakgroep Statistiek & Meettheorie FSW, Rijksuniversiteit Groningen,
  Oude Boteringestr. 23, 9712 GC Groningen. tel. 050 - 115394.

[1]. The differences with MANOVA in SPSS[X] (SPSS Inc. 1983) are minor. (See
   Appendix, however.)

Default Model Specifications

1. Between-subjects factors

Although many forms of specification are possible, one may first reasonably ask what model parameters are estimated when <u>no</u> specification is made. In other words, what are the defaults? For a between-subjects design, or for between-subjects factors in a design which also includes within-subjects (repeated measures) factors, the default model is one with so-called "deviation contrasts" as main-effect parameters. Specifically, in a one-factor design, the model for the mean at the i<u>th</u> level of the factor, μ_i, is

$$\mu_i = \mu + \alpha_i$$

with the restriction

$$\sum_i \alpha_i = 0$$

The parameters estimated are μ and all but the last α_i.

2. Within-subjects factors, using WSDESIGN

Turning to within-subjects designs, the default model for the simplest choice of commands has only a very faint connection with the "deviation contrast" model described above. Concretely, consider an example from Winer (1971, pp. 267-273) of a one-factor design, with reaction times measured under four drug conditions. MANOVA commands to carry out an analysis might look as follows:

```
MANOVA          RT1 TO RT4/
                WSFACTOR=DRUG/
                WSDESIGN/
                PRINT=SIGNIF(BRIEF)/
                ANALYSIS(REPEATED)
```

Here the four responses of each subject have previously been read in as
the four variables RT1,RT2,RT3, and RT4. This set of commands produces
both multivariate and univariate (mixed model) tests of the hypothesis
of no differences among the population mean reaction times for the four
drug conditions. It also produces estimates of the parameters θ_i in the
following model for these mean reaction times:

$$\mu_1 = \theta_1/2 + \theta_2/\sqrt{2} - \theta_3/\sqrt{6} - \theta_4/(2\sqrt{3})$$
$$\mu_2 = \theta_1/2 \qquad\qquad + 2\theta_3/\sqrt{6} - \theta_4/(2\sqrt{3})$$
$$\mu_3 = \theta_1/2 \qquad\qquad\qquad\qquad + 3\theta_4/(2\sqrt{3})$$
$$\mu_4 = \theta_1/2 - \theta_2/\sqrt{2} - \theta_3/\sqrt{6} - \theta_4/(2\sqrt{3})$$

Expressed in terms of the means, these θ_i represent the (orthonormal)
contrasts

$$\theta_1 = \frac{1}{2}(\mu_1 + \mu_2 + \mu_3 + \mu_4)$$

$$\theta_2 = \sqrt{\frac{1}{2}} \ (\mu_1 - \mu_4)$$

$$\theta_3 = \sqrt{\frac{2}{3}} \ (\mu_2 - \frac{\mu_1 + \mu_3}{2})$$

$$\theta_4 = \frac{\sqrt{3}}{2} \ (\mu_3 - \frac{\mu_1 + \mu_2 + \mu_4}{3})$$

Comparing with the earlier default model, θ_1 turns out to be 2μ and θ_4
to be $2\alpha_3/\sqrt{3}$.

One may wonder if there are many users of SPSS MANOVA who will have
any interest in these "default parameters" or their associated estimates.
In fact, this default model was chosen to facilitate computation of the
mixed model hypothesis test referred to above (given as "averaged $\underline{F}$" in
the MANOVA output), and not with an eye to estimation.

3. Within-subjects factors, using TRANSFORM=WSDESIGN

A second "default" for repeated measures analysis is obtained by
removing the "WSDESIGN" instruction and inserting

        TRANSFORM=WSDESIGN/

This choice renders the "averaged $\underline{F}$" output meaningless by generating a model without orthonormal contrasts. In the drug conditions example discussed above, denoting the parameters by ϕ_i, the default model for the cell means becomes

$$\mu_1 = \phi_1/4 + 3\phi_2/4 - \phi_3/4 - \phi_4/4$$
$$\mu_2 = \phi_1/4 - \phi_2/4 + 3\phi_3/4 - \phi_4/4$$
$$\mu_3 = \phi_1/4 - \phi_2/4 - \phi_3/4 + 3\phi_4/4$$
$$\mu_4 = \phi_1/4 - \phi_2/4 - \phi_3/4 - \phi_4/4$$

At first sight, this model may seem hardly more appealing than the previous one. A look at the contrasts represented by the ϕ_i, however, may change this impression:

$$\phi_1 = \mu_1 + \mu_2 + \mu_3 + \mu_4$$
$$\phi_2 = \mu_1 - \mu_4$$
$$\phi_3 = \mu_2 - \mu_4$$
$$\phi_4 = \mu_3 - \mu_4$$

The parameters ϕ_2, ϕ_3, and ϕ_4, referred to as "simple" contrasts within SPSS MANOVA, would be especially useful in this case if the fourth drug condition were some sort of "control".

Thus, this default model represents an improvement over its orthonormal predecessor for users interested in estimation. The (unanswered) question still remains, however, as to why a model with deviation contrasts should be chosen as the default for between-subjects factors, while one with simple contrasts serves as default for within-subjects factors. That the two models are related (albeit in a roundabout way) can be seen by reading the coefficients of the ϕ_i in the model for the μ_i "column-wise". These turn out to be just the coefficients which must be used to express the deviation parameters as functions of the μ_i. Thus, for instance, the coefficients for ϕ_2 in the model are 3/4, -1/4, -1/4, and -1/4. The parameter α_1 (the second parameter in the deviation model) may be written as

$$\alpha_1 = \mu_1 - (\mu_1 + \mu_2 + \mu_3 + \mu_4)/4$$
$$= (3/4)\mu_1 - (1/4)\mu_2 - (1/4)\mu_3 - (1/4)\mu_4$$

thus employing these same coefficients. The significance of this relationship will become apparent later. In any event, it is not a relationship which is of value to the unwary user, who may very well think that the general statement regarding contrasts: "DEVIATION Chosen by default" (Hull & Nie, 1981, p.72), applies to within- as well as between-subjects factors.

User-specified Models for Within-subjects Factors

1. Using CONTRAST

So much for defaults. Now consider the possibilities for a user who wishes to specify a model with parameters representing contrasts of interest. Hull & Nie (1981, p.63) give an illustration of such a case which is simplified here to emphasize one aspect. Thus modified, the story goes as follows:

Consider an example where temperature has been measured on three successive days. Assume we want comparisons of adjacent days in the DAYS factor. Then we could write the following transformation to handle this design:

```
MANOVA          TEMP1 TO TEMP3/
                WSFACTOR=DAYS(3)/
                CONTRAST(DAYS)=REPEATED/
                TRANSFORM=WSDESIGN DAYS/
                PRINT=SIGNIF(BRIEF)/
                ANALYSIS(REPEATED)
```

Checking the intention of the "repeated" contrast command (Hull & Nie, 1981, p.74), the three parameters for the above example should represent the contrasts

$$(\mu_1 + \mu_2 + \mu_3)/3 \; ,$$
$$\mu_1 - \mu_2 \quad , \quad \text{and}$$
$$\mu_2 - \mu_3 \quad , \quad \text{respectively.}$$

In fact, the parameter estimates output on the basis of the above commands correspond to the population quantities

$$\mu_1 \quad + \mu_2 \quad + \mu_3 \, ,$$

$$(2/3)\mu_1 - (1/3)\mu_2 - (1/3)\mu_3 \, , \text{ and}$$

$$(1/3)\mu_1 + (1/3)\mu_2 - (2/3)\mu_3 \, , \text{ respectively.}$$

Thus the user would learn nothing about the differences in mean temperature on "adjacent days".

What is going on here? Hull & Nie (1981, p.62) tell us exactly (though they seem to have forgotten in the above example):

> The transformation matrix is generated
> from the basis matrices corresponding
> to the contrast matrices specified in
> any previous CONTRAST subcommands for
> the within-subjects factors.

Concretely, for the temperature example, the repeated contrast matrix (to be read row-wise) is

$$\begin{pmatrix} 1/3 & 1/3 & 1/3 \\ 1 & -1 & 0 \\ 0 & 1 & -1 \end{pmatrix}.$$

The columns of this matrix are then interpreted as coefficients for parameters (say ψ_i) in a model for the means (μ_i):

$$\mu_1 = (1/3) \, \psi_1 + \psi_2$$
$$\mu_2 = (1/3) \, \psi_1 - \psi_2 + \psi_3$$
$$\mu_3 = (1/3) \, \psi_1 \qquad - \psi_3$$

This implies that

$$\psi_1 = \mu_1 + \mu_2 + \mu_3 ,$$
$$\psi_2 = (2/3)\mu_1 - (1/3)\mu_2 - (1/3)\mu_3 , \text{ and}$$
$$\psi_3 = (1/3)\mu_1 + (1/3)\mu_2 - (2/3)\mu_3 ,$$

just the contrasts which are estimated in the example.

Returning to the default situation, this is indeed handled as though a deviation contrast command for the within-subjects factor had been given. That is, the columns of the deviation contrast matrix are used to define a model for the means, and the parameters for that model, which happen to be simple contrasts, are estimated.

It should be emphasized that this state of affairs applies only to within-subjects factors. Contrast commands applying to between-subjects factors result in estimates of the specified contrasts for these factors (as one would expect).

2. Using TRANSFORM

For designs having only one within-subjects factor, there is an alternative set of commands available. To illustrate, consider the example of the reaction times measured under four drug conditions, which was discussed earlier. Another possible MANOVA set-up is

```
MANOVA        RT1 TO RT4/
              TRANSFORM=DEVIATION/
              ANALYSIS=(RT1/RT2,RT3,RT4)
```

(note that WSFACTOR, WSDESIGN, and ANALYSIS (REPEATED) are not used).

Here, a multivariate test for the drug effect is carried out, and the parameters of the deviation contrast model are estimated. In other words, the parameters estimated are the parameters specified in the "transform" command. All of the specifications available for the "contrast" command are also available here, and all do what one would expect. The limitation, as mentioned above, is that the dependent variables in the "manova" statement must be responses to the levels of a single within-subjects factor.

Correcting Contrast Specifications

1. Standard specifications

For more complex designs, the only practical choice is the "wsfactors-wsdesign " command sequence. While one may hope that, in future releases of SPSS, these commands will operate in a manner which is consistent with the user's expectations, a practical point remains: what should one do now? A table is given below with all the current MANOVA contrast specifications and the specifications required to actually obtain estimates of these contrasts when using the "wsfactors-wsdesign " commands.

Examination of Table 1 reveals that only one of the standard specifications - POLYNOMIAL - does exactly what a user would expect. This is because the polynomial contrasts used in

Table 1. SPSS-MANOVA contrast specification for within-subjects factors

desired contrasts	required specification
POLYNOMIAL	POLYNOMIAL
DIFFERENCE	DIFFERENCE*
HELMERT	HELMERT*
DEVIATION	SIMPLE
SIMPLE	DEVIATION
REPEATED	SPECIAL (see text)
SPECIAL	SPECIAL (see text)

* The t-statistics given will be correct, but the point and interval estimates will be multiples of the desired values.

Example: A 3x4 within-subjects design with simple contrasts for the first factor (A) and polynomial contrasts for the second (B).

```
MANOVA          Y11 TO Y14,Y21 TO Y24,Y31 TO Y34/
                WSFACTORS=A(3),B(4)/
                CONTRAST(A)=DEVIATION/
                CONTRAST(B)=POLYNOMIAL/
                TRANSFORM=WSDESIGN/
                PRINT=SIGNIF(BRIEF)/
                ANALYSIS(REPEATED)
```

SPSS-MANOVA are orthonormal, so the basis and contrast matrices are identical. The orthogonal (but not orthonormal) DIFFERENCE and HELMERT contrasts produced for within-subject factors must be multiplied by the sum of their squared (original) coefficients to obtain the desired values. (This is relevant for point and interval estimates of the contrast, but not for the associated t-statistics.) For example, the second difference contrast should be

$$\mu_3 - (\mu_1 + \mu_2)/2$$

The sum of squared coefficients here is

$$1 + \frac{1}{4} + \frac{1}{4} = 3/2$$

Thus the point and interval estimates of the second difference contrast given for a within-subjects factor must be multiplied by 3/2 to obtain the correctly scaled values.

The DEVIATION and SIMPLE specifications should, as noted earlier, just be interchanged to obtain the intended contrasts.

No standard specification produces repeated contrasts, so a user wishing to compare adjacent levels of a within-subjects factor must make use of a SPECIAL specification. For a factor with three levels (say DAYS in the temperature example discussed earlier), the necessary command is

$$
\begin{array}{rrr}
\text{CONTRAST(DAYS)=SPECIAL (1} & 1 & 1 \\
2 & -1 & -1 \\
1 & 1 & -2)/
\end{array}
$$

More generally, for $\underline{k}$ levels, the matrix specified should have the form

$$\begin{pmatrix} 1 & 1 & 1 & \cdots & 1 & 1 & 1 \\ k-1 & -1 & -1 & \cdots & -1 & -1 & -1 \\ k-2 & k-2 & -2 & \cdots & -2 & -2 & -2 \\ \vdots & \vdots & \vdots & & \vdots & \vdots & \vdots \\ 2 & 2 & 2 & \cdots & 2 & 2-k & 2-k \\ 1 & 1 & 1 & \cdots & 1 & 1 & 1-k \end{pmatrix}$$

The point and interval estimates for the contrasts produced by this specification should be multiplied by the factor k to produce correctly scaled values. (Alternatively, the above coefficients may all be divided by k, provided that the results have an exact-finite-decimal representation. See below for a related example of this.)

2. Non-standard specifications

Finally, what should a user interested in a set of non-standard contrasts do? Basically, the answer is: find the inverse of the desired contrast matrix, transpose it, rescale the rows if necessary for convenience of input and use the result in a SPECIAL specification. To give an illustration for the four drug conditions example, suppose one were interested in comparing the first condition with the average of the third and fourth, the second with the same average, and, finally, the third with the fourth condition. The corresponding contrast matrix (with the grand mean represented in the first row) is

$$\begin{pmatrix} \frac{1}{4} & \frac{1}{4} & \frac{1}{4} & \frac{1}{4} \\ 1 & 0 & -\frac{1}{2} & -\frac{1}{2} \\ 0 & 1 & -\frac{1}{2} & -\frac{1}{2} \\ 0 & 0 & 1 & -1 \end{pmatrix}$$

The inverse of this matrix transposed may be found numerically as

$$
\begin{pmatrix}
1 & 1 & 1 & 1 \\
\frac{3}{4} & -\frac{1}{4} & -\frac{1}{4} & -\frac{1}{4} \\
-\frac{1}{4} & \frac{3}{4} & -\frac{1}{4} & -\frac{1}{4} \\
0 & 0 & \frac{1}{2} & -\frac{1}{2}
\end{pmatrix}
$$

Here no rescaling of the rows is needed, since the fractions in the matrix may be simply represented in exact decimal form, and the specification becomes

$$
\text{CONTRAST(DRUG)=SPECIAL(}
\begin{array}{cccc}
1 & 1 & 1 & 1 \\
.75 & -.25 & -.25 & -.25 \\
-.25 & .75 & -.25 & -.25 \\
0 & 0 & .5 & -.5
\end{array}
\text{)/}
$$

Correct Scaling of Contrasts

For the user who is interested in obtaining correctly scaled point and interval estimates of contrasts, there is one other consideration which must be mentioned. In addition to the "unexpected" contrasts generated for within-subjects designs, the reader may have noticed that the first row of the generated contrast matrices is always a row of "ones" (except for the orthonormal default case). For a one-way within-subjects design, this implies that the first parameter estimated is the sum of the population means for each level. In the case of between-subjects designs, this first parameter is the average of the individual means.

This point has not been discussed until now because researchers in the social sciences are not usually interested in estimating the grand mean for a given study. For multifactorial designs having at least one within-subjects factor, however, the choice of sum rather than average has implications for the scaling of other generated parameters as well. Explicitly, the presence of a within-subjects factor in a design results in the multiplication of all contrasts associated with the remaining factors by a constant equal to the number of levels of that within-subjects factor.

This influence may be illustrated using a (modified) example from Hull & Nie (1981, p.50). (See also Winer 1971, pp. 546-553.) The design is complete factorial, with one between-subjects factor (NOISE) and two within-subjects factors(PERIOD and DIAL). The (modified) MANOVA setup is as follows:

```
MANOVA          Y1 TO Y9 BY NOISE (1,2)/
                WSFACTORS=PERIOD(3),DIAL(3)/
                CONTRAST(PERIOD)=SIMPLE/
                CONTRAST(DIAL)=SIMPLE/
                TRANSFORM=WSDESIGN/
                PRINT=SIGNIF(BRIEF)/
                ANALYSIS(REPEATED)
```

Here the intention is to estimate parameters for a complete deviation model. This is the default for the between-subjects factor and is obtained for the two within-subjects factors by requesting simple contrasts.

The first parameter estimated will be 9 times the grand mean (the constant 9 coming from the product of the numbers of levels of the two within-subjects factors: 3*3). The second parameter will be 9 times the deviation contrast for the first NOISE level (based on the same product as above). The third parameter will be 3 times the deviation contrast for the first level of PERIOD. (The constant 3 is here the number of levels of the other within-subjects factor , DIAL.) To complete the story, it is useful to introduce some formal notation.

Using i, j, and k as indices for the levels of NOISE, PERIOD, and DIAL, respectively, the complete deviation model for the cell means (μ_{ijk}) may be written as

$$\mu_{ijk} = \mu + \alpha_i + \beta_j + \gamma_k + \alpha\beta_{ij} + \alpha\gamma_{ik} + \beta\gamma_{jk} + \alpha\beta\gamma_{ijk}$$

with i=1,2, j=1,2,3, and k=1,2,3.
(The deviation model places the following restrictions on the parameters:

$$\sum_i \alpha_i = \sum_j \beta_j = \sum_k \gamma_k = 0,$$

$$\sum_j \alpha\beta_{ij} = \sum_k \alpha\gamma_{ik} = 0 \quad \text{for i=1,2,}$$

$$\sum_i \alpha\beta_{ij} = \sum_k \beta\gamma_{jk} = 0 \quad \text{for j=1,2,3,}$$

$$\sum_i \alpha\gamma_{ik} = \sum_j \beta\gamma_{jk} = 0 \quad \text{for } k=1,2,3,$$

$$\sum_k \alpha\beta\gamma_{ijk} = 0 \text{ for } i=1,2, \ j=1,2,3,$$

$$\sum_j \alpha\beta\gamma_{ijk} = 0 \text{ for } i=1,2, \ k=1,2,3, \quad \text{and}$$

$$\sum_i \alpha\beta\gamma_{ijk} = 0 \text{ for } j=1,2,3, \ k=1,2,3.)$$

Table 2 gives a complete summary in terms of this model of
the contrasts estimated by the foregoing MANOVA setup. Besides the
inconvenient ordering of the contrasts and the confusing labelling
(in ESTIMATES FOR Y1, the name Y1 does not refer to the original first
reponse, but to the first transformed response, namely the sum of
the nine original responses), the reader should notice that the constant
factor multiplying the parameter of interest is the product of the
numbers of levels of all within-subjects factors not represented in
the subscripts of the parameter. This is a general rule which, together
with the previous recommendations, may be used to obtain estimates
of desired contrasts for designs having repeated measures on one or
more factors.

Conclusions

It is unfortunate that easily avoidable confusions crop up in
trying to obtain apparently straightforward repeated measures analyses
with SPSS MANOVA. Nonetheless, as indicated, the program is still
usable for estimating contrasts in these cases. This fact, when added
to the important combination of flexibility and accessibility which
SPSS MANOVA offers users, provides support to a choice of the program
as a general aid in applying linear models to data. While a systematic
comparison of SPSS MANOVA with alternative programs is beyond the scope
of this note, the potential user should be warned that none of the

Table 2

Contrasts estimated for NOISE x PERIOD x DIAL design using SPSS MANOVA

order in output	labelling in output	estimated contrasts in terms of deviation model parameters
1	ESTIMATES FOR Y1 CONSTANT	9μ
2	NOISE	$9\alpha_1$
3	ESTIMATES FOR Y2 PERIOD	$3\beta_1$
4	NOISE AND PERIOD	$3\alpha\beta_{11}$
5	ESTIMATES FOR Y3 PERIOD	$3\beta_2$
6	NOISE AND PERIOD	$3\alpha\beta_{12}$
7	ESTIMATES FOR Y4 DIAL	$3\gamma_1$
8	NOISE AND DIAL	$3\alpha\gamma_{11}$
9	ESTIMATES FOR Y5 DIAL	$3\gamma_2$
10	NOISE AND DIAL	$3\alpha\gamma_{12}$
11	ESTIMATES FOR Y6 PERIOD BY DIAL	$\beta\gamma_{11}$
12	NOISE AND PERIOD BY DIAL	$\alpha\beta\gamma_{111}$
13	ESTIMATES FOR Y7 PERIOD BY DIAL	$\beta\gamma_{12}$
14	NOISE AND PERIOD BY DIAL	$\alpha\beta\gamma_{112}$
15	ESTIMATES FOR Y8 PERIOD BY DIAL	$\beta\gamma_{21}$
16	NOISE AND PERIOD BY DIAL	$\alpha\beta\gamma_{121}$
17	ESTIMATES FOR Y9 PERIOD BY DIAL	$\beta\gamma_{22}$
18	NOISE AND PERIOD BY DIAL	$\alpha\beta\gamma_{122}$

alternatives known to the author is free of confusions, limitations and, occasionally, serious errors. An illustration of this point for the program MULTIVARIANCE (Finn, 1978) may be found in Lewis & Knippenberg (1981). It should be noted that, regarding the problem of contrast specification for within-subjects factors, MULTIVARIANCE normally makes the same confusion between basis and contrast matrices as does SPSS MANOVA. An option exists, however, for correcting this confusion (Finn, 1980, p. 34, 76). Whatever choice of program one makes, it cannot be too strongly emphasized that all analyses should be carried out with the utmost care and that, whenever feasible, results should be checked, either by hand or with results from alternative ways of carrying out the same analyses. To put it another way, the existence of sophisticated programs does not relieve investigators of the primary responsibility for the correctness of any analyses they report.

Acknowledgements

References

Finn, J.D. MULTIVARIANCE User's Guide. Chicago: National Educational Resources, 1980 (Version VI, Release 2).

Hull, C.H., & Nie, N.H. SPSS UPDATE 7-9. New York: McGraw-Hill, 1981.

Lewis, C., & Van Knippenberg, C. Estimation and model comparisons for repeated measures data. Kwantitatieve Methoden, 1981, 3, nr.5, 129-150.

SPSS Inc. SPSS[X] User's Guide. New York: McGraw-Hill, 1983.

Winer, B.J. Statistical Principles in Experimental Design. Second Edition. New York: McGraw-Hill, 1971.

Appendix

   While the author has not had the opportunity to see MANOVA output
from SPSS[x] (at the University of Groningen, the currently available version
is SPSS for the CYBER (NOS), Release 8.3), he has studied the description of
MANOVA given in the SPSS[x] User's Guide (SPSS Inc.,1983) which documents
Release 1 of SPSS[x].

   In the "Help for Old Friends" appendix (SPSS Inc., 1983, pp.767-
768), a list of modifications to SPSS MANOVA is given. Nothing directly
pertaining to the issues discussed in this note is mentioned. A careful
reading of the MANOVA description (SPSS Inc., 1983, pp.464-539), however,
suggests that TRANSFORM has been modified so that TRANSFORM=WSDESIGN
is no longer recognized. This leaves transformations which are suitable
when only one within-subjects factor is present in a design, plus
the possibility of obtaining orthonormal transformations using WSDESIGN.

   Specifically, in an "Annotated Example for MANOVA" (SPSS Inc., 1983,
p.505), the following remarks appear regarding model specification for
a simple repeated measures design:

> The CONTRAST subcommand specifies a special set of
> contrasts for comparisons of the means across scores.
> The within-subjects factor requires orthogonal contrasts,
> so that you could specify difference, helmert, or poly-
> nomial contrasts ... If you do not specify orthogonal
> contrasts, MANOVA takes your specified contrasts and
> orthonormalizes them.

The last sentence is, as we have seen, incomplete. In fact, a specified
non-orthogonal contrast matrix will be first inverted, then transposed,
and, only then, orthonormalized.

   Thus the message for SPSS[x] users seems to be: if you want to estimate
parameters corresponding to effects for within-subjects factors, then

   a) work with designs having only a single within-
      subjects factor and use TRANSFORM,

   b) include only within-subjects factors having two
      levels (so that the issue of contrast choice is
      irrelevant), or

     c) when dealing with multi-factor, within-subjects
       designs, restrict attention to orthogonal contrast
       sets for those within-subjects factors having more
       than two levels.

An alternative message for such users might be: continue using Release
9 of SPSS as long as it is available to you!

Ontvangen: 12-10-1983