4 The average $F$ test. If

```
PRINT=SIGNIF(AVERF)/
```

is specified, MANOVA outputs an averaged $F$ test for each tested effect. This is particularly useful for repeated measures designs (see Section 1.44). The sum of squares for the effect and the sum of squares for the error in the averaged $F$ test are obtained by summing over the hypothesis sum of squares and the error sum of squares, respectively, for each variable. The averaged $F$ test for the TR effect in the dental calculus example is given in Figure 1.33d.

**Figure 1.33d**

AVERAGED F-TEST WITH (12,300) D. F.

| | HYPOTH. SS | ERROR SS | HYPOTH. MS | ERROR MS | F | SIG. OF F |
|---|---|---|---|---|---|---|
| (AVER.) | 103.80979 | 823.74994 | 8.65082 | 2.74583 | 3.15052 | .000 |

5 A brief table of multivariate significance tests. A summary table, similar to the univariate ANOVA table, (with Wilks' lambda and the corresponding approximate $F$ statistic replacing the univariate $F$) can be obtained by specifying

```
PRINT=SIGNIF(BRIEF)/
```

Note that the BRIEF specification overrides requests for the standard multivariate significance tests, the hypothesis SSCP matrix, and step-down analysis. The BRIEF output for Figure 1.32a is given in Figure 1.33e.

**Figure 1.33e**

TESTS OF SIGNIFICANCE FOR WITHIN CELLS USING SEQUENTIAL SUMS OF SQUARES

| SOURCE OF VARIATION | WILKS LAMBDA | APPROX MULT F | SIG. OF F | AVERAGED F | SIG. OF F |
|---|---|---|---|---|---|
| CONSTANT | .46843 | 37.07044 | 0.0 | 76.86413 | 0.0 |
| YEAR | .95923 | 1.38843 | .251 | 2.83448 | .038 |
| TR | .80733 | 1.82255 | .045 | 3.15052 | .000 |
| YEAR BY TR | .97555 | .81881 | .487 | 1.32601 | .266 |

## 1.34 Principal Components Analysis

Principal components analysis (which is performed on each error matrix used in the model) can be requested via the PRINT subcommand. If

```
PRINT=PRINCOMPS(COR)/
```

is specified, the principal components of the error correlation matrix are printed, while

```
PRINT=PRINCOMPS(COV)/
```

produces the principal components of the error-covariance matrix.

The output for a principal components analysis includes

1 A table listing the eigenvalues of the error matrix (COR or COV) and the proportion and cumulative proportion of the total variance accounted for by each component.

2 The principal components of the error matrix.

3 The determinant of the error matrix, the Bartlett test of sphericity, and $F$ max tests. The Bartlett test statistic, which has an approximate chi-square distribution with $q(q-1)/2$ degrees of freedom, is used to test the hypothesis that the population error correlation matrix is an identity matrix (or, equivalently, that the population error variance-covariance matrix is a diagonal matrix). The $F$ max statistic (the ratio of the largest to the smallest diagonal element of the error variance-covariance matrix) is used to test the hypothesis that the variances of the q response variables are equal. The critical points of the distribution of $F$ max under the null hypothesis can be found in Winer (1971) and depend on q and $n_e$. Both the Bartlett test and $F$ max test can be obtained simply by requesting the error correlation matrix; i.e., by specifying

```
PRINT=ERROR(COR)/
```

in a MANOVA run. It is not necessary to perform a principal components analysis in order to obtain these statistics.