Applying the appropriate computation formulas, the following sums of squares are obtained:

ROWS

$$\frac{1}{C}\sum_{r=1}^{R} T_{r.}^2 - \frac{T^2}{N} = \frac{394{,}350}{4} - \frac{(1{,}970)^2}{40} = 1{,}565.00$$

COLUMNS

$$\frac{1}{R}\sum_{c=1}^{C} T_{.c}^2 - \frac{T^2}{N} = \frac{1{,}045{,}756}{10} - \frac{(1{,}970)^2}{40} = 7{,}553.10$$

INTERACTION

$$\sum_{r=1}^{R}\sum_{c=1}^{C} X_{rc}^2 - \frac{1}{C}\sum_{r=1}^{R} T_{r.}^2 - \frac{1}{R}\sum_{c=1}^{C} T_{.c}^2 + \frac{T^2}{N}$$

$$= 122{,}984 - \frac{394{,}350}{4} - \frac{1{,}045{,}756}{10} + \frac{(1{,}970)^2}{40}$$

$$= 16{,}843.40$$

TOTAL

$$\sum_{r=1}^{R}\sum_{c=1}^{C} X_{rc}^2 - \frac{T^2}{N} = 122{,}984 - \frac{(1{,}970)^2}{40} = 25{,}961.50$$

Table 19.2 summarizes the analysis-of-variance data for this example. Because this is a mixed model with $n = 1$ and $F_r = s_r^2/s_{rc}^2 = .279$, no meaningful test of row effects is possible. The proper error term for column effects is s_{rc}^2. The F ratio for column effects is found to be 4.04. The F ratios required for significance with 3 and 27 degrees of freedom associated with the numerator and denominator, respectively, are 2.96 at the 5 percent and 4.60 at the 1 percent levels. Thus the column differences

Table 19.2

Analysis of variance for data of Table 19.1

Source of variation	Sum of squares	Degrees of freedom	Variance estimate
Rows	1,565.00	9	$173.89 = s_r^2$
Columns	7,553.10	3	$2{,}517.70 = s_c^2$
Interaction	16,843.40	27	$623.83 = s_{rc}^2$
Total	25,961.50		

$F_c = \dfrac{s_c^2}{s_{rc}^2} = 4.04 \qquad F_r = \dfrac{s_r^2}{s_{rc}^2} = .279$