Examples of Different Results using car package

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Contents

1 Tested Version and Books used for the Validation

1.1 Packages Used

- 'sasLM' version: 0.10.3
- 'SAS' version: 9.4 Licensed and University Edition
- 'car' version: 3.1.2
- R version: R version 4.3.3 (2024-02-29 ucrt)

The 'car' package is not necessary for 'sasLM.' It is used for the comparison of the results.

If you see any difference betwwen 'car' and 'sasLM', 'SAS' results coincide with 'sasLM', not with 'car.'

Before 'sasLM' is available on CRAN, you can download using the following command in R.

```
install.packages("sasLM", repos="http://r.acr.kr")
```

1.2 Books and Articles used for the Test

1. Snee RD. Computation and Use of Expected Mean Squares in Analysis of Variance. J Qual Tech. 1974:6(3);128-137.
2. Goodnight JH. The General Linear Models Procedure, Proceedings of the First International SAS User's Group, SAS Institute, Raleigh, N.C. 1976.
3. Littell RC, Stroup WW, Freund RJ. SAS for Linear Models 4e. John Wiley & Sons Inc. 2002.
4. Sahai H, Ojeda MM. Analysis of Variance for Random Models Volume 2 Unbalanced Data. 2005.
5. Federer WT, King F. Variations on Split Plot and Split Block Experiment Designs. John Wiley & Sons Inc. 2007.
6. Hinkelmann K, Kempthorne O. Design and Analysis of Experiments Volume 1 Introduction to Experimental Design. 2e. John Wiley & Sons Inc. 2008.
7. Searle SR, Gruber MHJ. Linear Models 2e, Kindle Edition. John Wiley & Sons Inc. 2016.

2 Snee EMS ANOVA 1974

Reference

- Snee RD. Computation and Use of Expected Mean Squares in Analysis of Variance. J Qual Tech. 1974:6(3);128-137.

(1) MODEL

```
Snee = read.csv("http://r.acr.kr/Snee_EMS_ANOVA1974.csv")
Snee = af(Snee, c("Machine", "Analyst", "Test", "Day"))
aov3(Y ~ Day/Machine/Analyst/Test, Snee)
```

```
Response : Y
                           Df Sum Sq Mean Sq F value Pr(>F)
MODEL                     167 751.27  4.4986
 Day                       41 359.44  8.7669
 Day:Machine               42 199.40  4.7477
 Day:Machine:Analyst       42 118.80  2.8285
 Day:Machine:Analyst:Test  42  70.30  1.6739
RESIDUALS                   0   0.00
CORRECTED TOTAL           167 751.27
```

```
options(contrasts=c("contr.sum", "contr.poly"))
Anova(lm(Y ~ Day/Machine/Analyst/Test, Snee), type=3, singular.ok=TRUE)
# NOT WORKING
```

3 Goodnight

Reference

- Goodnight JH. The General Linear Models Procedure, Proceedings of the First International SAS User's Group, SAS Institute, Raleigh, N.C. 1976.

3.1 p33

(2) MODEL

```
p33 = read.csv("http://r.acr.kr/Goodnight-p33.csv")
p33 = af(p33, c("A", "B"))
aov3(y ~ A + B + A:B, p33) # p35
```

```
Response : y
                Df Sum Sq Mean Sq F value Pr(>F)
MODEL            4 34.905  8.7261
 A               1  3.028  3.0276
 B               1 23.523 23.5225
 A:B             1  0.008  0.0081
RESIDUALS        0  0.000
CORRECTED TOTAL  4 34.905
```

```
options(contrasts = c("contr.sum", "contr.poly"))
Anova(lm(y ~ A + B + A:B, p33), type=3, singular.ok=TRUE) # NOT WORKING
```

4 SAS for Linear Models 4e

Reference

- Littell RC, Stroup WW, Freund RJ. SAS for Linear Models 4e. John Wiley & Sons Inc. 2002.

4.1 p403

(3) MODEL

```
p403 = read.table("http://r.acr.kr/sas4lm/p403.txt", header=TRUE)
p403 = af(p403, c("PATIENT", "VISIT"))
aov3(HR ~ SEQUENCE + PATIENT %in% SEQUENCE + VISIT + DRUG + RESIDS + RESIDT, p403)
```

```
Response : HR
                  Df Sum Sq Mean Sq F value    Pr(>F)
MODEL             29 6408.7 220.989  3.9120 3.127e-05 ***
 SEQUENCE          5  701.2 140.237  2.4825   0.04665 *
 VISIT             2  146.8  73.389  1.2991   0.28350
 DRUG              2  344.0 171.975  3.0443   0.05826 .
 RESIDS            1  309.2 309.174  5.4731   0.02414 *
 RESIDT            1    0.8   0.840  0.0149   0.90351
 SEQUENCE:PATIENT 18 4692.3 260.685  4.6147 2.210e-05 ***
RESIDUALS         42 2372.6  56.490
CORRECTED TOTAL   71 8781.3
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
options(contrasts=c("contr.sum", "contr.poly"))
Anova(lm(HR ~ SEQUENCE + PATIENT %in% SEQUENCE + VISIT + DRUG + RESIDS + RESIDT,
         p403), type=3, singular.ok=TRUE) # NOT OK
```

```
Note: model has aliased coefficients
      sums of squares computed by model comparison

Anova Table (Type III tests)

Response: HR
                 Sum Sq Df F values   Pr(>F)
SEQUENCE            0.0  0
VISIT             146.8  2   1.2991  0.28350
DRUG              343.9  2   3.0443  0.05826 .
RESIDS            309.2  1   5.4731  0.02414 *
RESIDT              0.8  1   0.0149  0.90351
SEQUENCE:PATIENT 4692.3 18   4.6147 2.21e-05 ***
Residuals        2372.6 42
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

4.2 p417

(4) MODEL

```
p417 = read.table("http://r.acr.kr/sas4lm/p417.txt", header=TRUE)
p417 = af(p417, c("TRT", "POT", "PLANT"))
aov3(Y ~ TRT + POT %in% TRT, p417) # p418 Output 11.28
```

```
Response : Y
                Df  Sum Sq Mean Sq F value    Pr(>F)
MODEL            7 267.226  38.175  12.433 7.522e-05 ***
 TRT             2 200.111 100.055  32.586 8.626e-06 ***
 TRT:POT         5  30.306   6.061   1.974    0.1499
RESIDUALS       13  39.917   3.071
CORRECTED TOTAL 20 307.143
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
options(contrasts=c("contr.sum", "contr.poly"))
Anova(lm(Y ~ TRT + POT %in% TRT, p417), type=3, singular.ok=TRUE) # NOT OK
```

```
Note: model has aliased coefficients
      sums of squares computed by model comparison

Anova Table (Type III tests)

Response: Y
          Sum Sq Df F values  Pr(>F)
TRT       22.310  1    7.266 0.01835 *
TRT:POT   30.306  5    1.974 0.14991
Residuals 39.917 13
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

4.3 p431

(5) MODEL

```
p431 = read.table("http://r.acr.kr/sas4lm/p431.txt", header=TRUE)
p431 = af(p431, c("line", "sire", "agedam", "steerno"))
aov3(avdlygn ~ line + line:sire + agedam + line:agedam + age + intlwt, p431)
```

```
Response : avdlygn
                Df Sum Sq Mean Sq F value   Pr(>F)
MODEL           16 2.5275 0.15797  3.1437 0.001091 **
 line            2 0.1362 0.06810  1.3553 0.267560
 agedam          2 0.1301 0.06505  1.2946 0.283392
 age             1 0.3813 0.38128  7.5878 0.008277 **
 intlwt          1 0.2697 0.26970  5.3674 0.024830 *
 line:sire       6 0.9739 0.16231  3.2303 0.009543 **
 line:agedam     4 0.4534 0.11336  2.2560 0.076821 .
RESIDUALS       48 2.4119 0.05025
CORRECTED TOTAL 64 4.9394
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
# p433 Output 11.40
```

```
options(contrasts=c("contr.sum", "contr.poly"))
Anova(lm(avdlygn ~ line + line:sire + agedam + line:agedam + age + intlwt, p431),
      type=3, singular.ok=TRUE) # NOT OK for line
```

```
Note: model has aliased coefficients
      sums of squares computed by model comparison
Anova Table (Type III tests)

Response: avdlygn
             Sum Sq Df F values   Pr(>F)
line        0.00000  0
agedam      0.13011  2   1.2946 0.283392
age         0.38128  1   7.5878 0.008277 **
intlwt      0.26970  1   5.3674 0.024830 *
line:sire   0.97389  6   3.2303 0.009543 **
line:agedam 0.45343  4   2.2560 0.076821 .
Residuals   2.41192 48
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

5 Sahai - Unbalanced

Reference

- Sahai H, Ojeda MM. Analysis of Variance for Random Models Volume 2 Unbalanced Data. 2005.

5.1 Table 15.3

(6) MODEL

```
T15.3 = read.table("http://r.acr.kr/sahai/T15.3.txt")
colnames(T15.3) = c("Dam", "Sire", "pH")
T15.3 = af(T15.3, c("Dam", "Sire"))
aov3(pH ~ Dam/Sire, T15.3) # p301
```

```
Response : pH
                 Df  Sum Sq   Mean Sq F value    Pr(>F)
MODEL            36 0.25804 0.0071678  2.8977 7.200e-06 ***
 Dam             14 0.17940 0.0128146  5.1805 1.347e-07 ***
 Dam:Sire        22 0.08002 0.0036374  1.4705   0.09662 .
RESIDUALS       123 0.30425 0.0024736
CORRECTED TOTAL 159 0.56229
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
options(contrasts = c("contr.sum", "contr.poly"))
Anova(lm(pH ~ Dam/Sire, T15.3), type=3, singular.ok=TRUE) # NOT OK
```

```
Note: model has aliased coefficients
      sums of squares computed by model comparison
Anova Table (Type III tests)

Response: pH
            Sum Sq  Df F values    Pr(>F)
Dam       0.081011   6   5.4584 4.898e-05 ***
Dam:Sire  0.080024  22   1.4705   0.09662 .
Residuals 0.304253 123
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

5.2 Table 16.3

(7) MODEL

```
T16.3 = read.csv("http://r.acr.kr/sahai/T16.3.csv")
colnames(T16.3) = c("Plot", "Sample", "Subsample", "Residue")
T16.3 = af(T16.3, c("Plot", "Sample", "Subsample"))
aov3(Residue ~ Plot/Sample/Subsample, T16.3) # p344
```

```
Response : Residue
                       Df Sum Sq  Mean Sq F value    Pr(>F)
MODEL                  54 3.1897 0.059069  5.8842 1.476e-05 ***
 Plot                  10 1.7869 0.178686 17.7998 2.547e-08 ***
 Plot:Sample           22 0.9917 0.045079  4.4906 0.0004209 ***
 Plot:Sample:Subsample 22 0.3576 0.016253  1.6191 0.1330632
RESIDUALS              22 0.2208 0.010039
CORRECTED TOTAL        76 3.4106
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
options(contrasts = c("contr.sum", "contr.poly"))
Anova(lm(Residue ~ Plot/Sample/Subsample, T16.3), type=3, singular.ok=TRUE)
```

```
Note: model has aliased coefficients
      sums of squares computed by model comparison

Anova Table (Type III tests)

Response: Residue
                       Sum Sq Df F values  Pr(>F)
Plot                  0.00000  0
Plot:Sample           0.36613 11   3.3156 0.00805 **
Plot:Sample:Subsample 0.35758 22   1.6191 0.13306
Residuals             0.22085 22
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
# NOT OK
```

6 Federer - Variations

Reference

- Federer WT, King F. Variations on Split Plot and Split Block Experiment Designs. John Wiley & Sons Inc. 2007.

6.1 Example 2.2

(8) MODEL

```
ex2.2 = read.table("http://r.acr.kr/split/sbex2_2.txt", header=TRUE)
ex2.2 = af(ex2.2, c("Row", "Column", "R", "S"))
aov3(Y ~ Row + R + S + R:S + Row:R + Column:S + Column:R:S, ex2.2)
```

```
Response : Y
                Df  Sum Sq Mean Sq F value Pr(>F)
MODEL           99 22310.4  225.36
 Row             0
 R               4  1159.8  289.94
 S               3   351.9  117.29
 R:S            12   826.0   68.83
 Row:R           0
 S:Column       12  3863.3  321.94
 R:S:Column     48 11982.3  249.63
RESIDUALS        0     0.0
CORRECTED TOTAL 99 22310.4
```

```
options(contrasts=c("contr.sum", "contr.poly"))
Anova(lm(Y ~ Row + R + S + R:S + Row:R + Column:S + Column:R:S, ex2.2), type=3,
      singular.ok=TRUE) # NOT WORKING
```

6.2 Example 3.1

(9) MODEL

```
ex3.1a = read.table("http://r.acr.kr/split/Ex3.1-example.txt", header=TRUE)
ex3.1a = af(ex3.1a, c("row", "P", "column", "R", "S"))
aov3(height ~ row + R + P + S + S:R + row:P + R:P + row:R:P + S:P + S:P:row +
    S:R:P + R:S:P:row, ex3.1a)
```

```
Response : height
                 Df Sum Sq Mean Sq F value Pr(>F)
MODEL           199 7534.8   37.86
 row              4 2017.0  504.26
 R                4   90.6   22.66
 P                1  253.1  253.13
 S                3   16.4    5.46
 R:S             12  195.0   16.25
 row:P            4  167.2   41.81
 R:P              4  505.0  126.24
 P:S              3   14.3    4.77
 row:R:P         32 2933.5   91.67
 row:P:S         24  234.7    9.78
 R:P:S           12  100.3    8.36
 row:R:P:S       96 1007.5   10.49
RESIDUALS         0    0.0
CORRECTED TOTAL 199 7534.8
```

```
options(contrasts=c("contr.sum", "contr.poly"))
Anova(lm(height ~ row + R + P + S + S:R + row:P + R:P + row:R:P + S:P +
         S:P:row + S:R:P + R:S:P:row, ex3.1a), type=3, singular.ok=TRUE)
         # NOT WORKING
```

6.3 Appendix 3.1 p94

(10) MODEL

```
ex3.1b = read.table("http://r.acr.kr/split/spexvar3.txt", header=TRUE)
ex3.1b = af(ex3.1b, c("rep", "var", "nit", "row", "col"))
aov3(yield ~ rep + var + rep:var + nit + var:nit + row + col, ex3.1b)
```

```
Response : yield
                Df Sum Sq Mean Sq F value    Pr(>F)
MODEL           37  48090  1299.7 11.3414 6.734e-11 ***
 rep             2   5943  2971.3 25.9273 1.449e-07 ***
 var             2   2800  1399.9 12.2155 0.0001005 ***
 nit             3  11978  3992.6 34.8397 1.775e-10 ***
 row             9    945   105.0  0.9162 0.5230151
 col             2   3171  1585.7 13.8373 4.012e-05 ***
 rep:var         4    998   249.4  2.1767 0.0926008 .
 var:nit         6    478    79.6  0.6949 0.6553307
RESIDUALS       34   3896   114.6
CORRECTED TOTAL 71  51986
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
options(contrasts=c("contr.sum", "contr.poly"))
Anova(lm(yield ~ rep + var + rep:var + nit + var:nit + row + col, ex3.1b),
      type=3, singular.ok=TRUE) # NOT OK for var
```

```
Note: model has aliased coefficients
      sums of squares computed by model comparison

Anova Table (Type III tests)

Response: yield
           Sum Sq Df F values    Pr(>F)
rep        5942.5  2  25.9273 1.449e-07 ***
var           0.0  0
nit       11977.9  3  34.8397 1.775e-10 ***
row         945.0  9   0.9162    0.5230
col        3171.5  2  13.8373 4.012e-05 ***
rep:var     997.8  4   2.1767    0.0926 .
var:nit     477.8  6   0.6949    0.6553
Residuals  3896.4 34
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

6.4 Example 5.1

(11) MODEL

```
ex5.1 = read.table("http://r.acr.kr/split/sbsp.txt", header=TRUE)
ex5.1 = af(ex5.1, c("R", "A", "C", "B", "Tx"))
aov3(Y ~ R + A + A:R + C + B + B:C + Tx + A:Tx + B:Tx, ex5.1)
```

```
Response : Y
                Df  Sum Sq Mean Sq F value    Pr(>F)
MODEL           24 196.238  8.1766  7.0476 0.0008758 ***
 R               2  22.186 11.0928  9.5611 0.0039244 **
 A               1  15.185 15.1853 13.0886 0.0040418 **
 C               2   1.010  0.5049  0.4352 0.6578395
 B               1   1.792  1.7922  1.5448 0.2397515
 Tx              5 103.333 20.6667 17.8131 6.055e-05 ***
 R:A             2  27.426 13.7132 11.8197 0.0018198 **
 C:B             2   0.085  0.0424  0.0366 0.9642020
 A:Tx            4   2.655  0.6636  0.5720 0.6886524
 B:Tx            4   2.050  0.5126  0.4418 0.7761730
RESIDUALS       11  12.762  1.1602
CORRECTED TOTAL 35 209.000
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
options(contrasts=c("contr.sum", "contr.poly"))
Anova(lm(Y ~ R + A + A:R + C + B + B:C + Tx + A:Tx + B:Tx, ex5.1),
      type=3, singular.ok=TRUE) # NOT OK
```

```
Note: model has aliased coefficients
      sums of squares computed by model comparison

Anova Table (Type III tests)

Response: Y
           Sum Sq Df F values    Pr(>F)
R          22.186  2   9.5611  0.003924 **
A           0.000  0
C           1.010  2   0.4352  0.657839
B           0.000  0
Tx        103.333  5  17.8131 6.055e-05 ***
R:A        27.426  2  11.8197  0.001820 **
C:B         0.085  2   0.0366  0.964202
A:Tx        2.655  4   0.5720  0.688652
B:Tx        2.050  4   0.4418  0.776173
Residuals  12.762 11
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

(12) MODEL

```
aov3(Y ~ R + A + A:R + C + B + C:B + Tx + A:Tx + B:Tx + A:B:Tx, ex5.1)
```

```
Response : Y
                Df  Sum Sq Mean Sq F value    Pr(>F)
MODEL           28 204.200  7.2929 10.6354 0.0017194 **
 R               2  28.112 14.0562 20.4986 0.0011846 **
 A               1  14.655 14.6551 21.3720 0.0024176 **
 C               2   0.471  0.2356  0.3436 0.7205632
 B               1   1.769  1.7694  2.5804 0.1522328
 Tx              5 103.815 20.7630 30.2793 0.0001336 ***
 R:A             1   2.017  2.0174  2.9420 0.1300172
 C:B             1   0.644  0.6445  0.9399 0.3646045
 A:Tx            4   2.951  0.7378  1.0760 0.4358837
 B:Tx            4   3.553  0.8882  1.2954 0.3579988
 A:B:Tx          4   7.962  1.9905  2.9029 0.1038803
RESIDUALS        7   4.800  0.6857
CORRECTED TOTAL 35 209.000
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
options(contrasts=c("contr.sum", "contr.poly"))
Anova(lm(Y ~ R + A + A:R + C + B + C:B + Tx + A:Tx + B:Tx + A:B:Tx, ex5.1),
      type=3, singular.ok=TRUE) # NOT OK
```

```
Note: model has aliased coefficients
      sums of squares computed by model comparison

Anova Table (Type III tests)

Response: Y
          Sum Sq Df F values   Pr(>F)
R         11.643  1  16.9793 0.004456 **
A          0.000  0
C          0.002  1   0.0025 0.961483
B          0.000  0
Tx        89.178  3  43.3503 6.87e-05 ***
R:A        2.017  1   2.9420 0.130017
C:B        0.644  1   0.9399 0.364604
A:Tx       0.543  3   0.2640 0.849381
B:Tx       3.384  3   1.6451 0.264128
A:B:Tx     7.962  4   2.9029 0.103880
Residuals  4.800  7
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

6.5 Example 7.1

(13) MODEL

```
ex7.1 = read.table("http://r.acr.kr/split/asped.txt", header=TRUE)
ex7.1 = af(ex7.1, c("R", "G", "F"))
aov3(Y ~ R + G + R:G + F + F:G, ex7.1)
```

```
Response : Y
                 Df Sum Sq Mean Sq F value    Pr(>F)
MODEL            95 577.83  6.0824  5.3082 1.068e-05 ***
 R                3   5.75  1.9167  1.6727    0.1994
 G               27 343.48 12.7216 11.1025 4.286e-08 ***
 F                2  50.50 25.2525 22.0385 3.686e-06 ***
 R:G              9  11.75  1.3056  1.1394    0.3749
 G:F             54  77.98  1.4441  1.2603    0.2718
RESIDUALS        24  27.50  1.1458
CORRECTED TOTAL 119 605.33
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
options(contrasts=c("contr.sum", "contr.poly"))
Anova(lm(Y ~ R + G + R:G + F + F:G, ex7.1), type=3, singular.ok=TRUE) # NOT OK
```

```
Note: model has aliased coefficients
      sums of squares computed by model comparison

Anova Table (Type III tests)

Response: Y
           Sum Sq Df F values    Pr(>F)
R           0.000  0
G         202.417  3  58.8848 3.258e-11 ***
F          50.505  2  22.0385 3.686e-06 ***
R:G        11.750  9   1.1394    0.3749
G:F        77.983 54   1.2603    0.2718
Residuals  27.500 24
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

6.6 Example 7.3

(14) MODEL

```
ex7.3 = read.table("http://r.acr.kr/split/assped.txt", header=TRUE)
ex7.3 = af(ex7.3, c("R", "T", "G", "F"))
aov3(Y ~ R + T + R:T + G + G:T + R:T:G + F + F:T + F:G + F:G:T, ex7.3)
```

```
Response : Y
                 Df Sum Sq Mean Sq  F value    Pr(>F)
MODEL           155 656.12   4.233  13.4461 3.997e-14 ***
 R                3  12.49   4.162  13.2206 5.655e-06 ***
 T                1  11.16  11.158  35.4430 8.021e-07 ***
 G               22 389.01  17.682  56.1668 < 2.2e-16 ***
 F                2 120.56  60.282 191.4828 < 2.2e-16 ***
 R:T              3   1.15   0.384   1.2206  0.316281
 T:G             22  18.42   0.837   2.6601  0.004445 **
 T:F              2   0.82   0.411   1.3060  0.283432
 G:F             44  23.47   0.533   1.6943  0.053191 .
 R:T:G           12   8.78   0.731   2.3235  0.025315 *
 T:G:F           44  10.74   0.244   0.7753  0.790640
RESIDUALS        36  11.33   0.315
CORRECTED TOTAL 191 667.45
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
options(contrasts=c("contr.sum", "contr.poly"))
Anova(lm(Y ~ R + T + R:T + G + G:T + R:T:G + F + F:T + F:G + F:G:T, ex7.3),
      type=3, singular.ok=TRUE) # NOT OK
```

```
Note: model has aliased coefficients
      sums of squares computed by model comparison

Anova Table (Type III tests)

Response: Y
           Sum Sq Df F values    Pr(>F)
R           0.000  0
T           0.000  0
G          73.444  2 116.6471 < 2.2e-16 ***
F         120.563  2 191.4828 < 2.2e-16 ***
R:T         0.000  0
T:G         5.778  2   9.1765 0.0006018 ***
T:F         0.822  2   1.3060 0.2834316
G:F        23.469 44   1.6943 0.0531910 .
R:T:G       8.778 12   2.3235 0.0253153 *
T:G:F      10.740 44   0.7753 0.7906401
Residuals  11.333 36
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

6.7 Example 8.1

(15) MODEL

```
ex8.1 = read.table("http://r.acr.kr/split/asbed.txt", header=TRUE)
ex8.1 = af(ex8.1, c("R", "A", "B"))
aov3(Y ~ R + A + R:A + B + B:R + A:B + A:B:R, ex8.1)
```

```
Response : Y
                 Df Sum Sq Mean Sq F value Pr(>F)
MODEL           104 3951.8  37.999
 R                2  372.2 186.111
 A               12  572.3  47.692
 B                8  185.8  23.231
 R:A              6   50.0   8.333
 R:B              4   87.4  21.861
 A:B             60 1012.3  16.871
 R:A:B           12   49.0   4.083
RESIDUALS         0    0.0
CORRECTED TOTAL 104 3951.8
```

```
options(contrasts=c("contr.sum", "contr.poly"))
Anova(lm(Y ~ R + A + R:A + B + B:R + A:B + A:B:R, ex8.1), type="III",
      singular.ok=TRUE) # NOT WORKING
```

6.8 Example 9.2

(16) MODEL

```
ex9.2 = read.table("http://r.acr.kr/split/Ex9.2-sbex.txt", header=TRUE)
ex9.2 = af(ex9.2, c("rep", "hyb", "gen"))
aov3(yield ~ rep + hyb + rep:hyb + gen + gen:rep + gen:hyb, ex9.2)
```

```
Response : yield
                Df  Sum Sq Mean Sq F value    Pr(>F)
MODEL           40 247.813  6.1953  4.4606 0.0011186 **
 rep             1   0.167  0.1667  0.1200 0.7335481
 hyb             9  66.796  7.4218  5.3437 0.0018370 **
 gen             2  30.671 15.3356 11.0416 0.0009707 ***
 rep:hyb         8  67.000  8.3750  6.0300 0.0011569 **
 rep:gen         2  12.111  6.0556  4.3600 0.0308015 *
 hyb:gen        18  60.504  3.3613  2.4201 0.0408545 *
RESIDUALS       16  22.222  1.3889
CORRECTED TOTAL 56 270.035
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
options(contrasts=c("contr.sum", "contr.poly"))
Anova(lm(yield ~ rep + hyb + rep:hyb + gen + gen:rep + gen:hyb, ex9.2), type=3,
      singular.ok=TRUE) # NOT OK
```

```
Note: model has aliased coefficients
      sums of squares computed by model comparison

Anova Table (Type III tests)

Response: yield
          Sum Sq Df F values    Pr(>F)
rep        0.000  0
hyb       66.704  8   6.0033 0.0011847 **
gen       30.671  2  11.0416 0.0009707 ***
rep:hyb   67.000  8   6.0300 0.0011569 **
rep:gen   12.111  2   4.3600 0.0308015 *
hyb:gen   60.504 18   2.4201 0.0408545 *
Residuals 22.222 16
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

6.9 Example 10.1

(17) MODEL

```
ex10.1 = read.table("http://r.acr.kr/split/Ex10.1-New.txt", header=TRUE)
ex10.1 = af(ex10.1, c("Site", "Block", "A", "B", "C"))
f10.1 = Yield ~ Site/Block + A/Site + B/Site + A:B + A:B:Site + A:B:Site:Block +
        C + A:C + B:C + A:B:C + C:Site + A:C:Site + B:C:Site + A:B:C:Site
aov3(f10.1, ex10.1)
```

```
Response : Yield
                 Df     Sum Sq   Mean Sq    F value  Pr(>F)
MODEL           239 1639561484   6860090 2.1620e+03 < 2e-16 ***
 Site             3     552717    184239 5.8064e+01 < 2e-16 ***
 A                4 1387680917 346920229 1.0933e+05 < 2e-16 ***
 B                1  100939695 100939695 3.1812e+04 < 2e-16 ***
 C                3   19356264   6452088 2.0334e+03 < 2e-16 ***
 Site:Block       8    7062320    882790 2.7822e+02 < 2e-16 ***
 Site:A          12      34068      2839 8.9470e-01 0.55301
 Site:B           3       1618       539 1.6990e-01 0.91662
 A:B              4   31444008   7861002 2.4775e+03 < 2e-16 ***
 A:C             12   26075792   2172983 6.8483e+02 < 2e-16 ***
 B:C              3   23901387   7967129 2.5109e+03 < 2e-16 ***
 Site:C           9      47625      5292 1.6677e+00 0.09747 .
 Site:A:B        12      33737      2811 8.8600e-01 0.56185
 A:B:C           12   41996729   3499727 1.1030e+03 < 2e-16 ***
 Site:A:C        36     104110      2892 9.1140e-01 0.61768
 Site:B:C         9      61111      6790 2.1400e+00 0.02701 *
 Site:Block:A:B  72     186911      2596 8.1810e-01 0.84155
 Site:A:B:C      36      82475      2291 7.2200e-01 0.87941
RESIDUALS       240     761522      3173
CORRECTED TOTAL 479 1640323006
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
options(contrasts=c("contr.sum", "contr.poly"))
Anova(lm(f10.1, ex10.1), type=3, singular.ok=TRUE) # NOT OK for Site:Block
```

```
Note: model has aliased coefficients
      sums of squares computed by model comparison

Anova Table (Type III tests)

Response: Yield
                  Sum Sq  Df   F values  Pr(>F)
Site              552717   3 5.8064e+01 < 2e-16 ***
A              1387680917   4 1.0933e+05 < 2e-16 ***
B               100939695   1 3.1812e+04 < 2e-16 ***
C                19356264   3 2.0334e+03 < 2e-16 ***
Site:Block              0   0
```

```
Site:A              34068  12 8.9470e-01 0.55301
Site:B               1618   3 1.6990e-01 0.91662
A:B              31444008   4 2.4775e+03 < 2e-16 ***
A:C              26075792  12 6.8483e+02 < 2e-16 ***
B:C              23901388   3 2.5109e+03 < 2e-16 ***
Site:C              47625   9 1.6677e+00 0.09747 .
Site:A:B            33737  12 8.8600e-01 0.56185
A:B:C            41996729  12 1.1030e+03 < 2e-16 ***
Site:A:C           104110  36 9.1140e-01 0.61768
Site:B:C            61111   9 2.1400e+00 0.02701 *
Site:Block:A:B     186911  72 8.1810e-01 0.84155
Site:A:B:C          82475  36 7.2200e-01 0.87941
Residuals          761522 240
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

7 Hinkelmann & Kempthorne - Volume 1

Reference

- Hinkelmann K, Kempthorne O. Design and Analysis of Experiments Volume 1 Introduction to Experimental Design. 2e. John Wiley & Sons Inc. 2008.

7.1 p410

(18) MODEL

```
v1p410 = read.table("http://r.acr.kr/kemp/v1p410.txt", head=TRUE)
v1p410$carry = ifelse(v1p410$carry == 0, 3, v1p410$carry)
v1p410 = af(v1p410,c("period", "sequence", "steer", "trt", "carry"))
aov3(y ~ period + sequence + steer:sequence + trt + carry, v1p410) # OK
```

```
Response : y
                Df  Sum Sq Mean Sq F value    Pr(>F)
MODEL           17 1302.51  76.618  8.7402 1.572e-05 ***
 period          2  172.31  86.154  9.8279 0.0013030 **
 sequence        5  318.69  63.738  7.2709 0.0006954 ***
 trt             2  440.61 220.304 25.1311 6.164e-06 ***
 carry           2   16.43   8.215  0.9372 0.4100385
 sequence:steer  6  118.50  19.750  2.2530 0.0849122 .
RESIDUALS       18  157.79   8.766
CORRECTED TOTAL 35 1460.31
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
options(contrasts=c("contr.sum", "contr.poly"))
Anova(lm(y ~ period + sequence + steer:sequence + trt + carry, v1p410), type=3,
      singular.ok=TRUE) # NOT OK for sequence
```

```
Note: model has aliased coefficients
      sums of squares computed by model comparison

Anova Table (Type III tests)

Response: y
               Sum Sq Df F values    Pr(>F)
period         172.31  2   9.8279  0.001303 **
sequence         0.00  0
trt            440.61  2  25.1311 6.164e-06 ***
carry           16.43  2   0.9372  0.410038
sequence:steer 118.50  6   2.2530  0.084912 .
Residuals      157.79 18
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

8 Searle - Linear Models 2e

Reference

- Searle SR, Gruber MHJ. Linear Models 2e, Kindle Edition. John Wiley & Sons Inc. 2016.

8.1 7.2 (p390, 59%)

(19) MODEL

```
weight = c(8,13,9,12,7,11,6,12,12,14,9,7,14,16,10,14,11,13)
treatment = c("ta","ta","ta","ta","ta","ta","tb","tb","tb","tb","tc","tc","tc",
              "tc","tc","tc","tc","tc")
variety = c("va","va","va","vc","vd","vd","va","va","vb","vb","vb","vb","vc",
            "vc","vd","vd","vd","vd")
d1 = data.frame(weight, treatment, variety)
aov3(weight ~ treatment*variety, d1)
```

```
Response : weight
                  Df  Sum Sq Mean Sq F value  Pr(>F)
MODEL              7  82.000 11.7143  2.0918 0.13995
 treatment         2  12.471  6.2353  1.1134 0.36595
 variety           3  34.872 11.6240  2.0757 0.16719
 treatment:variety 2  34.714 17.3571  3.0995 0.08965 .
RESIDUALS         10  56.000  5.6000
CORRECTED TOTAL   17 138.000
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
options(contrasts = c("contr.sum", "contr.poly"))
Anova(lm(weight ~ treatment*variety, d1), type=3, singular.ok=TRUE) # NOT OK
```

```
Note: model has aliased coefficients
      sums of squares computed by model comparison

Anova Table (Type III tests)

Response: weight
                  Sum Sq Df F values  Pr(>F)
treatment          0.000  0
variety            0.000  0
treatment:variety 34.714  2   3.0995 0.08965 .
Residuals         56.000 10
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

8.2 7.2 (p393, 60%)

(20) MODEL

```
percent = c(31,33,44,36,38,26,37,59,42,42,34,42,28,39,36,32,38,42,36,22,42,46,
            26,37,43)
refinery = c(rep("g",9),rep("n",8),rep("s",8))
process = as.factor(c(1,1,1,1,1,1,2,2,2,1,1,1,1,2,2,2,2,1,1,1,2,2,2,2,2))
source0 = c("t","t","t","t","o","m","t","t","o","m","i","i","i","t","o","m","m",
            "t","o","i","o","o","m","i","i")
d2 = data.frame(percent, refinery, process, source=source0)
aov3(percent ~ refinery*source, d2)
```

```
Response : percent
                 Df  Sum Sq Mean Sq F value Pr(>F)
MODEL            10  442.56  44.256  0.6361 0.7616
 refinery         2   10.77   5.383  0.0774 0.9259
 source           3  282.63  94.211  1.3542 0.2972
 refinery:source  5  155.47  31.095  0.4469 0.8086
RESIDUALS        14  974.00  69.571
CORRECTED TOTAL  24 1416.56
```

```
options(contrasts=c("contr.sum", "contr.poly"))
Anova(lm(percent ~ refinery*source, d2), type=3, singular.ok=TRUE) # NOT OK
```

```
Note: model has aliased coefficients
      sums of squares computed by model comparison

Anova Table (Type III tests)

Response: percent
                Sum Sq Df F values Pr(>F)
refinery          2.52  1   0.0362 0.8518
source          268.19  2   1.9275 0.1822
refinery:source 155.47  5   0.4469 0.8086
Residuals       974.00 14
```

9 Web site examples

9.1 https://github.com/djnavarro/psyr

(21) MODEL

```
d21 = read.csv("http://r.acr.kr/psyr/coffee.csv")
GLM(babble ~ sugar*milk - 1, d21)
```

```
$ANOVA
Response : babble
                  Df Sum Sq Mean Sq F value   Pr(>F)
MODEL              6 472.54  78.756  298.84 2.39e-12 ***
RESIDUALS         12   3.16   0.264
UNCORRECTED TOTAL 18 475.70
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

$Fitness
  Root MSE babble Mean Coef Var  R-square  Adj R-sq
 0.5133631    5.066667 10.13217 0.9933519 0.9900279

$`Type I`
           Df Sum Sq Mean Sq  F value    Pr(>F)
sugar       3 465.64 155.213 588.9486 2.756e-13 ***
milk        1   0.96   0.956   3.6279  0.081061 .
sugar:milk  2   5.94   2.972  11.2769  0.001754 **
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

$`Type II`
           Df Sum Sq Mean Sq F value   Pr(>F)
sugar       2 3.0696 1.53482  5.8238 0.017075 *
milk        1 0.9561 0.95611  3.6279 0.081061 .
sugar:milk  2 5.9439 2.97193 11.2769 0.001754 **
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

$`Type III`
CAUTION: Singularity Exists !
           Df Sum Sq Mean Sq F value   Pr(>F)
sugar       2 2.1318  1.0659  4.0446 0.045426 *
milk        1 1.0041  1.0041  3.8102 0.074672 .
sugar:milk  2 5.9439  2.9719 11.2769 0.001754 **
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
options(contrasts=c("contr.sum", "contr.poly"))
r21 = lm(babble ~ sugar*milk - 1, d21)
```

```r
Anova(r21, type=2) # NOT OK
```

```
Anova Table (Type II tests)

Response: babble
           Sum Sq Df  F value    Pr(>F)
sugar      453.76  3 573.9233 3.214e-13 ***
milk         0.96  1   3.6279  0.081061 .
sugar:milk   5.94  2  11.2769  0.001754 **
Residuals    3.16 12
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```r
Anova(r21, type=3) # NOT OK
```

```
Anova Table (Type III tests)

Response: babble
           Sum Sq Df  F value    Pr(>F)
sugar      454.77  3 575.1970 3.172e-13 ***
milk         1.00  1   3.8102  0.074672 .
sugar:milk   5.94  2  11.2769  0.001754 **
Residuals    3.16 12
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

10 Bioequivalence (BE) data example

(22) MODEL

```
GLM(log(CMAX) ~ SEQ/SUBJ + PRD + TRT, BEdata) # a BE dataset in sasLM package
```

```
$ANOVA
Response : log(CMAX)
                Df  Sum Sq Mean Sq F value    Pr(>F)
MODEL           48 23.1924 0.48317  5.6278 4.395e-08 ***
RESIDUALS       42  3.6059 0.08585
CORRECTED TOTAL 90 26.7983
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

$Fitness
  Root MSE log(CMAX) Mean Coef Var  R-square  Adj R-sq
 0.2930098       6.071036 4.826355 0.8654428 0.7116631

$`Type I`
         Df  Sum Sq Mean Sq F value    Pr(>F)
SEQ       1  0.6454 0.64544  7.5178  0.008938 **
SEQ:SUBJ 45 22.4395 0.49866  5.8081 3.359e-08 ***
PRD       1  0.0969 0.09686  1.1281  0.294242
TRT       1  0.0106 0.01057  0.1231  0.727410
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

$`Type II`
         Df  Sum Sq Mean Sq F value    Pr(>F)
SEQ       1  0.6440 0.64395  7.5005  0.009011 **
SEQ:SUBJ 45 22.5232 0.50052  5.8298 3.173e-08 ***
PRD       1  0.0996 0.09958  1.1599  0.287632
TRT       1  0.0106 0.01057  0.1231  0.727410
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

$`Type III`
         Df  Sum Sq Mean Sq F value    Pr(>F)
SEQ       1  0.3368 0.33679  3.9228   0.05421 .
SEQ:SUBJ 45 22.5232 0.50052  5.8298 3.173e-08 ***
PRD       1  0.0996 0.09958  1.1599   0.28763
TRT       1  0.0106 0.01057  0.1231   0.72741
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
options(contrasts=c("contr.sum", "contr.poly"))
Anova(lm(log(CMAX) ~ SEQ/SUBJ + PRD + TRT, BEdata), type=3, singular.ok=TRUE)
```

```
Note: model has aliased coefficients
      sums of squares computed by model comparison

Anova Table (Type III tests)

Response: log(CMAX)
           Sum Sq Df F values    Pr(>F)
SEQ        0.0000  0
PRD        0.0996  1   1.1599    0.2876
TRT        0.0106  1   0.1231    0.7274
SEQ:SUBJ  22.5232 45   5.8298 3.173e-08 ***
Residuals  3.6059 42
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

11 Sesssion Information

```
R version 4.3.3 (2024-02-29 ucrt)
Platform: x86_64-w64-mingw32/x64 (64-bit)
Running under: Windows 10 x64 (build 19044)

Matrix products: default


locale:
[1] LC_COLLATE=Korean_Korea.utf8  LC_CTYPE=Korean_Korea.utf8
[3] LC_MONETARY=Korean_Korea.utf8 LC_NUMERIC=C
[5] LC_TIME=Korean_Korea.utf8

time zone: Asia/Seoul
tzcode source: internal

attached base packages:
[1] stats     graphics  grDevices utils     datasets  methods   base

other attached packages:
[1] car_3.1-2      carData_3.0-5  sasLM_0.10.3   mvtnorm_1.2-4  rmarkdown_2.25

loaded via a namespace (and not attached):
 [1] digest_0.6.34   fastmap_1.1.1   xfun_0.41       abind_1.4-5
 [5] knitr_1.45      htmltools_0.5.7 cli_3.6.2       compiler_4.3.3
 [9] tools_4.3.3     evaluate_0.23   yaml_2.3.8      rlang_1.1.3
[13] MASS_7.3-60.0.1
```