Examples of NOT OK using car package

Kyun-Seop Bae MD PhD

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Contents

1 Tested Version and Books used for the Validation

1.1 Packages Used

- 'sasLM' version: 0.9.3
- 'SAS' version: 9.4 Licensed and University Edition
- 'car' version: 3.1.1
- R version: R version 4.2.2 (2022-10-31 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"))
Snee
```

```
    Machine Analyst Test Day    Y
1         1       1    1   1  6.1
2         1       1    1   2  8.5
3         1       1    1   3  8.6
4         1       1    1   4  9.3
5         1       1    1   5  8.1
6         1       1    1   6  8.5
7         1       1    1   7  9.8
8         1       1    1   8  9.0
9         1       1    1   9 11.0
10        1       1    1  10  9.7
11        1       1    1  11 10.5
12        1       1    1  12  8.3
13        1       1    1  13  8.4
14        1       1    1  14 10.2
15        1       1    1  15  9.3
16        1       1    1  16  7.1
17        1       1    1  17  5.8
18        1       1    1  18  8.9
19        1       1    1  19 11.5
20        1       1    1  20 10.3
21        1       1    1  21  9.1
22        1       1    1  22  5.7
23        1       1    1  23  8.5
24        1       1    1  24  9.6
25        1       1    1  25  9.4
26        1       1    1  26 10.3
27        1       1    1  27  7.0
28        1       1    1  28 11.5
29        1       1    1  29  6.0
30        1       1    1  30  8.0
31        1       1    1  31 13.4
32        1       1    1  32 12.1
```

33	1	1	1	33	14.2
34	1	1	1	34	10.0
35	1	1	1	35	6.5
36	1	1	1	36	6.5
37	1	1	1	37	9.2
38	1	1	1	38	11.0
39	1	1	1	39	8.6
40	1	1	1	40	8.9
41	1	1	1	41	6.6
42	1	1	1	42	8.4
43	1	1	2	1	6.6
44	1	1	2	2	9.6
45	1	1	2	3	6.7
46	1	1	2	4	7.2
47	1	1	2	5	7.1
48	1	1	2	6	9.0
49	1	1	2	7	9.8
50	1	1	2	8	8.0
51	1	1	2	9	10.9
52	1	1	2	10	10.6
53	1	1	2	11	8.4
54	1	1	2	12	10.6
55	1	1	2	13	7.2
56	1	1	2	14	8.0
57	1	1	2	15	8.7
58	1	1	2	16	8.7
59	1	1	2	17	6.8
60	1	1	2	18	6.6
61	1	1	2	19	7.1
62	1	1	2	20	10.0
63	1	1	2	21	9.5
64	1	1	2	22	7.7
65	1	1	2	23	8.8
66	1	1	2	24	12.2
67	1	1	2	25	10.4
68	1	1	2	26	10.6
69	1	1	2	27	10.6
70	1	1	2	28	7.3
71	1	1	2	29	7.0
72	1	1	2	30	7.0
73	1	1	2	31	9.2
74	1	1	2	32	11.7
75	1	1	2	33	10.6
76	1	1	2	34	10.4
77	1	1	2	35	8.4
78	1	1	2	36	6.8
79	1	1	2	37	10.1
80	1	1	2	38	11.0

81	1	1	2	39	10.0
82	1	1	2	40	8.0
83	1	1	2	41	7.2
84	1	1	2	42	8.8
85	1	2	1	1	6.6
86	1	2	1	2	8.2
87	1	2	1	3	8.0
88	1	2	1	4	6.5
89	1	2	1	5	2.3
90	1	2	1	6	4.0
91	1	2	1	7	11.7
92	1	2	1	8	6.8
93	1	2	1	9	10.5
94	1	2	1	10	10.3
95	1	2	1	11	10.0
96	1	2	1	12	8.8
97	1	2	1	13	6.7
98	1	2	1	14	8.9
99	1	2	1	15	9.9
100	1	2	1	16	8.2
101	1	2	1	17	7.5
102	1	2	1	18	6.6
103	1	2	1	19	3.1
104	1	2	1	20	7.2
105	1	2	1	21	10.7
106	1	2	1	22	8.4
107	1	2	1	23	7.6
108	1	2	1	24	12.6
109	1	2	1	25	9.6
110	1	2	1	26	12.6
111	1	2	1	27	10.8
112	1	2	1	28	5.1
113	1	2	1	29	6.6
114	1	2	1	30	8.6
115	1	2	1	31	12.5
116	1	2	1	32	10.4
117	1	2	1	33	10.6
118	1	2	1	34	7.2
119	1	2	1	35	7.8
120	1	2	1	36	4.4
121	1	2	1	37	8.7
122	1	2	1	38	11.2
123	1	2	1	39	10.3
124	1	2	1	40	7.0
125	1	2	1	41	7.7
126	1	2	1	42	7.6
127	2	1	1	1	8.8
128	2	1	1	2	8.1

```
129       2       1    1   3  7.4
130       2       1    1   4  8.0
131       2       1    1   5  9.5
132       2       1    1   6  9.2
133       2       1    1   7 12.8
134       2       1    1   8  9.2
135       2       1    1   9 11.3
136       2       1    1  10  9.3
137       2       1    1  11  4.0
138       2       1    1  12  9.7
139       2       1    1  13  4.6
140       2       1    1  14  2.1
141       2       1    1  15  9.7
142       2       1    1  16 10.0
143       2       1    1  17 10.2
144       2       1    1  18  9.2
145       2       1    1  19 10.8
146       2       1    1  20  9.4
147       2       1    1  21 10.3
148       2       1    1  22 10.3
149       2       1    1  23  8.3
150       2       1    1  24 11.6
151       2       1    1  25  9.4
152       2       1    1  26 11.3
153       2       1    1  27 11.4
154       2       1    1  28  9.6
155       2       1    1  29  2.2
156       2       1    1  30  6.6
157       2       1    1  31 11.5
158       2       1    1  32  9.1
159       2       1    1  33  4.6
160       2       1    1  34  7.9
161       2       1    1  35  9.0
162       2       1    1  36  8.1
163       2       1    1  37  9.4
164       2       1    1  38 10.9
165       2       1    1  39  9.0
166       2       1    1  40  7.8
167       2       1    1  41  9.3
168       2       1    1  42  6.8
```

```
GLM(Y ~ Day/Machine/Analyst/Test, Snee)
```

```
$ANOVA
Response : Y
                Df Sum Sq Mean Sq F value Pr(>F)
MODEL          167 751.27  4.4986
```

```
RESIDUALS         0   0.00
CORRECTED TOTAL 167 751.27

$Fitness
 Root MSE   Y Mean Coef Var R-square
       NA 8.736905       NA        1

$`Type I`
                         Df Sum Sq Mean Sq F value Pr(>F)
Day                      41 365.58  8.9166
Day:Machine              42 196.59  4.6807
Day:Machine:Analyst      42 118.80  2.8285
Day:Machine:Analyst:Test 42  70.30  1.6739

$`Type II`
                         Df Sum Sq Mean Sq F value Pr(>F)
Day                      41 365.58  8.9166
Day:Machine              42 196.59  4.6807
Day:Machine:Analyst      42 118.80  2.8285
Day:Machine:Analyst:Test 42  70.30  1.6739

$`Type III`
                         Df Sum Sq Mean Sq F value Pr(>F)
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
```

```r
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"))
p33
```

```
  A B    y
1 1 1 2.96
2 1 2 7.90
3 2 1 4.79
4 2 2 9.55
5 3 3 9.53
```

```
GLM(y ~ A + B + A:B, p33) # p35
```

```
$ANOVA
Response : y
                Df Sum Sq Mean Sq F value Pr(>F)
MODEL            4 34.905  8.7261
RESIDUALS        0  0.000
CORRECTED TOTAL  4 34.905

$Fitness
 Root MSE y Mean Coef Var R-square
       NA  6.946       NA        1

$`Type I`
    Df  Sum Sq Mean Sq F value Pr(>F)
A    2 11.3739  5.6870
B    1 23.5225 23.5225
A:B  1  0.0081  0.0081

$`Type II`
    Df  Sum Sq Mean Sq F value Pr(>F)
A    1  3.0276  3.0276
B    1 23.5225 23.5225
```

```
A:B  1  0.0081  0.0081

$`Type III`
CAUTION: Singularity Exists !
    Df  Sum Sq Mean Sq F value Pr(>F)
A    1  3.0276  3.0276
B    1 23.5225 23.5225
A:B  1  0.0081  0.0081
```

```r
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"))
p403
```

```
   PATIENT SEQUENCE VISIT BASEHR  HR     DRUG RESIDT RESIDS
1        1        B     2     86  86  placebo      0      0
2        1        B     3     86 106     test     -1     -1
3        1        B     4     62  79 standard      1      0
4        2        F     2     48  66     test      0      0
5        2        F     3     58  56  placebo      1      0
6        2        F     4     74  79 standard     -1     -1
7        3        B     2     78  84  placebo      0      0
8        3        B     3     78  76     test     -1     -1
9        3        B     4     82  91 standard      1      0
10       4        D     2     66  79 standard      0      0
11       4        D     3     72 100     test      0      1
12       4        D     4     90  82  placebo      1      0
13       5        C     2     74  74     test      0      0
14       5        C     3     90  71 standard      1      0
15       5        C     4     66  62  placebo      0      1
16       6        B     2     62  64  placebo      0      0
17       6        B     3     74  90     test     -1     -1
18       6        B     4     58  85 standard      1      0
19       7        A     2     94  75 standard      0      0
20       7        A     3     72  82  placebo      0      1
21       7        A     4    100 102     test     -1     -1
22       8        A     2     54  63 standard      0      0
23       8        A     3     54  58  placebo      0      1
24       8        A     4     66  62     test     -1     -1
25       9        D     2     82  91 standard      0      0
26       9        D     3     96  86     test      0      1
27       9        D     4     78  88  placebo      1      0
28      10        C     2     86  82     test      0      0
29      10        C     3     70  71 standard      1      0
30      10        C     4     58  62  placebo      0      1
31      11        F     2     82  80     test      0      0
```

```
32      11        F     3     80  78  placebo      1      0
33      11        F     4     72  75 standard     -1     -1
34      12        E     2     96  90  placebo      0      0
35      12        E     3     92  93 standard     -1     -1
36      12        E     4     82  88     test      0      1
37      13        D     2     78  87 standard      0      0
38      13        D     3     72  80     test      0      1
39      13        D     4     76  78  placebo      1      0
40      14        F     2     98  86     test      0      0
41      14        F     3     86  86  placebo      1      0
42      14        F     4     70  79 standard     -1     -1
43      15        A     2     86  71 standard      0      0
44      15        A     3     66  70  placebo      0      1
45      15        A     4     74  90     test     -1     -1
46      16        E     2     86  86  placebo      0      0
47      16        E     3     90 103 standard     -1     -1
48      16        E     4     82  86     test      0      1
49      17        A     2     66  83 standard      0      0
50      17        A     3     82  86  placebo      0      1
51      17        A     4     86 102     test     -1     -1
52      18        F     2     66  82     test      0      0
53      18        F     3     78  80  placebo      1      0
54      18        F     4     74  95 standard     -1     -1
55      19        E     2     74  80  placebo      0      0
56      19        E     3     78  79 standard     -1     -1
57      19        E     4     70  74     test      0      1
58      20        B     2     66  70  placebo      0      0
59      20        B     3     74  62     test     -1     -1
60      20        B     4     62  67 standard      1      0
61      21        C     2     82  90     test      0      0
62      21        C     3     90 103 standard      1      0
63      21        C     4     76  82  placebo      0      1
64      22        C     2     82  82     test      0      0
65      22        C     3     66  83 standard      1      0
66      22        C     4     90  82  placebo      0      1
67      23        E     2     82  66  placebo      0      0
68      23        E     3     74  87 standard     -1     -1
69      23        E     4     82  82     test      0      1
70      24        D     2     72  75 standard      0      0
71      24        D     3     82  86     test      0      1
72      24        D     4     74  82  placebo      1      0
```

```
GLM(HR ~ SEQUENCE + PATIENT %in% SEQUENCE + VISIT + DRUG + RESIDS + RESIDT, p403)
```

```
$ANOVA
Response : HR
                Df Sum Sq Mean Sq F value    Pr(>F)
```

```
MODEL           29 6408.7  220.99   3.912 3.127e-05 ***
RESIDUALS       42 2372.6   56.49
CORRECTED TOTAL 71 8781.3
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

$Fitness
 Root MSE  HR Mean Coef Var  R-square Adj R-sq
 7.515988 80.80556 9.301326 0.7298134 0.543256

$`Type I`
                 Df Sum Sq Mean Sq F value   Pr(>F)
SEQUENCE          5  508.9  101.79  1.8019 0.133346
SEQUENCE:PATIENT 18 4692.3  260.69  4.6147 2.21e-05 ***
VISIT             2  146.8   73.39  1.2991 0.283499
DRUG              2  668.8  334.39  5.9194 0.005435 **
RESIDS            1  391.0  391.02  6.9219 0.011854 *
RESIDT            1    0.8    0.84  0.0149 0.903511
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

$`Type II`
                 Df Sum Sq Mean Sq F value   Pr(>F)
SEQUENCE          5  701.2 140.237  2.4825  0.04665 *
SEQUENCE:PATIENT 18 4692.3 260.685  4.6147 2.21e-05 ***
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
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

$`Type III`
                 Df Sum Sq Mean Sq F value   Pr(>F)
SEQUENCE          5  701.2 140.237  2.4825  0.04665 *
SEQUENCE:PATIENT 18 4692.3 260.685  4.6147 2.21e-05 ***
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
---
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"))
p417
```

```
   Obs TRT POT PLANT  Y
1    1   1   1     1 15
2    2   1   1     2 13
3    3   1   1     3 16
4    4   1   2     1 17
5    5   1   2     2 19
6    6   1   3     1 12
7    7   2   1     1 20
8    8   2   1     2 21
9    9   2   2     1 20
10  10   2   2     2 23
11  11   2   2     3 19
12  12   2   2     4 19
13  13   3   1     1 12
14  14   3   1     2 13
15  15   3   1     3 14
16  16   3   2     1 11
17  17   3   3     1 12
18  18   3   3     2 13
19  19   3   3     3 15
20  20   3   3     4 11
21  21   3   3     5  9
```

```
GLM(Y ~ TRT + POT %in% TRT, p417) # p418 Output 11.28
```

```
$ANOVA
Response : Y
                Df  Sum Sq Mean Sq F value    Pr(>F)
MODEL            7 267.226  38.175  12.433 7.522e-05 ***
RESIDUALS       13  39.917   3.071
CORRECTED TOTAL 20 307.143
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

$Fitness
 Root MSE   Y Mean Coef Var  R-square  Adj R-sq
 1.752288 15.42857 11.35742 0.8700388 0.8000596

$`Type I`
        Df  Sum Sq Mean Sq F value    Pr(>F)
TRT      2 236.921 118.460  38.580 3.412e-06 ***
TRT:POT  5  30.306   6.061   1.974    0.1499
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

$`Type II`
        Df  Sum Sq Mean Sq F value    Pr(>F)
TRT      2 236.921 118.460  38.580 3.412e-06 ***
TRT:POT  5  30.306   6.061   1.974    0.1499
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

$`Type III`
        Df  Sum Sq Mean Sq F value    Pr(>F)
TRT      2 200.111 100.055  32.586 8.626e-06 ***
TRT:POT  5  30.306   6.061   1.974    0.1499
---
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"))
p431
```

```
   Obs line sire agedam steerno age intlwt avdlygn
1    1    1    1      3       1 192    390    2.24
2    2    1    1      3       2 154    403    2.65
3    3    1    1      4       3 185    432    2.41
4    4    1    1      4       4 193    457    2.25
5    5    1    1      5       5 186    483    2.58
6    6    1    1      5       6 177    469    2.67
7    7    1    1      5       7 177    428    2.71
8    8    1    1      5       8 163    439    2.47
9    9    1    2      4       9 188    439    2.29
10  10    1    2      4      10 178    407    2.26
11  11    1    2      5      11 198    498    1.97
12  12    1    2      5      12 193    459    2.14
13  13    1    2      5      13 186    459    2.44
14  14    1    2      5      14 175    375    2.52
15  15    1    2      5      15 171    382    1.72
16  16    1    2      5      16 168    417    2.75
17  17    1    3      3      17 154    389    2.38
18  18    1    3      4      18 184    414    2.46
19  19    1    3      5      19 174    483    2.29
20  20    1    3      5      20 170    430    2.30
21  21    1    3      5      21 169    443    2.94
22  22    2    4      3      22 158    381    2.50
23  23    2    4      3      23 158    365    2.44
24  24    2    4      4      24 169    386    2.44
25  25    2    4      4      25 144    339    2.15
26  26    2    4      5      26 159    419    2.54
27  27    2    4      5      27 152    469    2.74
28  28    2    4      5      28 149    379    2.50
29  29    2    4      5      29 149    375    2.54
30  30    2    5      3      30 189    395    2.65
31  31    2    5      4      31 187    447    2.52
```

```
32  32    2    5      4      32 165    430    2.67
33  33    2    5      5      33 181    453    2.79
34  34    2    5      5      34 177    385    2.33
35  35    2    5      5      35 151    414    2.67
36  36    2    5      5      36 147    353    2.69
37  37    3    6      4      37 184    411    3.00
38  38    3    6      4      38 184    420    2.49
39  39    3    6      5      39 187    427    2.25
40  40    3    6      5      40 184    409    2.49
41  41    3    6      5      41 183    337    2.02
42  42    3    6      5      42 177    352    2.31
43  43    3    7      3      43 205    472    2.57
44  44    3    7      3      44 193    340    2.37
45  45    3    7      4      45 162    375    2.64
46  46    3    7      5      46 206    451    2.37
47  47    3    7      5      47 205    472    2.22
48  48    3    7      5      48 187    402    1.90
49  49    3    7      5      49 178    464    2.61
50  50    3    7      5      50 175    414    2.13
51  51    3    8      3      51 200    466    2.16
52  52    3    8      3      52 184    356    2.33
53  53    3    8      3      53 175    449    2.52
54  54    3    8      4      54 178    360    2.45
55  55    3    8      5      55 189    385    1.44
56  56    3    8      5      56 184    431    1.72
57  57    3    8      5      57 183    401    2.17
58  58    3    9      3      58 166    404    2.68
59  59    3    9      4      59 187    482    2.43
60  60    3    9      4      60 186    350    2.36
61  61    3    9      4      61 184    483    2.44
62  62    3    9      5      62 180    425    2.66
63  63    3    9      5      63 177    420    2.46
64  64    3    9      5      64 175    440    2.52
65  65    3    9      5      65 164    405    2.42
```

```
GLM(avdlygn ~ line + line:sire + agedam + line:agedam + age + intlwt, p431)
```

```
$ANOVA
Response : avdlygn
                Df Sum Sq  Mean Sq F value   Pr(>F)
MODEL           16 2.5275 0.157966  3.1437 0.001091 **
RESIDUALS       48 2.4119 0.050248
CORRECTED TOTAL 64 4.9394
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

$Fitness
```

```
  Root MSE avdlygn Mean Coef Var R-square Adj R-sq
 0.2241612     2.411385 9.295956 0.511696 0.348928

$`Type I`
            Df  Sum Sq  Mean Sq F value  Pr(>F)
line         2 0.38009 0.190046  3.7821 0.02983 *
line:sire    6 0.92634 0.154391  3.0726 0.01260 *
agedam       2 0.11894 0.059471  1.1835 0.31497
line:agedam  4 0.64889 0.162222  3.2284 0.02000 *
age          1 0.18349 0.183487  3.6516 0.06200 .
intlwt       1 0.26970 0.269704  5.3674 0.02483 *
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

$`Type II`
            Df  Sum Sq Mean Sq F value   Pr(>F)
line         2 0.05526 0.02763  0.5498 0.580636
line:sire    6 0.97389 0.16231  3.2303 0.009543 **
agedam       2 0.33106 0.16553  3.2943 0.045640 *
line:agedam  4 0.45343 0.11336  2.2560 0.076821 .
age          1 0.38128 0.38128  7.5878 0.008277 **
intlwt       1 0.26970 0.26970  5.3674 0.024830 *
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

$`Type III`
            Df  Sum Sq Mean Sq F value   Pr(>F)
line         2 0.13620 0.06810  1.3553 0.267560
line:sire    6 0.97389 0.16231  3.2303 0.009543 **
agedam       2 0.13011 0.06505  1.2946 0.283392
line:agedam  4 0.45343 0.11336  2.2560 0.076821 .
age          1 0.38128 0.38128  7.5878 0.008277 **
intlwt       1 0.26970 0.26970  5.3674 0.024830 *
---
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"))
T15.3
```

```
    Dam Sire   pH
1     1    1 7.48
2     1    1 7.48
3     1    1 7.52
4     1    1 7.54
5     6    1 7.54
6     6    1 7.36
7     6    1 7.36
8     6    1 7.40
9    11    1 7.52
10   11    1 7.54
11   11    1 7.52
12   11    1 7.56
13   11    1 7.53
14    1    2 7.48
15    1    2 7.53
16    1    2 7.43
17    1    2 7.39
18    6    2 7.44
19    6    2 7.47
20    6    2 7.48
21    6    2 7.48
22   11    2 7.56
23   11    2 7.39
24   11    2 7.52
25   11    2 7.49
26   11    2 7.48
27    2    1 7.45
28    2    1 7.43
29    2    1 7.49
30    2    1 7.40
```

31	2	1	7.40
32	6	3	7.43
33	6	3	7.52
34	6	3	7.50
35	6	3	7.46
36	6	3	7.39
37	12	1	7.50
38	12	1	7.45
39	12	1	7.43
40	12	1	7.44
41	12	1	7.49
42	2	2	7.50
43	2	2	7.45
44	2	2	7.43
45	2	2	7.36
46	7	1	7.41
47	7	1	7.42
48	7	1	7.36
49	7	1	7.47
50	12	2	7.52
51	12	2	7.43
52	12	2	7.38
53	12	2	7.33
54	3	1	7.40
55	3	1	7.45
56	3	1	7.42
57	3	1	7.48
58	7	2	7.47
59	7	2	7.36
60	7	2	7.43
61	7	2	7.38
62	7	2	7.41
63	13	1	7.39
64	13	1	7.37
65	13	1	7.33
66	13	1	7.43
67	13	1	7.42
68	3	2	7.45
69	3	2	7.33
70	3	2	7.40
71	3	2	7.46
72	7	3	7.53
73	7	3	7.40
74	7	3	7.44
75	7	3	7.40
76	7	3	7.45
77	13	2	7.43
78	13	2	7.38

79	13	2	7.44
80	3	3	7.40
81	3	3	7.47
82	3	3	7.40
83	3	3	7.47
84	3	3	7.47
85	8	1	7.52
86	8	1	7.53
87	8	1	7.48
88	13	3	7.46
89	13	3	7.44
90	13	3	7.37
91	13	3	7.54
92	4	1	7.38
93	4	1	7.48
94	4	1	7.46
95	8	2	7.40
96	8	2	7.48
97	8	2	7.50
98	8	2	7.40
99	8	2	7.51
100	14	1	7.50
101	14	1	7.53
102	14	1	7.51
103	14	1	7.43
104	4	2	7.37
105	4	2	7.31
106	4	2	7.45
107	4	2	7.41
108	9	1	7.40
109	9	1	7.34
110	9	1	7.37
111	9	1	7.45
112	14	2	7.44
113	14	2	7.45
114	14	2	7.39
115	14	2	7.52
116	5	1	7.44
117	5	1	7.51
118	5	1	7.49
119	5	1	7.51
120	5	1	7.52
121	9	2	7.42
122	9	2	7.37
123	9	2	7.46
124	9	2	7.40
125	14	3	7.42
126	14	3	7.48

```
127  14    3 7.45
128  14    3 7.51
129  14    3 7.48
130   5    2 7.49
131   5    2 7.49
132   5    2 7.49
133   5    2 7.50
134  10    1 7.39
135  10    1 7.31
136  10    1 7.30
137  10    1 7.41
138  10    1 7.48
139  15    1 7.47
140  15    1 7.49
141  15    1 7.45
142  15    1 7.43
143  15    1 7.42
144   5    3 7.48
145   5    3 7.59
146   5    3 7.59
147  10    2 7.50
148  10    2 7.44
149  10    2 7.40
150  10    2 7.45
151  15    2 7.45
152  15    2 7.42
153  15    2 7.52
154  15    2 7.51
155  15    2 7.32
156  15    3 7.51
157  15    3 7.51
158  15    3 7.53
159  15    3 7.45
160  15    3 7.51
```

```
GLM(pH ~ Dam/Sire, T15.3) # p301
```

```
$ANOVA
Response : pH
                 Df  Sum Sq   Mean Sq F value  Pr(>F)
MODEL            36 0.25804 0.0071678  2.8977 7.2e-06 ***
RESIDUALS       123 0.30425 0.0024736
CORRECTED TOTAL 159 0.56229
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

$Fitness
```

```
   Root MSE  pH Mean  Coef Var  R-square  Adj R-sq
 0.04973534 7.449813 0.6676053 0.4589074 0.3005388

$`Type I`
         Df   Sum Sq   Mean Sq F value    Pr(>F)
Dam      14 0.178017 0.0127155  5.1405 1.563e-07 ***
Dam:Sire 22 0.080024 0.0036374  1.4705   0.09662 .
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

$`Type II`
         Df   Sum Sq   Mean Sq F value    Pr(>F)
Dam      14 0.178017 0.0127155  5.1405 1.563e-07 ***
Dam:Sire 22 0.080024 0.0036374  1.4705   0.09662 .
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

$`Type III`
         Df   Sum Sq   Mean Sq F value    Pr(>F)
Dam      14 0.179405 0.0128146  5.1805 1.347e-07 ***
Dam:Sire 22 0.080024 0.0036374  1.4705   0.09662 .
---
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"))
T16.3
```

```
   Plot Sample Subsample Residue
1     1      1         1    0.52
2     1      1         1    0.43
3     1      1         2    0.40
4     1      1         2    0.52
5     1      2         1    0.26
6     1      2         2    0.54
7     1      3         1    0.52
8     2      1         1    0.50
9     2      1         1    0.59
10    2      1         2    0.47
11    2      1         2    0.50
12    2      2         1    0.04
13    2      2         2    0.43
14    2      3         1    1.08
15    3      1         1    0.34
16    3      1         1    0.26
17    3      1         2    0.32
18    3      1         2    0.45
19    3      2         1    0.25
20    3      2         2    0.38
21    3      3         1    0.29
22    4      1         1    0.18
23    4      1         1    0.24
24    4      1         2    0.31
25    4      1         2    0.29
26    4      2         1    0.13
27    4      2         2    0.25
28    4      3         1    0.10
29    5      1         1    1.05
30    5      1         1    0.66
31    5      1         2    0.60
32    5      1         2    0.51
33    5      2         1    0.95
34    5      2         2    0.84
35    5      3         1    0.92
36    6      1         1    0.52
37    6      1         1    0.66
38    6      1         2    0.55
39    6      1         2    0.40
40    6      2         1    0.33
41    6      2         2    0.26
```

```
42    6      3         1    0.41
43    7      1         1    0.77
44    7      1         1    0.56
45    7      1         2    0.51
46    7      1         2    0.60
47    7      2         1    0.44
48    7      2         2    0.50
49    7      3         1    0.44
50    8      1         1    0.89
51    8      1         1    0.92
52    8      1         2    0.75
53    8      1         2    0.58
54    8      2         1    0.64
55    8      2         2    0.54
56    8      3         1    0.36
57    9      1         1    0.50
58    9      1         1    0.67
59    9      1         2    0.60
60    9      1         2    0.53
61    9      2         1    0.60
62    9      2         2    0.71
63    9      3         1    0.92
64   10      1         1    0.58
65   10      1         1    0.52
66   10      1         2    0.56
67   10      1         2    0.44
68   10      2         1    0.46
69   10      2         2    0.52
70   10      3         1    0.52
71   11      1         1    0.24
72   11      1         1    0.36
73   11      1         2    0.48
74   11      1         2    0.30
75   11      2         1    0.53
76   11      2         2    0.50
77   11      3         1    0.39
```

```
GLM(Residue ~ Plot/Sample/Subsample, T16.3) # p344
```

```
$ANOVA
Response : Residue
                Df Sum Sq  Mean Sq F value    Pr(>F)
MODEL           54 3.1897 0.059069  5.8842 1.476e-05 ***
RESIDUALS       22 0.2208 0.010039
CORRECTED TOTAL 76 3.4106
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
$Fitness
 Root MSE Residue Mean Coef Var  R-square Adj R-sq
 0.100193    0.5023377 19.94535 0.9352456 0.776303

$`Type I`
                      Df  Sum Sq  Mean Sq F value    Pr(>F)
Plot                  10 1.84041 0.184041 18.3332 1.929e-08 ***
Plot:Sample           22 0.99175 0.045079  4.4906 0.0004209 ***
Plot:Sample:Subsample 22 0.35757 0.016253  1.6191 0.1330632
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

$`Type II`
                      Df  Sum Sq  Mean Sq F value    Pr(>F)
Plot                  10 1.84041 0.184041 18.3332 1.929e-08 ***
Plot:Sample           22 0.99175 0.045079  4.4906 0.0004209 ***
Plot:Sample:Subsample 22 0.35757 0.016253  1.6191 0.1330632
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

$`Type III`
                      Df  Sum Sq  Mean Sq F value    Pr(>F)
Plot                  10 1.78686 0.178686 17.7998 2.547e-08 ***
Plot:Sample           22 0.99175 0.045079  4.4906 0.0004209 ***
Plot:Sample:Subsample 22 0.35757 0.016253  1.6191 0.1330632
---
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"))
ex2.2
```

```
    Row Column R S       Y
1     1      1 1 1 1027.85
2     1      1 1 2  982.74
3     1      1 1 3 1007.24
4     1      1 1 4 1008.47
5     1      2 2 1 1004.33
6     1      2 2 2  977.86
7     1      2 2 3  999.15
8     1      2 2 4  990.86
9     1      3 3 1  992.57
10    1      3 3 2  993.71
11    1      3 3 3 1012.57
12    1      3 3 4  968.25
13    1      4 4 1  994.60
14    1      4 4 2 1021.81
15    1      4 4 3  995.03
16    1      4 4 4 1002.17
17    1      5 5 1 1019.89
18    1      5 5 2 1017.48
19    1      5 5 3  987.82
20    1      5 5 4  995.63
21    2      4 1 1  996.18
22    2      4 1 2  981.96
23    2      4 1 3  985.63
24    2      4 1 4  965.80
25    2      5 2 1  996.61
26    2      5 2 2 1011.94
27    2      5 2 3  972.76
28    2      5 2 4 1011.99
29    2      2 3 1 1021.61
30    2      2 3 2 1014.46
```

31	2	2	3	3	980.03
32	2	2	3	4	1014.80
33	2	3	4	1	1028.78
34	2	3	4	2	1006.01
35	2	3	4	3	1015.04
36	2	3	4	4	1000.72
37	2	1	5	1	994.91
38	2	1	5	2	999.91
39	2	1	5	3	1010.29
40	2	1	5	4	1018.49
41	3	5	1	1	985.72
42	3	5	1	2	1012.60
43	3	5	1	3	984.62
44	3	5	1	4	973.47
45	3	1	2	1	1013.52
46	3	1	2	2	1017.40
47	3	1	2	3	996.63
48	3	1	2	4	989.91
49	3	4	3	1	1003.92
50	3	4	3	2	999.33
51	3	4	3	3	995.70
52	3	4	3	4	988.14
53	3	2	4	1	1010.08
54	3	2	4	2	997.66
55	3	2	4	3	1012.12
56	3	2	4	4	1019.53
57	3	3	5	1	1004.83
58	3	3	5	2	983.86
59	3	3	5	3	1018.60
60	3	3	5	4	1020.95
61	4	2	1	1	991.79
62	4	2	1	2	979.47
63	4	2	1	3	1004.70
64	4	2	1	4	1032.75
65	4	3	2	1	1004.52
66	4	3	2	2	996.53
67	4	3	2	3	1016.95
68	4	3	2	4	983.79
69	4	1	3	1	990.17
70	4	1	3	2	972.21
71	4	1	3	3	1002.17
72	4	1	3	4	1017.56
73	4	5	4	1	1006.13
74	4	5	4	2	1005.57
75	4	5	4	3	1003.18
76	4	5	4	4	992.21
77	4	4	5	1	1011.02
78	4	4	5	2	982.79

```
79    4      4 5 3 1018.23
80    4      4 5 4  976.68
81    5      3 1 1  993.54
82    5      3 1 2 1006.80
83    5      3 1 3 1001.24
84    5      3 1 4 1010.73
85    5      4 2 1  985.04
86    5      4 2 2  987.54
87    5      4 2 3  990.53
88    5      4 2 4  982.68
89    5      5 3 1 1012.14
90    5      5 3 2  999.32
91    5      5 3 3 1005.51
92    5      5 3 4  998.86
93    5      1 4 1  985.12
94    5      1 4 2  984.14
95    5      1 4 3 1010.74
96    5      1 4 4 1004.63
97    5      2 5 1  967.39
98    5      2 5 2 1009.78
99    5      2 5 3 1027.49
100   5      2 5 4 1001.61
```

```
GLM(Y ~ Row + R + S + R:S + Row:R + Column:S + Column:R:S, ex2.2)
```

```
$ANOVA
Response : Y
                Df Sum Sq Mean Sq F value Pr(>F)
MODEL           99  22310  225.36
RESIDUALS        0      0
CORRECTED TOTAL 99  22310

$Fitness
 Root MSE   Y Mean Coef Var R-square
       NA 1000.098       NA        1

$`Type I`
           Df  Sum Sq Mean Sq F value Pr(>F)
Row         4   147.4   36.86
R           4  1159.8  289.94
S           3   351.9  117.29
R:S        12   826.0   68.83
Row:R      16  3979.8  248.74
S:Column   12  3863.3  321.94
R:S:Column 48 11982.3  249.63

$`Type II`
```

```
           Df  Sum Sq Mean Sq F value Pr(>F)
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

$`Type III`
CAUTION: Singularity Exists !
           Df  Sum Sq Mean Sq F value Pr(>F)
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
```

```
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"))
ex3.1a
```

```
    row P column R S height
1     1 1      1 3 4    103
2     1 1      1 3 2     98
3     1 1      1 3 3    101
4     1 1      1 3 1    101
5     1 1      2 4 2    100
6     1 1      2 4 3     98
7     1 1      2 4 1    100
8     1 1      2 4 4     99
9     1 1      3 5 3     99
10    1 1      3 5 1     99
11    1 1      3 5 2    100
12    1 1      3 5 4     97
13    1 1      4 2 2     99
```

14	1	1	4	2	1	102
15	1	1	4	2	3	99
16	1	1	4	2	4	100
17	1	1	5	1	1	102
18	1	1	5	1	2	107
19	1	1	5	1	3	98
20	1	1	5	1	4	99
21	1	2	1	3	4	101
22	1	2	1	3	2	101
23	1	2	1	3	3	99
24	1	2	1	3	1	100
25	1	2	2	4	2	97
26	1	2	2	4	3	85
27	1	2	2	4	1	99
28	1	2	2	4	4	97
29	1	2	3	5	3	98
30	1	2	3	5	1	96
31	1	2	3	5	2	88
32	1	2	3	5	4	98
33	1	2	4	2	2	95
34	1	2	4	2	1	90
35	1	2	4	2	3	99
36	1	2	4	2	4	87
37	1	2	5	1	1	98
38	1	2	5	1	2	98
39	1	2	5	1	3	99
40	1	2	5	1	4	89
41	2	1	1	2	4	99
42	2	1	1	2	2	97
43	2	1	1	2	3	98
44	2	1	1	2	1	95
45	2	1	2	3	2	99
46	2	1	2	3	3	98
47	2	1	2	3	1	96
48	2	1	2	3	4	93
49	2	1	3	1	3	97
50	2	1	3	1	1	99
51	2	1	3	1	2	95
52	2	1	3	1	4	98
53	2	1	4	4	2	97
54	2	1	4	4	1	95
55	2	1	4	4	3	99
56	2	1	4	4	4	94
57	2	1	5	5	1	98
58	2	1	5	5	2	93
59	2	1	5	5	3	98
60	2	1	5	5	4	96
61	2	2	1	2	4	99

62	2	2	1	2	2	89
63	2	2	1	2	3	98
64	2	2	1	2	1	94
65	2	2	2	3	2	98
66	2	2	2	3	3	91
67	2	2	2	3	1	97
68	2	2	2	3	4	96
69	2	2	3	1	3	94
70	2	2	3	1	1	97
71	2	2	3	1	2	98
72	2	2	3	1	4	96
73	2	2	4	4	2	99
74	2	2	4	4	1	89
75	2	2	4	4	3	97
76	2	2	4	4	4	98
77	2	2	5	5	1	99
78	2	2	5	5	2	96
79	2	2	5	5	3	93
80	2	2	5	5	4	98
81	3	1	1	4	4	99
82	3	1	1	4	2	88
83	3	1	1	4	3	98
84	3	1	1	4	1	96
85	3	1	2	5	2	98
86	3	1	2	5	3	99
87	3	1	2	5	1	92
88	3	1	2	5	4	88
89	3	1	3	2	3	98
90	3	1	3	2	1	85
91	3	1	3	2	2	88
92	3	1	3	2	4	95
93	3	1	4	1	2	97
94	3	1	4	1	1	87
95	3	1	4	1	3	96
96	3	1	4	1	4	88
97	3	1	5	3	1	88
98	3	1	5	3	2	85
99	3	1	5	3	3	78
100	3	1	5	3	4	78
101	3	2	1	4	4	88
102	3	2	1	4	2	85
103	3	2	1	4	3	78
104	3	2	1	4	1	80
105	3	2	2	5	2	80
106	3	2	2	5	3	79
107	3	2	2	5	1	77
108	3	2	2	5	4	78
109	3	2	3	2	3	90

110	3	2	3	2	1	91
111	3	2	3	2	2	92
112	3	2	3	2	4	93
113	3	2	4	1	2	99
114	3	2	4	1	1	97
115	3	2	4	1	3	98
116	3	2	4	1	4	99
117	3	2	5	3	1	80
118	3	2	5	3	2	81
119	3	2	5	3	3	82
120	3	2	5	3	4	83
121	4	1	1	1	4	80
122	4	1	1	1	2	81
123	4	1	1	1	3	84
124	4	1	1	1	1	80
125	4	1	2	2	2	90
126	4	1	2	2	3	90
127	4	1	2	2	1	90
128	4	1	2	2	4	90
129	4	1	3	3	3	99
130	4	1	3	3	1	98
131	4	1	3	3	2	97
132	4	1	3	3	4	99
133	4	1	4	5	2	95
134	4	1	4	5	1	95
135	4	1	4	5	3	95
136	4	1	4	5	4	96
137	4	1	5	4	1	99
138	4	1	5	4	2	95
139	4	1	5	4	3	98
140	4	1	5	4	4	98
141	4	2	1	1	4	98
142	4	2	1	1	2	99
143	4	2	1	1	3	97
144	4	2	1	1	1	99
145	4	2	2	2	2	88
146	4	2	2	2	3	87
147	4	2	2	2	1	88
148	4	2	2	2	4	86
149	4	2	3	3	3	99
150	4	2	3	3	1	97
151	4	2	3	3	2	96
152	4	2	3	3	4	95
153	4	2	4	5	2	89
154	4	2	4	5	1	88
155	4	2	4	5	3	87
156	4	2	4	5	4	85
157	4	2	5	4	1	90

```
158   4 2      5 4 2     90
159   4 2      5 4 3     90
160   4 2      5 4 4     97
161   5 1      1 5 4     98
162   5 1      1 5 2     98
163   5 1      1 5 3     99
164   5 1      1 5 1     97
165   5 1      2 1 2     98
166   5 1      2 1 3     97
167   5 1      2 1 1     98
168   5 1      2 1 4     89
169   5 1      3 4 3     88
170   5 1      3 4 1     87
171   5 1      3 4 2     88
172   5 1      3 4 4     88
173   5 1      4 3 2     98
174   5 1      4 3 1     95
175   5 1      4 3 3     97
176   5 1      4 3 4     99
177   5 1      5 2 1     98
178   5 1      5 2 2     98
179   5 1      5 2 3     95
180   5 1      5 2 4     99
181   5 2      1 5 4     88
182   5 2      1 5 2     87
183   5 2      1 5 3     99
184   5 2      1 5 1     98
185   5 2      2 1 2     99
186   5 2      2 1 3     95
187   5 2      2 1 1     99
188   5 2      2 1 4     90
189   5 2      3 4 3     98
190   5 2      3 4 1     99
191   5 2      3 4 2     99
192   5 2      3 4 4     92
193   5 2      4 3 2     88
194   5 2      4 3 1     86
195   5 2      4 3 3     87
196   5 2      4 3 4     83
197   5 2      5 2 1     99
198   5 2      5 2 2     96
199   5 2      5 2 3     98
200   5 2      5 2 4     99
```

```
GLM(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)
```

```
$ANOVA
```

```
Response : height
                Df Sum Sq Mean Sq F value Pr(>F)
MODEL           199 7534.8  37.863
RESIDUALS         0    0.0
CORRECTED TOTAL 199 7534.8

$Fitness
 Root MSE height Mean Coef Var R-square
       NA      93.965       NA        1

$`Type I`
          Df  Sum Sq Mean Sq F value Pr(>F)
row        4 2017.03  504.26
R          4   90.63   22.66
P          1  253.12  253.12
S          3   16.38    5.46
R:S       12  195.05   16.25
row:P      4  167.25   41.81
R:P        4  504.95  126.24
row:R:P   32 2933.52   91.67
P:S        3   14.29    4.76
row:P:S   24  234.68    9.78
R:P:S     12  100.33    8.36
row:R:P:S 96 1007.52   10.49

$`Type II`
          Df  Sum Sq Mean Sq F value Pr(>F)
row        4 2017.03  504.26
R          4   90.63   22.66
P          1  253.12  253.12
S          3   16.38    5.46
R:S       12  195.05   16.25
row:P      4  167.25   41.81
R:P        4  504.95  126.24
row:R:P   32 2933.52   91.67
P:S        3   14.29    4.76
row:P:S   24  234.68    9.78
R:P:S     12  100.33    8.36
row:R:P:S 96 1007.52   10.49

$`Type III`
          Df  Sum Sq Mean Sq F value Pr(>F)
row        4 2017.03  504.26
R          4   90.63   22.66
P          1  253.13  253.13
S          3   16.38    5.46
R:S       12  195.05   16.25
row:P      4  167.25   41.81
```

```
R:P         4  504.95  126.24
row:R:P    32 2933.52   91.67
P:S         3   14.30    4.77
row:P:S    24  234.68    9.78
R:P:S      12  100.33    8.36
row:R:P:S  96 1007.52   10.49
```

```
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
```

```
alias(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) # NO ALIAS
```

```
Model :
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
```

(10) MODEL

- p94 Appendix 3.1

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

```
   row col rep var nit set reps yield
1    1   1   1   3   3   1    1   156
2    1   2   1   3   2   1    1   118
3    1   3   4   3   2   2    1   109
4    1   4   4   3   3   2    1    99
5    2   1   1   3   1   1    1   140
6    2   2   1   3   4   1    1   105
7    2   3   4   3   4   2    1    63
8    2   4   4   3   1   2    1    70
9    3   1   1   1   4   1    1   111
10   3   2   1   1   1   1    1   130
11   3   3   4   2   4   2    1    80
12   3   4   4   2   2   2    1    94
13   4   1   1   1   3   1    1   174
14   4   2   1   1   2   1    1   157
15   4   3   4   2   3   2    1   126
16   4   4   4   2   1   2    1    82
17   5   1   1   2   4   1    1   117
18   5   2   1   2   1   1    1   114
```

19	5	3	4	1	1	2	1	90
20	5	4	4	1	2	2	1	100
21	6	1	1	2	2	1	1	161
22	6	2	1	2	3	1	1	141
23	6	3	4	1	3	2	1	116
24	6	4	4	1	4	2	1	62
25	7	1	2	3	2	1	2	104
26	7	2	2	3	4	1	2	70
27	7	3	5	2	3	2	2	96
28	7	4	5	2	4	2	2	60
29	8	1	2	3	1	1	2	89
30	8	2	2	3	3	1	2	117
31	8	3	5	2	2	2	2	89
32	8	4	5	2	1	2	2	102
33	9	1	2	1	3	1	2	122
34	9	2	2	1	4	1	2	74
35	9	3	5	1	2	2	2	112
36	9	4	5	1	3	2	2	86
37	10	1	2	1	1	1	2	89
38	10	2	2	1	2	1	2	81
39	10	3	5	1	4	2	2	68
40	10	4	5	1	1	2	2	64
41	11	1	2	2	1	1	2	103
42	11	2	2	2	4	1	2	64
43	11	3	5	3	2	2	2	132
44	11	4	5	3	3	2	2	124
45	12	1	2	2	2	1	2	132
46	12	2	2	2	3	1	2	133
47	12	3	5	3	1	2	2	129
48	12	4	5	3	4	2	2	89
49	13	1	3	2	1	1	3	108
50	13	2	3	2	2	1	3	126
51	13	3	6	1	2	2	3	118
52	13	4	6	1	4	2	3	53
53	14	1	3	2	3	1	3	149
54	14	2	3	2	4	1	3	70
55	14	3	6	1	3	2	3	113
56	14	4	6	1	1	2	3	74
57	15	1	3	3	3	1	3	144
58	15	2	3	3	1	1	3	124
59	15	3	6	2	3	2	3	104
60	15	4	6	2	2	2	3	86
61	16	1	3	3	2	1	3	121
62	16	2	3	3	4	1	3	96
63	16	3	6	2	4	2	3	89
64	16	4	6	2	1	2	3	82
65	17	1	3	1	4	1	3	61
66	17	2	3	1	3	1	3	100

```
67  17   3   6   3   4   2    3    97
68  17   4   6   3   1   2    3    99
69  18   1   3   1   1   1    3    91
70  18   2   3   1   2   1    3    97
71  18   3   6   3   2   2    3   119
72  18   4   6   3   3   2    3   121
```

```
GLM(yield ~ rep + var + rep:var + nit + var:nit + row + col, ex3.1b)
```

```
$ANOVA
Response : yield
                Df Sum Sq Mean Sq F value    Pr(>F)
MODEL           37  48090  1299.7  11.341 6.734e-11 ***
RESIDUALS       34   3896   114.6
CORRECTED TOTAL 71  51986
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

$Fitness
 Root MSE yield Mean Coef Var  R-square  Adj R-sq
 10.70513   103.9722 10.29615 0.9250491 0.8434848

$`Type I`
        Df  Sum Sq Mean Sq F value    Pr(>F)
rep      5 15875.3  3175.1 27.7056 4.391e-11 ***
var      2  1786.4   893.2  7.7939 0.0016359 **
rep:var 10  6013.3   601.3  5.2472 0.0001207 ***
nit      3 20020.5  6673.5 58.2331 1.754e-13 ***
var:nit  6   321.7    53.6  0.4679 0.8271333
row      9   900.9   100.1  0.8734 0.5575581
col      2  3171.5  1585.7 13.8373 4.012e-05 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

$`Type II`
        Df  Sum Sq Mean Sq F value    Pr(>F)
rep      2  5942.5  2971.3 25.9273 1.449e-07 ***
var      2  2799.8  1399.9 12.2155 0.0001005 ***
rep:var  4   997.8   249.4  2.1767 0.0926008 .
nit      3 12559.3  4186.4 36.5308 9.683e-11 ***
var:nit  6   477.8    79.6  0.6949 0.6553307
row      9   945.0   105.0  0.9162 0.5230151
col      2  3171.5  1585.7 13.8373 4.012e-05 ***
---
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)
rep      2  5942.5  2971.3 25.9273 1.449e-07 ***
var      2  2799.8  1399.9 12.2155 0.0001005 ***
rep:var  4   997.8   249.4  2.1767 0.0926008 .
nit      3 11977.9  3992.6 34.8397 1.775e-10 ***
var:nit  6   477.8    79.6  0.6949 0.6553307
row      9   945.0   105.0  0.9162 0.5230151
col      2  3171.5  1585.7 13.8373 4.012e-05 ***
---
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
```

6.3 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"))
ex5.1
```

```
   R A C B Tx Y
1  1 1 1 2  1 2
2  1 1 1 1  2 5
```

```
3  1 1 2 2  4 6
4  1 1 2 1  3 9
5  1 1 3 1  6 8
6  1 1 3 2  5 5
7  1 2 1 2  4 9
8  1 2 1 1  3 7
9  1 2 2 2  6 8
10 1 2 2 1  5 4
11 1 2 3 1  1 3
12 1 2 3 2  2 5
13 2 2 1 2  6 8
14 2 2 1 1  5 5
15 2 2 2 2  1 3
16 2 2 2 1  2 5
17 2 2 3 1  4 9
18 2 2 3 2  3 7
19 2 1 1 2  3 3
20 2 1 1 1  6 4
21 2 1 2 2  5 3
22 2 1 2 1  1 0
23 2 1 3 1  2 1
24 2 1 3 2  4 2
25 3 1 1 2  5 5
26 3 1 1 1  1 5
27 3 1 2 2  2 5
28 3 1 2 1  4 9
29 3 1 3 1  3 7
30 3 1 3 2  6 8
31 3 2 1 2  2 6
32 3 2 1 1  4 8
33 3 2 2 2  3 7
34 3 2 2 1  6 8
35 3 2 3 1  5 6
36 3 2 3 2  1 3
```

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

```
$ANOVA
Response : Y
                Df  Sum Sq Mean Sq F value    Pr(>F)
MODEL           24 196.238  8.1766  7.0476 0.0008758 ***
RESIDUALS       11  12.762  1.1602
CORRECTED TOTAL 35 209.000
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

$Fitness
```

```
 Root MSE Y Mean Coef Var  R-square  Adj R-sq
 1.077122    5.5 19.58405 0.9389372 0.8057093

$`Type I`
     Df  Sum Sq Mean Sq F value    Pr(>F)
R     2  33.500 16.7500 14.4373 0.0008391 ***
A     1  16.000 16.0000 13.7908 0.0034197 **
R:A   2  32.167 16.0833 13.8626 0.0009856 ***
C     2   0.500  0.2500  0.2155 0.8094766
B     1   1.778  1.7778  1.5323 0.2415358
C:B   2   0.389  0.1944  0.1676 0.8478141
Tx    5 103.333 20.6667 17.8131 6.055e-05 ***
A:Tx  5   6.521  1.3042  1.1241 0.4027183
B:Tx  4   2.050  0.5126  0.4418 0.7761730
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

$`Type II`
     Df  Sum Sq Mean Sq F value    Pr(>F)
R     2  23.116 11.5581  9.9622  0.003396 **
A     1  12.375 12.3751 10.6664  0.007519 **
R:A   2  27.426 13.7132 11.8197  0.001820 **
C     2   0.970  0.4850  0.4180  0.668392
B     1   1.757  1.7574  1.5148  0.244080
C:B   2   0.085  0.0424  0.0366  0.964202
Tx    5 103.333 20.6667 17.8131 6.055e-05 ***
A:Tx  4   2.655  0.6636  0.5720  0.688652
B:Tx  4   2.050  0.5126  0.4418  0.776173
---
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)
R     2  22.186 11.0928  9.5611  0.003924 **
A     1  15.185 15.1853 13.0886  0.004042 **
R:A   2  27.426 13.7132 11.8197  0.001820 **
C     2   1.010  0.5049  0.4352  0.657839
B     1   1.792  1.7922  1.5448  0.239751
C:B   2   0.085  0.0424  0.0366  0.964202
Tx    5 103.333 20.6667 17.8131 6.055e-05 ***
A:Tx  4   2.655  0.6636  0.5720  0.688652
B:Tx  4   2.050  0.5126  0.4418  0.776173
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

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

```
Model :
Y ~ R + A + A:R + C + B + B:C + Tx + A:Tx + B:Tx

Complete :
       (Intercept) R1   R2   A1   C1   C2   B1   Tx1  Tx2  Tx3  Tx4  Tx5  R1:A1
B1:Tx5    0           0    0 -1/5    0    0 -1/5    0    0    0    0    0    0
       R2:A1 C1:B1 C2:B1 A1:Tx1 A1:Tx2 A1:Tx3 A1:Tx4 A1:Tx5 B1:Tx1 B1:Tx2 B1:Tx3
B1:Tx5    0     0     0   1/5    1/5    1/5    1/5     -1    1/5    1/5    1/5
       B1:Tx4
B1:Tx5  1/5
```

```
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

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

```
$ANOVA
Response : Y
                Df Sum Sq Mean Sq F value   Pr(>F)
MODEL           28  204.2  7.2929  10.635 0.001719 **
```

```
RESIDUALS        7    4.8  0.6857
CORRECTED TOTAL 35  209.0
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

$Fitness
  Root MSE Y Mean Coef Var  R-square  Adj R-sq
 0.8280787    5.5 15.05598 0.9770335 0.8851675

$`Type I`
       Df  Sum Sq Mean Sq F value    Pr(>F)
R       2  33.500 16.7500 24.4271 0.0006969 ***
A       1  16.000 16.0000 23.3333 0.0018985 **
R:A     2  32.167 16.0833 23.4549 0.0007889 ***
C       2   0.500  0.2500  0.3646 0.7069339
B       1   1.778  1.7778  2.5926 0.1513998
C:B     2   0.389  0.1944  0.2836 0.7613494
Tx      5 103.333 20.6667 30.1389 0.0001357 ***
A:Tx    5   6.521  1.3042  1.9019 0.2123307
B:Tx    4   2.050  0.5126  0.7475 0.5896365
A:B:Tx  4   7.962  1.9905  2.9029 0.1038803
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

$`Type II`
       Df  Sum Sq Mean Sq F value    Pr(>F)
R       2  31.838 15.9191 23.2153 0.0008139 ***
A       1  12.375 12.3751 18.0470 0.0038017 **
R:A     1   2.017  2.0174  2.9420 0.1300172
C       2   0.500  0.2500  0.3645 0.7069558
B       1   1.757  1.7574  2.5629 0.1534298
C:B     1   0.644  0.6445  0.9399 0.3646045
Tx      5 103.333 20.6667 30.1389 0.0001357 ***
A:Tx    4   2.655  0.6636  0.9678 0.4812226
B:Tx    4   2.050  0.5126  0.7475 0.5896365
A:B:Tx  4   7.962  1.9905  2.9029 0.1038803
---
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)
R       2  28.112 14.0562 20.4986 0.0011846 **
A       1  14.655 14.6551 21.3720 0.0024176 **
R:A     1   2.017  2.0174  2.9420 0.1300172
C       2   0.471  0.2356  0.3436 0.7205632
B       1   1.769  1.7694  2.5804 0.1522328
C:B     1   0.644  0.6445  0.9399 0.3646045
```

```
Tx      5 103.815 20.7630 30.2793 0.0001336 ***
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
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

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

```
Model :
Y ~ R + A + A:R + C + B + C:B + Tx + A:Tx + B:Tx + A:B:Tx

Complete :
          (Intercept) R1   R2   A1   C1   C2   B1   Tx1  Tx2  Tx3  Tx4  Tx5
B1:Tx5       0           0    0 -1/5    0    0 -1/5    0    0    0    0    0
A1:B1:Tx5 -1/6           0    0    0    0    0    0  1/6  1/6  1/6  1/6 -5/6
A1:B1:Tx6    0         2/3    0 4/45  2/3 -2/3 4/45 -1/3  1/3 -1/3    0    0
          R1:A1 R2:A1 C1:B1 C2:B1 A1:Tx1 A1:Tx2 A1:Tx3 A1:Tx4 A1:Tx5 B1:Tx1
B1:Tx5       0     0     0     0   1/5    1/5    1/5    1/5     -1    1/5
A1:B1:Tx5    0     0     0     0     0      0      0      0      0      0
A1:B1:Tx6 -2/9   4/9  -2/9  -2/9  -1/5   -1/5   -1/5    4/5      0   -1/5
          B1:Tx2 B1:Tx3 B1:Tx4 A1:B1:Tx1 A1:B1:Tx2 A1:B1:Tx3 A1:B1:Tx4
B1:Tx5     1/5    1/5    1/5      0         0         0         0
A1:B1:Tx5    0      0      0      0         0         0         0
A1:B1:Tx6 -1/5   -1/5    4/5      1        -1         1         0
```

```
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
```

6.4 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"))
ex7.1
```

```
    Y R  G F
1   2 1 25 1
2   4 1 25 2
3   6 1 25 3
4   1 1 26 1
5   3 1 26 2
6   5 1 26 3
7   9 1 27 1
8   9 1 27 2
9   8 1 27 3
10  9 1 28 1
11  9 1 28 2
12  7 1 28 3
13  2 1  1 1
14  5 1  1 2
15  7 1  1 3
16  3 1  2 1
17  6 1  2 2
18  5 1  2 3
19  4 1  3 1
20  7 1  3 2
21  6 1  3 3
22  5 1  4 1
23  8 1  4 2
24  4 1  4 3
25  6 1  5 1
26  8 1  5 2
27  8 1  5 3
28  7 1  6 1
29  8 1  6 2
30  7 1  6 3
31  3 2 25 1
32  3 2 25 2
33  7 2 25 3
```

34	2	2	26	1
35	2	2	26	2
36	4	2	26	3
37	8	2	27	1
38	8	2	27	2
39	8	2	27	3
40	7	2	28	1
41	8	2	28	2
42	9	2	28	3
43	1	2	7	1
44	2	2	7	2
45	3	2	7	3
46	2	2	8	1
47	3	2	8	2
48	5	2	8	3
49	3	2	9	1
50	4	2	9	2
51	4	2	9	3
52	4	2	10	1
53	4	2	10	2
54	5	2	10	3
55	8	2	11	1
56	8	2	11	2
57	8	2	11	3
58	3	2	12	1
59	5	2	12	2
60	7	2	12	3
61	4	3	25	1
62	6	3	25	2
63	8	3	25	3
64	2	3	26	1
65	5	3	26	2
66	7	3	26	3
67	8	3	27	1
68	7	3	27	2
69	9	3	27	3
70	7	3	28	1
71	7	3	28	2
72	9	3	28	3
73	7	3	13	1
74	7	3	13	2
75	9	3	13	3
76	5	3	14	1
77	6	3	14	2
78	8	3	14	3
79	3	3	15	1
80	5	3	15	2
81	6	3	15	3

```
82  7 3 16 1
83  7 3 16 2
84  9 3 16 3
85  6 3 17 1
86  8 3 17 2
87  8 3 17 3
88  5 3 18 1
89  7 3 18 2
90  8 3 18 3
91  4 4 25 1
92  5 4 25 2
93  6 4 25 3
94  5 4 26 1
95  2 4 26 2
96  5 4 26 3
97  9 4 27 1
98  9 4 27 2
99  9 4 27 3
100 9 4 28 1
101 8 4 28 2
102 7 4 28 3
103 5 4 19 1
104 8 4 19 2
105 9 4 19 3
106 6 4 20 1
107 6 4 20 2
108 8 4 20 3
109 7 4 21 1
110 4 4 21 2
111 8 4 21 3
112 8 4 22 1
113 7 4 22 2
114 9 4 22 3
115 9 4 23 1
116 8 4 23 2
117 9 4 23 3
118 9 4 24 1
119 8 4 24 2
120 9 4 24 3
```

```
GLM(Y ~ R + G + R:G + F + F:G, ex7.1)
```

```
$ANOVA
Response : Y
                Df Sum Sq Mean Sq F value    Pr(>F)
MODEL           95 577.82  6.0824  5.3082 1.068e-05 ***
RESIDUALS       24  27.50  1.1458
```

```
CORRECTED TOTAL 119 605.32
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

$Fitness
 Root MSE Y Mean Coef Var  R-square  Adj R-sq
 1.070436  6.175   17.335 0.9545699 0.7747422

$`Type I`
    Df Sum Sq Mean Sq F value    Pr(>F)
R    3  84.76 28.2528 24.6570 1.655e-07 ***
G   27 343.48 12.7216 11.1025 4.286e-08 ***
R:G  9  11.75  1.3056  1.1394    0.3749
F    2  59.85 29.9250 26.1164 9.481e-07 ***
G:F 54  77.98  1.4441  1.2603    0.2718
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

$`Type II`
    Df Sum Sq Mean Sq F value    Pr(>F)
R    3   5.75  1.9167  1.6727    0.1994
G   27 343.48 12.7216 11.1025 4.286e-08 ***
R:G  9  11.75  1.3056  1.1394    0.3749
F    2  59.85 29.9250 26.1164 9.481e-07 ***
G:F 54  77.98  1.4441  1.2603    0.2718
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

$`Type III`
    Df Sum Sq Mean Sq F value    Pr(>F)
R    3   5.75  1.9167  1.6727    0.1994
G   27 343.48 12.7216 11.1025 4.286e-08 ***
R:G  9  11.75  1.3056  1.1394    0.3749
F    2  50.50 25.2525 22.0385 3.686e-06 ***
G:F 54  77.98  1.4441  1.2603    0.2718
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```r
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
```

6.5 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"))
ex7.3
```

```
    Y R T  G F
1   2 1 1  1 1
2   4 1 1  1 2
3   6 1 1  1 3
4   3 1 1  2 1
5   5 1 1  2 2
6   7 1 1  2 3
7   7 1 1  3 1
8   7 1 1  3 2
9   9 1 1  3 3
10  8 1 1  4 1
11  8 1 1  4 2
12  9 1 1  4 3
13  8 1 1  5 1
14  8 1 1  5 2
15  9 1 1  5 3
16  2 1 1 21 1
17  5 1 1 21 2
18  7 1 1 21 3
19  4 1 1 22 1
20  6 1 1 22 2
21  7 1 1 22 3
22  6 1 1 23 1
23  7 1 1 23 2
24  8 1 1 23 3
25  3 1 2  1 1
26  4 1 2  1 2
27  5 1 2  1 3
28  4 1 2  2 1
```

29	6	1	2	2	2
30	8	1	2	2	3
31	7	1	2	3	1
32	8	1	2	3	2
33	9	1	2	3	3
34	9	1	2	4	1
35	8	1	2	4	2
36	9	1	2	4	3
37	7	1	2	5	1
38	9	1	2	5	2
39	9	1	2	5	3
40	3	1	2	21	1
41	6	1	2	21	2
42	7	1	2	21	3
43	5	1	2	22	1
44	7	1	2	22	2
45	8	1	2	22	3
46	6	1	2	23	1
47	7	1	2	23	2
48	8	1	2	23	3
49	4	2	1	6	1
50	5	2	1	6	2
51	6	2	1	6	3
52	6	2	1	7	1
53	7	2	1	7	2
54	8	2	1	7	3
55	7	2	1	8	1
56	8	2	1	8	2
57	9	2	1	8	3
58	7	2	1	9	1
59	8	2	1	9	2
60	9	2	1	9	3
61	3	2	1	10	1
62	5	2	1	10	2
63	6	2	1	10	3
64	3	2	1	21	1
65	5	2	1	21	2
66	7	2	1	21	3
67	5	2	1	22	1
68	5	2	1	22	2
69	7	2	1	22	3
70	6	2	1	23	1
71	7	2	1	23	2
72	9	2	1	23	3
73	5	2	2	6	1
74	6	2	2	6	2
75	7	2	2	6	3
76	6	2	2	7	1

77	7	2	2	7	2
78	7	2	2	7	3
79	7	2	2	8	1
80	9	2	2	8	2
81	8	2	2	8	3
82	7	2	2	9	1
83	7	2	2	9	2
84	9	2	2	9	3
85	4	2	2	10	1
86	5	2	2	10	2
87	7	2	2	10	3
88	2	2	2	21	1
89	4	2	2	21	2
90	5	2	2	21	3
91	6	2	2	22	1
92	7	2	2	22	2
93	8	2	2	22	3
94	6	2	2	23	1
95	7	2	2	23	2
96	8	2	2	23	3
97	4	3	1	11	1
98	5	3	1	11	2
99	6	3	1	11	3
100	7	3	1	12	1
101	8	3	1	12	2
102	8	3	1	12	3
103	6	3	1	13	1
104	7	3	1	13	2
105	7	3	1	13	3
106	7	3	1	14	1
107	7	3	1	14	2
108	9	3	1	14	3
109	2	3	1	15	1
110	3	3	1	15	2
111	4	3	1	15	3
112	4	3	1	21	1
113	5	3	1	21	2
114	5	3	1	21	3
115	6	3	1	22	1
116	7	3	1	22	2
117	8	3	1	22	3
118	7	3	1	23	1
119	8	3	1	23	2
120	8	3	1	23	3
121	5	3	2	11	1
122	5	3	2	11	2
123	6	3	2	11	3
124	8	3	2	12	1

125 8 3 2 12 2
126 9 3 2 12 3
127 7 3 2 13 1
128 7 3 2 13 2
129 9 3 2 13 3
130 7 3 2 14 1
131 8 3 2 14 2
132 8 3 2 14 3
133 4 3 2 15 1
134 5 3 2 15 2
135 7 3 2 15 3
136 3 3 2 21 1
137 6 3 2 21 2
138 6 3 2 21 3
139 7 3 2 22 1
140 7 3 2 22 2
141 9 3 2 22 3
142 7 3 2 23 1
143 8 3 2 23 2
144 9 3 2 23 3
145 1 4 1 16 1
146 3 4 1 16 2
147 5 4 1 16 3
148 2 4 1 17 1
149 4 4 1 17 2
150 5 4 1 17 3
151 3 4 1 18 1
152 4 4 1 18 2
153 6 4 1 18 3
154 4 4 1 19 1
155 5 4 1 19 2
156 7 4 1 19 3
157 5 4 1 20 1
158 5 4 1 20 2
159 7 4 1 20 3
160 5 4 1 21 1
161 6 4 1 21 2
162 8 4 1 21 3
163 5 4 1 22 1
164 7 4 1 22 2
165 7 4 1 22 3
166 6 4 1 23 1
167 8 4 1 23 2
168 9 4 1 23 3
169 2 4 2 16 1
170 2 4 2 16 2
171 4 4 2 16 3
172 3 4 2 17 1

```
173 5 4 2 17 2
174 6 4 2 17 3
175 4 4 2 18 1
176 6 4 2 18 2
177 7 4 2 18 3
178 5 4 2 19 1
179 7 4 2 19 2
180 7 4 2 19 3
181 6 4 2 20 1
182 7 4 2 20 2
183 8 4 2 20 3
184 4 4 2 21 1
185 6 4 2 21 2
186 7 4 2 21 3
187 7 4 2 22 1
188 8 4 2 22 2
189 8 4 2 22 3
190 7 4 2 23 1
191 8 4 2 23 2
192 9 4 2 23 3
```

```
GLM(Y ~ R + T + R:T + G + G:T + R:T:G + F + F:T + F:G + F:G:T, ex7.3)
```

```
$ANOVA
Response : Y
                 Df Sum Sq Mean Sq F value    Pr(>F)
MODEL           155 656.12  4.2330  13.446 3.997e-14 ***
RESIDUALS        36  11.33  0.3148
CORRECTED TOTAL 191 667.45
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

$Fitness
  Root MSE   Y Mean Coef Var R-square  Adj R-sq
 0.5610836 6.265625  8.95495  0.98302 0.9099118

$`Type I`
      Df Sum Sq Mean Sq  F value    Pr(>F)
R      3  27.06   9.019  28.6489 1.203e-09 ***
T      1  10.55  10.547  33.5018 1.334e-06 ***
R:T    3   2.97   0.991   3.1489  0.036705 *
G     22 389.01  17.682  56.1668 < 2.2e-16 ***
T:G   22  18.42   0.837   2.6601  0.004445 **
R:T:G 12   8.78   0.731   2.3235  0.025315 *
F      2 164.28  82.141 260.9173 < 2.2e-16 ***
T:F    2   0.84   0.422   1.3401  0.274574
G:F   44  23.47   0.533   1.6943  0.053191 .
```

```
T:G:F 44  10.74   0.244   0.7753  0.790640
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

$`Type II`
      Df Sum Sq Mean Sq  F value    Pr(>F)
R      3  12.49   4.162  13.2206 5.655e-06 ***
T      1  10.55  10.547  33.5018 1.334e-06 ***
R:T    3   1.15   0.384   1.2206  0.316281
G     22 389.01  17.682  56.1668 < 2.2e-16 ***
T:G   22  18.42   0.837   2.6601  0.004445 **
R:T:G 12   8.78   0.731   2.3235  0.025315 *
F      2 164.28  82.141 260.9173 < 2.2e-16 ***
T:F    2   0.84   0.422   1.3401  0.274574
G:F   44  23.47   0.533   1.6943  0.053191 .
T:G:F 44  10.74   0.244   0.7753  0.790640
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

$`Type III`
      Df Sum Sq Mean Sq  F value    Pr(>F)
R      3  12.49   4.162  13.2206 5.655e-06 ***
T      1  11.16  11.158  35.4430 8.021e-07 ***
R:T    3   1.15   0.384   1.2206  0.316281
G     22 389.01  17.682  56.1668 < 2.2e-16 ***
T:G   22  18.42   0.837   2.6601  0.004445 **
R:T:G 12   8.78   0.731   2.3235  0.025315 *
F      2 120.56  60.282 191.4828 < 2.2e-16 ***
T:F    2   0.82   0.411   1.3060  0.283432
G:F   44  23.47   0.533   1.6943  0.053191 .
T:G:F 44  10.74   0.244   0.7753  0.790640
---
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
```

6.6 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"))
ex8.1
```

```
     Y R  A B
1    9 1  1 1
2    2 1  1 2
3    8 1  1 7
4    7 1  1 8
5    5 1  1 9
6    9 1  2 1
7    7 1  2 2
8    3 1  2 7
9    5 1  2 8
10   4 1  2 9
11   9 1  3 1
12   2 1  3 2
13   8 1  3 7
14   7 1  3 8
15   5 1  3 9
16   9 1 10 1
17   1 1 10 2
18   9 1 10 7
19   7 1 10 8
20   5 1 10 9
21   9 1 11 1
22   7 1 11 2
23   3 1 11 7
24   5 1 11 8
25   4 1 11 9
26   9 1 12 1
```

27	2	1	12	2
28	8	1	12	7
29	7	1	12	8
30	5	1	12	9
31	9	1	13	1
32	7	1	13	2
33	3	1	13	7
34	5	1	13	8
35	4	1	13	9
36	9	2	4	3
37	7	2	4	4
38	13	2	4	7
39	8	2	4	8
40	8	2	4	9
41	9	2	5	3
42	12	2	5	4
43	8	2	5	7
44	7	2	5	8
45	8	2	5	9
46	9	2	6	3
47	7	2	6	4
48	13	2	6	7
49	9	2	6	8
50	12	2	6	9
51	9	2	10	3
52	11	2	10	4
53	9	2	10	7
54	7	2	10	8
55	5	2	10	9
56	9	2	11	3
57	7	2	11	4
58	13	2	11	7
59	5	2	11	8
60	4	2	11	9
61	9	2	12	3
62	12	2	12	4
63	8	2	12	7
64	7	2	12	8
65	5	2	12	9
66	9	2	13	3
67	7	2	13	4
68	13	2	13	7
69	5	2	13	8
70	4	2	13	9
71	19	3	7	5
72	17	3	7	6
73	13	3	7	7
74	15	3	7	8

```
75  14 3  7 9
76  19 3  8 5
77  12 3  8 6
78  18 3  8 7
79  17 3  8 8
80  45 3  8 9
81  19 3  9 5
82  17 3  9 6
83  13 3  9 7
84  25 3  9 8
85  34 3  9 9
86  15 3 10 5
87   9 3 10 6
88  11 3 10 7
89  10 3 10 8
90  10 3 10 9
91   9 3 11 5
92  17 3 11 6
93  13 3 11 7
94  15 3 11 8
95  14 3 11 9
96   9 3 12 5
97  12 3 12 6
98   8 3 12 7
99  17 3 12 8
100 15 3 12 9
101  9 3 13 5
102 17 3 13 6
103 13 3 13 7
104 15 3 13 8
105 14 3 13 9
```

```
GLM(Y ~ R + A + R:A + B + B:R + A:B + A:B:R, ex8.1)
```

```
$ANOVA
Response : Y
                 Df Sum Sq Mean Sq F value Pr(>F)
MODEL           104 3951.8  37.999
RESIDUALS         0    0.0
CORRECTED TOTAL 104 3951.8

$Fitness
 Root MSE  Y Mean Coef Var R-square
       NA 10.0381       NA        1

$`Type I`
      Df  Sum Sq Mean Sq F value Pr(>F)
```

```
R      2 1787.68  893.84
A     12  601.24   50.10
R:A    6   24.93    4.16
B      8  156.87   19.61
R:B    4  319.87   79.97
A:B   60 1012.26   16.87
R:A:B 12   49.00    4.08

$`Type II`
      Df  Sum Sq Mean Sq F value Pr(>F)
R      2  372.22 186.111
A     12  601.24  50.103
R:A    6   50.00   8.333
B      8  156.87  19.609
R:B    4   87.44  21.861
A:B   60 1012.26  16.871
R:A:B 12   49.00   4.083

$`Type III`
      Df  Sum Sq Mean Sq F value Pr(>F)
R      2  372.22 186.111
A     12  572.31  47.692
R:A    6   50.00   8.333
B      8  185.85  23.231
R:B    4   87.44  21.861
A:B   60 1012.26  16.871
R:A:B 12   49.00   4.083
```

```
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
```

6.7 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"))
ex9.2
```

```
   yield rep hyb gen
1     48   1   3   1
2     46   1   3   3
3     43   1   3   2
4     46   1   8   1
5     45   1   8   3
```

6	42	1	8	2
7	46	1	2	1
8	44	1	2	3
9	42	1	2	2
10	42	1	1	1
11	46	1	1	3
12	44	1	1	2
13	43	1	6	1
14	45	1	6	3
15	44	1	6	2
16	47	1	7	1
17	49	1	7	3
18	47	1	7	2
19	48	1	0	1
20	45	1	0	3
21	45	1	0	2
22	46	1	9	1
23	48	1	9	3
24	47	1	9	2
25	46	1	4	1
26	48	1	4	3
27	47	1	4	2
28	49	1	5	1
29	49	1	5	3
30	48	1	5	2
31	46	2	4	2
32	48	2	4	3
33	42	2	4	1
34	45	2	3	2
35	44	2	3	3
36	42	2	3	1
37	46	2	9	2
38	46	2	9	3
39	44	2	9	1
40	45	2	5	2
41	45	2	5	3
42	43	2	5	1
43	43	2	1	2
44	50	2	1	3
45	44	2	1	1
46	48	2	7	2
47	51	2	7	3
48	48	2	7	1
49	44	2	2	2
50	48	2	2	3
51	47	2	2	1
52	44	2	8	2
53	46	2	8	3

```
54    46   2   8   1
55    47   2   6   2
56    48   2   6   3
57    44   2   6   1
```

```
GLM(yield ~ rep + hyb + rep:hyb + gen + gen:rep + gen:hyb, ex9.2)
```

```
$ANOVA
Response : yield
                Df  Sum Sq Mean Sq F value   Pr(>F)
MODEL           40 247.813  6.1953  4.4606 0.001119 **
RESIDUALS       16  22.222  1.3889
CORRECTED TOTAL 56 270.035
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

$Fitness
 Root MSE yield Mean Coef Var  R-square  Adj R-sq
 1.178511   45.77193 2.574747 0.9177062 0.7119716

$`Type I`
        Df Sum Sq Mean Sq F value    Pr(>F)
rep      1  0.239  0.2388  0.1719 0.6839085
hyb      9 66.796  7.4218  5.3437 0.0018370 **
rep:hyb  8 67.000  8.3750  6.0300 0.0011569 **
gen      2 36.351 18.1754 13.0863 0.0004293 ***
rep:gen  2 16.923  8.4616  6.0924 0.0107858 *
hyb:gen 18 60.504  3.3613  2.4201 0.0408545 *
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

$`Type II`
        Df Sum Sq Mean Sq F value    Pr(>F)
rep      1  0.167  0.1667  0.1200 0.7335481
hyb      9 66.796  7.4218  5.3437 0.0018370 **
rep:hyb  8 67.000  8.3750  6.0300 0.0011569 **
gen      2 36.351 18.1754 13.0863 0.0004293 ***
rep:gen  2 12.111  6.0556  4.3600 0.0308015 *
hyb:gen 18 60.504  3.3613  2.4201 0.0408545 *
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

$`Type III`
        Df Sum Sq Mean Sq F value    Pr(>F)
rep      1  0.167  0.1667  0.1200 0.7335481
hyb      9 66.796  7.4218  5.3437 0.0018370 **
rep:hyb  8 67.000  8.3750  6.0300 0.0011569 **
```

```
gen      2 30.671 15.3356 11.0416 0.0009707 ***
rep:gen  2 12.111  6.0556  4.3600 0.0308015 *
hyb:gen 18 60.504  3.3613  2.4201 0.0408545 *
---
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
```

6.8 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"))
ex10.1
```

```
    Obs Site Block  A  B  C Yield
1     1    1    R1 A1 B1 C1  6979
2     2    1    R1 A1 B1 C2  7272
3     3    1    R1 A1 B1 C3  7565
4     4    1    R1 A1 B1 C4  7827
5     5    1    R1 A1 B2 C1  8113
6     6    1    R1 A1 B2 C2  7025
7     7    1    R1 A1 B2 C3  7340
8     8    1    R1 A1 B2 C4  7637
9     9    1    R1 A2 B1 C1  7910
```

10	10	1	R1	A2	B1	C2	8250
11	11	1	R1	A2	B1	C3	8611
12	12	1	R1	A2	B1	C4	8865
13	13	1	R1	A2	B2	C1	9090
14	14	1	R1	A2	B2	C2	9453
15	15	1	R1	A2	B2	C3	9762
16	16	1	R1	A2	B2	C4	8440
17	17	1	R1	A3	B1	C1	8785
18	18	1	R1	A3	B1	C2	8963
19	19	1	R1	A3	B1	C3	9278
20	20	1	R1	A3	B1	C4	11100
21	21	1	R1	A3	B2	C1	10800
22	22	1	R1	A3	B2	C2	10600
23	23	1	R1	A3	B2	C3	10200
24	24	1	R1	A3	B2	C4	10100
25	25	1	R1	A4	B1	C1	9834
26	26	1	R1	A4	B1	C2	10200
27	27	1	R1	A4	B1	C3	10400
28	28	1	R1	A4	B1	C4	10900
29	29	1	R1	A4	B2	C1	11000
30	30	1	R1	A4	B2	C2	12600
31	31	1	R1	A4	B2	C3	12400
32	32	1	R1	A4	B2	C4	12100
33	33	1	R1	A5	B1	C1	11900
34	34	1	R1	A5	B1	C2	11500
35	35	1	R1	A5	B1	C3	11800
36	36	1	R1	A5	B1	C4	12100
37	37	1	R1	A5	B2	C1	12400
38	38	1	R1	A5	B2	C2	12700
39	39	1	R1	A5	B2	C3	12800
40	40	1	R1	A5	B2	C4	13300
41	41	1	R2	A1	B1	C1	7132
42	42	1	R2	A1	B1	C2	7412
43	43	1	R2	A1	B1	C3	7659
44	44	1	R2	A1	B1	C4	7947
45	45	1	R2	A1	B2	C1	8241
46	46	1	R2	A1	B2	C2	7273
47	47	1	R2	A1	B2	C3	7493
48	48	1	R2	A1	B2	C4	7837
49	49	1	R2	A2	B1	C1	8050
50	50	1	R2	A2	B1	C2	8398
51	51	1	R2	A2	B1	C3	8700
52	52	1	R2	A2	B1	C4	8954
53	53	1	R2	A2	B2	C1	9380
54	54	1	R2	A2	B2	C2	9478
55	55	1	R2	A2	B2	C3	10000
56	56	1	R2	A2	B2	C4	8498
57	57	1	R2	A3	B1	C1	8944

58	58	1	R2	A3	B1	C2	9070
59	59	1	R2	A3	B1	C3	9388
60	60	1	R2	A3	B1	C4	11300
61	61	1	R2	A3	B2	C1	10900
62	62	1	R2	A3	B2	C2	10600
63	63	1	R2	A3	B2	C3	10400
64	64	1	R2	A3	B2	C4	10100
65	65	1	R2	A4	B1	C1	10100
66	66	1	R2	A4	B1	C2	10300
67	67	1	R2	A4	B1	C3	10500
68	68	1	R2	A4	B1	C4	10900
69	69	1	R2	A4	B2	C1	11200
70	70	1	R2	A4	B2	C2	12800
71	71	1	R2	A4	B2	C3	12600
72	72	1	R2	A4	B2	C4	12300
73	73	1	R2	A5	B1	C1	11900
74	74	1	R2	A5	B1	C2	11700
75	75	1	R2	A5	B1	C3	11800
76	76	1	R2	A5	B1	C4	12200
77	77	1	R2	A5	B2	C1	12500
78	78	1	R2	A5	B2	C2	12800
79	79	1	R2	A5	B2	C3	12900
80	80	1	R2	A5	B2	C4	13500
81	81	1	R3	A1	B1	C1	6794
82	82	1	R3	A1	B1	C2	7055
83	83	1	R3	A1	B1	C3	7368
84	84	1	R3	A1	B1	C4	7664
85	85	1	R3	A1	B2	C1	7918
86	86	1	R3	A1	B2	C2	6842
87	87	1	R3	A1	B2	C3	7215
88	88	1	R3	A1	B2	C4	7454
89	89	1	R3	A2	B1	C1	7768
90	90	1	R3	A2	B1	C2	7976
91	91	1	R3	A2	B1	C3	8356
92	92	1	R3	A2	B1	C4	8555
93	93	1	R3	A2	B2	C1	8885
94	94	1	R3	A2	B2	C2	9164
95	95	1	R3	A2	B2	C3	9592
96	96	1	R3	A2	B2	C4	8204
97	97	1	R3	A3	B1	C1	8464
98	98	1	R3	A3	B1	C2	8901
99	99	1	R3	A3	B1	C3	9021
100	100	1	R3	A3	B1	C4	11000
101	101	1	R3	A3	B2	C1	10700
102	102	1	R3	A3	B2	C2	10400
103	103	1	R3	A3	B2	C3	10200
104	104	1	R3	A3	B2	C4	9949
105	105	1	R3	A4	B1	C1	9642

106	106	1	R3	A4	B1	C2	9990
107	107	1	R3	A4	B1	C3	10300
108	108	1	R3	A4	B1	C4	10500
109	109	1	R3	A4	B2	C1	10900
110	110	1	R3	A4	B2	C2	12400
111	111	1	R3	A4	B2	C3	12200
112	112	1	R3	A4	B2	C4	11900
113	113	1	R3	A5	B1	C1	11600
114	114	1	R3	A5	B1	C2	11400
115	115	1	R3	A5	B1	C3	11600
116	116	1	R3	A5	B1	C4	11800
117	117	1	R3	A5	B2	C1	12200
118	118	1	R3	A5	B2	C2	12400
119	119	1	R3	A5	B2	C3	12700
120	120	1	R3	A5	B2	C4	13200
121	121	2	R1	A1	B1	C1	6940
122	122	2	R1	A1	B1	C2	7267
123	123	2	R1	A1	B1	C3	7475
124	124	2	R1	A1	B1	C4	7868
125	125	2	R1	A1	B2	C1	8077
126	126	2	R1	A1	B2	C2	7078
127	127	2	R1	A1	B2	C3	7299
128	128	2	R1	A1	B2	C4	7643
129	129	2	R1	A2	B1	C1	7916
130	130	2	R1	A2	B1	C2	8193
131	131	2	R1	A2	B1	C3	8653
132	132	2	R1	A2	B1	C4	8873
133	133	2	R1	A2	B2	C1	9036
134	134	2	R1	A2	B2	C2	9449
135	135	2	R1	A2	B2	C3	9770
136	136	2	R1	A2	B2	C4	8316
137	137	2	R1	A3	B1	C1	8793
138	138	2	R1	A3	B1	C2	8943
139	139	2	R1	A3	B1	C3	9291
140	140	2	R1	A3	B1	C4	11100
141	141	2	R1	A3	B2	C1	10900
142	142	2	R1	A3	B2	C2	10600
143	143	2	R1	A3	B2	C3	10200
144	144	2	R1	A3	B2	C4	9879
145	145	2	R1	A4	B1	C1	9861
146	146	2	R1	A4	B1	C2	10200
147	147	2	R1	A4	B1	C3	10300
148	148	2	R1	A4	B1	C4	10800
149	149	2	R1	A4	B2	C1	10900
150	150	2	R1	A4	B2	C2	12600
151	151	2	R1	A4	B2	C3	12400
152	152	2	R1	A4	B2	C4	12100
153	153	2	R1	A5	B1	C1	11800

```
154 154    2    R1 A5 B1 C2 11500
155 155    2    R1 A5 B1 C3 11600
156 156    2    R1 A5 B1 C4 12100
157 157    2    R1 A5 B2 C1 12400
158 158    2    R1 A5 B2 C2 12600
159 159    2    R1 A5 B2 C3 12800
160 160    2    R1 A5 B2 C4 13300
161 161    2    R2 A1 B1 C1  6819
162 162    2    R2 A1 B1 C2  7137
163 163    2    R2 A1 B1 C3  7398
164 164    2    R2 A1 B1 C4  7680
165 165    2    R2 A1 B2 C1  7903
166 166    2    R2 A1 B2 C2  6968
167 167    2    R2 A1 B2 C3  7172
168 168    2    R2 A1 B2 C4  7494
169 169    2    R2 A2 B1 C1  7811
170 170    2    R2 A2 B1 C2  8000
171 171    2    R2 A2 B1 C3  8350
172 172    2    R2 A2 B1 C4  8730
173 173    2    R2 A2 B2 C1  8956
174 174    2    R2 A2 B2 C2  9195
175 175    2    R2 A2 B2 C3  9547
176 176    2    R2 A2 B2 C4  8183
177 177    2    R2 A3 B1 C1  8484
178 178    2    R2 A3 B1 C2  8865
179 179    2    R2 A3 B1 C3  9115
180 180    2    R2 A3 B1 C4 11100
181 181    2    R2 A3 B2 C1 10700
182 182    2    R2 A3 B2 C2 10400
183 183    2    R2 A3 B2 C3 10000
184 184    2    R2 A3 B2 C4  9830
185 185    2    R2 A4 B1 C1  9789
186 186    2    R2 A4 B1 C2  9977
187 187    2    R2 A4 B1 C3 10200
188 188    2    R2 A4 B1 C4 10500
189 189    2    R2 A4 B2 C1 10900
190 190    2    R2 A4 B2 C2 12500
191 191    2    R2 A4 B2 C3 12300
192 192    2    R2 A4 B2 C4 11800
193 193    2    R2 A5 B1 C1 11600
194 194    2    R2 A5 B1 C2 11300
195 195    2    R2 A5 B1 C3 11500
196 196    2    R2 A5 B1 C4 12000
197 197    2    R2 A5 B2 C1 12100
198 198    2    R2 A5 B2 C2 12600
199 199    2    R2 A5 B2 C3 12700
200 200    2    R2 A5 B2 C4 13100
201 201    2    R3 A1 B1 C1  7189
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202	202	2	R3	A1	B1	C2	7371
203	203	2	R3	A1	B1	C3	7700
204	204	2	R3	A1	B1	C4	8047
205	205	2	R3	A1	B2	C1	8337
206	206	2	R3	A1	B2	C2	7327
207	207	2	R3	A1	B2	C3	7595
208	208	2	R3	A1	B2	C4	7867
209	209	2	R3	A2	B1	C1	8105
210	210	2	R3	A2	B1	C2	8396
211	211	2	R3	A2	B1	C3	8807
212	212	2	R3	A2	B1	C4	8953
213	213	2	R3	A2	B2	C1	9390
214	214	2	R3	A2	B2	C2	9733
215	215	2	R3	A2	B2	C3	9858
216	216	2	R3	A2	B2	C4	8640
217	217	2	R3	A3	B1	C1	9035
218	218	2	R3	A3	B1	C2	9194
219	219	2	R3	A3	B1	C3	9442
220	220	2	R3	A3	B1	C4	11400
221	221	2	R3	A3	B2	C1	11000
222	222	2	R3	A3	B2	C2	10800
223	223	2	R3	A3	B2	C3	10600
224	224	2	R3	A3	B2	C4	10200
225	225	2	R3	A4	B1	C1	9976
226	226	2	R3	A4	B1	C2	10300
227	227	2	R3	A4	B1	C3	10600
228	228	2	R3	A4	B1	C4	11000
229	229	2	R3	A4	B2	C1	11200
230	230	2	R3	A4	B2	C2	12800
231	231	2	R3	A4	B2	C3	12600
232	232	2	R3	A4	B2	C4	12200
233	233	2	R3	A5	B1	C1	11900
234	234	2	R3	A5	B1	C2	11700
235	235	2	R3	A5	B1	C3	11800
236	236	2	R3	A5	B1	C4	12300
237	237	2	R3	A5	B2	C1	12600
238	238	2	R3	A5	B2	C2	12900
239	239	2	R3	A5	B2	C3	13000
240	240	2	R3	A5	B2	C4	13500
241	241	3	R1	A1	B1	C1	7035
242	242	3	R1	A1	B1	C2	7161
243	243	3	R1	A1	B1	C3	7590
244	244	3	R1	A1	B1	C4	7909
245	245	3	R1	A1	B2	C1	8123
246	246	3	R1	A1	B2	C2	7088
247	247	3	R1	A1	B2	C3	7270
248	248	3	R1	A1	B2	C4	7705
249	249	3	R1	A2	B1	C1	7992

250	250	3	R1	A2	B1	C2	8293
251	251	3	R1	A2	B1	C3	8574
252	252	3	R1	A2	B1	C4	8872
253	253	3	R1	A2	B2	C1	9159
254	254	3	R1	A2	B2	C2	9451
255	255	3	R1	A2	B2	C3	9779
256	256	3	R1	A2	B2	C4	8399
257	257	3	R1	A3	B1	C1	8683
258	258	3	R1	A3	B1	C2	8991
259	259	3	R1	A3	B1	C3	9314
260	260	3	R1	A3	B1	C4	11300
261	261	3	R1	A3	B2	C1	10800
262	262	3	R1	A3	B2	C2	10600
263	263	3	R1	A3	B2	C3	10400
264	264	3	R1	A3	B2	C4	10100
265	265	3	R1	A4	B1	C1	9803
266	266	3	R1	A4	B1	C2	10100
267	267	3	R1	A4	B1	C3	10500
268	268	3	R1	A4	B1	C4	10700
269	269	3	R1	A4	B2	C1	11100
270	270	3	R1	A4	B2	C2	12600
271	271	3	R1	A4	B2	C3	12500
272	272	3	R1	A4	B2	C4	12100
273	273	3	R1	A5	B1	C1	11900
274	274	3	R1	A5	B1	C2	11600
275	275	3	R1	A5	B1	C3	11700
276	276	3	R1	A5	B1	C4	12000
277	277	3	R1	A5	B2	C1	12400
278	278	3	R1	A5	B2	C2	12600
279	279	3	R1	A5	B2	C3	12900
280	280	3	R1	A5	B2	C4	13400
281	281	3	R2	A1	B1	C1	7007
282	282	3	R2	A1	B1	C2	7311
283	283	3	R2	A1	B1	C3	7557
284	284	3	R2	A1	B1	C4	7935
285	285	3	R2	A1	B2	C1	8209
286	286	3	R2	A1	B2	C2	7048
287	287	3	R2	A1	B2	C3	7322
288	288	3	R2	A1	B2	C4	7783
289	289	3	R2	A2	B1	C1	8055
290	290	3	R2	A2	B1	C2	8247
291	291	3	R2	A2	B1	C3	8590
292	292	3	R2	A2	B1	C4	8901
293	293	3	R2	A2	B2	C1	9210
294	294	3	R2	A2	B2	C2	9521
295	295	3	R2	A2	B2	C3	9746
296	296	3	R2	A2	B2	C4	8480
297	297	3	R2	A3	B1	C1	8766

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298 298    3    R2 A3 B1 C2  9014
299 299    3    R2 A3 B1 C3  9370
300 300    3    R2 A3 B1 C4 11200
301 301    3    R2 A3 B2 C1 11000
302 302    3    R2 A3 B2 C2 10700
303 303    3    R2 A3 B2 C3 10300
304 304    3    R2 A3 B2 C4 10100
305 305    3    R2 A4 B1 C1  9872
306 306    3    R2 A4 B1 C2 10100
307 307    3    R2 A4 B1 C3 10400
308 308    3    R2 A4 B1 C4 10800
309 309    3    R2 A4 B2 C1 11100
310 310    3    R2 A4 B2 C2 12600
311 311    3    R2 A4 B2 C3 12500
312 312    3    R2 A4 B2 C4 12200
313 313    3    R2 A5 B1 C1 11900
314 314    3    R2 A5 B1 C2 11600
315 315    3    R2 A5 B1 C3 11700
316 316    3    R2 A5 B1 C4 12100
317 317    3    R2 A5 B2 C1 12400
318 318    3    R2 A5 B2 C2 12700
319 319    3    R2 A5 B2 C3 12900
320 320    3    R2 A5 B2 C4 13400
321 321    3    R3 A1 B1 C1  7108
322 322    3    R3 A1 B1 C2  7295
323 323    3    R3 A1 B1 C3  7675
324 324    3    R3 A1 B1 C4  7948
325 325    3    R3 A1 B2 C1  8220
326 326    3    R3 A1 B2 C2  7142
327 327    3    R3 A1 B2 C3  7413
328 328    3    R3 A1 B2 C4  7826
329 329    3    R3 A2 B1 C1  8038
330 330    3    R3 A2 B1 C2  8358
331 331    3    R3 A2 B1 C3  8718
332 332    3    R3 A2 B1 C4  9000
333 333    3    R3 A2 B2 C1  9410
334 334    3    R3 A2 B2 C2  9520
335 335    3    R3 A2 B2 C3  9812
336 336    3    R3 A2 B2 C4  8452
337 337    3    R3 A3 B1 C1  8894
338 338    3    R3 A3 B1 C2  9137
339 339    3    R3 A3 B1 C3  9409
340 340    3    R3 A3 B1 C4 11300
341 341    3    R3 A3 B2 C1 10900
342 342    3    R3 A3 B2 C2 10700
343 343    3    R3 A3 B2 C3 10400
344 344    3    R3 A3 B2 C4 10100
345 345    3    R3 A4 B1 C1  9975
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346	346	3	R3	A4	B1	C2	10200
347	347	3	R3	A4	B1	C3	10500
348	348	3	R3	A4	B1	C4	10900
349	349	3	R3	A4	B2	C1	11200
350	350	3	R3	A4	B2	C2	12700
351	351	3	R3	A4	B2	C3	12500
352	352	3	R3	A4	B2	C4	12200
353	353	3	R3	A5	B1	C1	11900
354	354	3	R3	A5	B1	C2	11600
355	355	3	R3	A5	B1	C3	11800
356	356	3	R3	A5	B1	C4	12300
357	357	3	R3	A5	B2	C1	12500
358	358	3	R3	A5	B2	C2	12800
359	359	3	R3	A5	B2	C3	12900
360	360	3	R3	A5	B2	C4	13500
361	361	4	R1	A1	B1	C1	6995
362	362	4	R1	A1	B1	C2	7287
363	363	4	R1	A1	B1	C3	7580
364	364	4	R1	A1	B1	C4	7774
365	365	4	R1	A1	B2	C1	8150
366	366	4	R1	A1	B2	C2	7026
367	367	4	R1	A1	B2	C3	7322
368	368	4	R1	A1	B2	C4	7698
369	369	4	R1	A2	B1	C1	7970
370	370	4	R1	A2	B1	C2	8243
371	371	4	R1	A2	B1	C3	8520
372	372	4	R1	A2	B1	C4	8812
373	373	4	R1	A2	B2	C1	9088
374	374	4	R1	A2	B2	C2	9508
375	375	4	R1	A2	B2	C3	9718
376	376	4	R1	A2	B2	C4	8326
377	377	4	R1	A3	B1	C1	8744
378	378	4	R1	A3	B1	C2	9061
379	379	4	R1	A3	B1	C3	9310
380	380	4	R1	A3	B1	C4	11300
381	381	4	R1	A3	B2	C1	10900
382	382	4	R1	A3	B2	C2	10600
383	383	4	R1	A3	B2	C3	10200
384	384	4	R1	A3	B2	C4	9971
385	385	4	R1	A4	B1	C1	9832
386	386	4	R1	A4	B1	C2	10200
387	387	4	R1	A4	B1	C3	10500
388	388	4	R1	A4	B1	C4	10700
389	389	4	R1	A4	B2	C1	11000
390	390	4	R1	A4	B2	C2	12600
391	391	4	R1	A4	B2	C3	12500
392	392	4	R1	A4	B2	C4	12100
393	393	4	R1	A5	B1	C1	11800

394	394	4	R1	A5	B1	C2	11600
395	395	4	R1	A5	B1	C3	11800
396	396	4	R1	A5	B1	C4	12100
397	397	4	R1	A5	B2	C1	12300
398	398	4	R1	A5	B2	C2	12600
399	399	4	R1	A5	B2	C3	12900
400	400	4	R1	A5	B2	C4	13300
401	401	4	R2	A1	B1	C1	6796
402	402	4	R2	A1	B1	C2	7122
403	403	4	R2	A1	B1	C3	7489
404	404	4	R2	A1	B1	C4	7695
405	405	4	R2	A1	B2	C1	8050
406	406	4	R2	A1	B2	C2	7010
407	407	4	R2	A1	B2	C3	7324
408	408	4	R2	A1	B2	C4	7540
409	409	4	R2	A2	B1	C1	7933
410	410	4	R2	A2	B1	C2	8130
411	411	4	R2	A2	B1	C3	8423
412	412	4	R2	A2	B1	C4	8674
413	413	4	R2	A2	B2	C1	9138
414	414	4	R2	A2	B2	C2	9380
415	415	4	R2	A2	B2	C3	9704
416	416	4	R2	A2	B2	C4	8313
417	417	4	R2	A3	B1	C1	8584
418	418	4	R2	A3	B1	C2	8890
419	419	4	R2	A3	B1	C3	9246
420	420	4	R2	A3	B1	C4	11100
421	421	4	R2	A3	B2	C1	10700
422	422	4	R2	A3	B2	C2	10500
423	423	4	R2	A3	B2	C3	10200
424	424	4	R2	A3	B2	C4	9882
425	425	4	R2	A4	B1	C1	9785
426	426	4	R2	A4	B1	C2	10100
427	427	4	R2	A4	B1	C3	10300
428	428	4	R2	A4	B1	C4	10800
429	429	4	R2	A4	B2	C1	11000
430	430	4	R2	A4	B2	C2	12500
431	431	4	R2	A4	B2	C3	12400
432	432	4	R2	A4	B2	C4	12100
433	433	4	R2	A5	B1	C1	11700
434	434	4	R2	A5	B1	C2	11500
435	435	4	R2	A5	B1	C3	11700
436	436	4	R2	A5	B1	C4	12100
437	437	4	R2	A5	B2	C1	12300
438	438	4	R2	A5	B2	C2	12600
439	439	4	R2	A5	B2	C3	12800
440	440	4	R2	A5	B2	C4	13300
441	441	4	R3	A1	B1	C1	7125

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442 442    4    R3 A1 B1 C2  7505
443 443    4    R3 A1 B1 C3  7752
444 444    4    R3 A1 B1 C4  8099
445 445    4    R3 A1 B2 C1  8409
446 446    4    R3 A1 B2 C2  7332
447 447    4    R3 A1 B2 C3  7512
448 448    4    R3 A1 B2 C4  7917
449 449    4    R3 A2 B1 C1  8176
450 450    4    R3 A2 B1 C2  8382
451 451    4    R3 A2 B1 C3  8861
452 452    4    R3 A2 B1 C4  9056
453 453    4    R3 A2 B2 C1  9419
454 454    4    R3 A2 B2 C2  9700
455 455    4    R3 A2 B2 C3 10000
456 456    4    R3 A2 B2 C4  8573
457 457    4    R3 A3 B1 C1  8953
458 458    4    R3 A3 B1 C2  9278
459 459    4    R3 A3 B1 C3  9538
460 460    4    R3 A3 B1 C4 11400
461 461    4    R3 A3 B2 C1 11100
462 462    4    R3 A3 B2 C2 10800
463 463    4    R3 A3 B2 C3 10600
464 464    4    R3 A3 B2 C4 10300
465 465    4    R3 A4 B1 C1 10000
466 466    4    R3 A4 B1 C2 10400
467 467    4    R3 A4 B1 C3 10700
468 468    4    R3 A4 B1 C4 11000
469 469    4    R3 A4 B2 C1 11200
470 470    4    R3 A4 B2 C2 12900
471 471    4    R3 A4 B2 C3 12600
472 472    4    R3 A4 B2 C4 12400
473 473    4    R3 A5 B1 C1 12000
474 474    4    R3 A5 B1 C2 11700
475 475    4    R3 A5 B1 C3 12000
476 476    4    R3 A5 B1 C4 12300
477 477    4    R3 A5 B2 C1 12500
478 478    4    R3 A5 B2 C2 12900
479 479    4    R3 A5 B2 C3 13000
480 480    4    R3 A5 B2 C4 13700
```

```
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
GLM(f10.1, ex10.1)
```

```
$ANOVA
Response : Yield
                 Df     Sum Sq Mean Sq F value    Pr(>F)
```

```
MODEL           239 1639561484 6860090    2162 < 2.2e-16 ***
RESIDUALS       240     761522    3173
CORRECTED TOTAL 479 1640323006
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

$Fitness
 Root MSE Yield Mean  Coef Var  R-square  Adj R-sq
 56.32947   9967.354 0.5651396 0.9995357 0.9990734

$`Type I`
               Df     Sum Sq   Mean Sq    F value  Pr(>F)
Site            3     552717    184239 5.8064e+01 < 2e-16 ***
Site:Block      8    7062320    882790 2.7822e+02 < 2e-16 ***
A               4 1387680917 346920229 1.0933e+05 < 2e-16 ***
Site:A         12      34068      2839 8.9470e-01 0.55301
B               1  100939695 100939695 3.1812e+04 < 2e-16 ***
Site:B          3       1618       539 1.6990e-01 0.91662
A:B             4   31444008   7861002 2.4775e+03 < 2e-16 ***
Site:A:B       12      33737      2811 8.8600e-01 0.56185
Site:Block:A:B 72     186911      2596 8.1810e-01 0.84155
C               3   19356264   6452088 2.0334e+03 < 2e-16 ***
A:C            12   26075792   2172983 6.8483e+02 < 2e-16 ***
B:C             3   23901388   7967129 2.5109e+03 < 2e-16 ***
A:B:C          12   41996729   3499727 1.1030e+03 < 2e-16 ***
Site:C          9      47625      5292 1.6677e+00 0.09747 .
Site:A:C       36     104110      2892 9.1140e-01 0.61768
Site:B:C        9      61111      6790 2.1400e+00 0.02701 *
Site:A:B:C     36      82475      2291 7.2200e-01 0.87941
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

$`Type II`
               Df     Sum Sq   Mean Sq    F value  Pr(>F)
Site            3     552717    184239 5.8064e+01 < 2e-16 ***
Site:Block      8    7062320    882790 2.7822e+02 < 2e-16 ***
A               4 1387680917 346920229 1.0933e+05 < 2e-16 ***
Site:A         12      34068      2839 8.9470e-01 0.55301
B               1  100939695 100939695 3.1812e+04 < 2e-16 ***
Site:B          3       1618       539 1.6990e-01 0.91662
A:B             4   31444008   7861002 2.4775e+03 < 2e-16 ***
Site:A:B       12      33737      2811 8.8600e-01 0.56185
Site:Block:A:B 72     186911      2596 8.1810e-01 0.84155
C               3   19356264   6452088 2.0334e+03 < 2e-16 ***
A:C            12   26075792   2172983 6.8483e+02 < 2e-16 ***
B:C             3   23901388   7967129 2.5109e+03 < 2e-16 ***
A:B:C          12   41996729   3499727 1.1030e+03 < 2e-16 ***
Site:C          9      47625      5292 1.6677e+00 0.09747 .
```

```
Site:A:C       36     104110      2892 9.1140e-01 0.61768
Site:B:C        9      61111      6790 2.1400e+00 0.02701 *
Site:A:B:C     36      82475      2291 7.2200e-01 0.87941
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

$`Type III`
               Df     Sum Sq   Mean Sq    F value  Pr(>F)
Site            3     552717    184239 5.8064e+01 < 2e-16 ***
Site:Block      8    7062320    882790 2.7822e+02 < 2e-16 ***
A               4 1387680917 346920229 1.0933e+05 < 2e-16 ***
Site:A         12      34068      2839 8.9470e-01 0.55301
B               1  100939695 100939695 3.1812e+04 < 2e-16 ***
Site:B          3       1618       539 1.6990e-01 0.91662
A:B             4   31444008   7861002 2.4775e+03 < 2e-16 ***
Site:A:B       12      33737      2811 8.8600e-01 0.56185
Site:Block:A:B 72     186911      2596 8.1810e-01 0.84155
C               3   19356264   6452088 2.0334e+03 < 2e-16 ***
A:C            12   26075792   2172983 6.8483e+02 < 2e-16 ***
B:C             3   23901387   7967129 2.5109e+03 < 2e-16 ***
A:B:C          12   41996729   3499727 1.1030e+03 < 2e-16 ***
Site:C          9      47625      5292 1.6677e+00 0.09747 .
Site:A:C       36     104110      2892 9.1140e-01 0.61768
Site:B:C        9      61111      6790 2.1400e+00 0.02701 *
Site:A:B:C     36      82475      2291 7.2200e-01 0.87941
---
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"))
v1p410
```

```
   period sequence steer trt carry  y
1       1        1     1   1     3 50
2       2        1     1   2     1 61
3       3        1     1   3     2 53
4       1        1     2   1     3 55
5       2        1     2   2     1 63
6       3        1     2   3     2 57
7       1        2     3   2     3 44
8       2        2     3   3     2 42
9       3        2     3   1     3 57
10      1        2     4   2     3 51
11      2        2     4   3     2 46
12      3        2     4   1     3 59
13      1        3     5   3     3 35
14      2        3     5   1     3 55
15      3        3     5   2     1 47
16      1        3     6   3     3 41
17      2        3     6   1     3 56
18      3        3     6   2     1 50
19      1        4     7   1     3 54
20      2        4     7   3     1 48
21      3        4     7   2     3 51
22      1        4     8   1     3 58
23      2        4     8   3     1 51
24      3        4     8   2     3 54
25      1        5     9   2     3 50
26      2        5     9   1     2 57
27      3        5     9   3     1 51
28      1        5    10   2     3 55
29      2        5    10   1     2 59
```

```
30      3        5    10   3     1 55
31      1        6    11   3     3 41
32      2        6    11   2     3 56
33      3        6    11   1     2 58
34      1        6    12   3     3 46
35      2        6    12   2     3 58
36      3        6    12   1     2 61
```

```
GLM(y ~ period + sequence + steer:sequence + trt + carry, v1p410) # OK
```

```
$ANOVA
Response : y
                Df  Sum Sq Mean Sq F value    Pr(>F)
MODEL           17 1302.51  76.618  8.7402 1.572e-05 ***
RESIDUALS       18  157.79   8.766
CORRECTED TOTAL 35 1460.31
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

$Fitness
 Root MSE   y Mean Coef Var  R-square  Adj R-sq
 2.960778 52.36111 5.654535 0.8919461 0.7898953

$`Type I`
               Df Sum Sq Mean Sq F value    Pr(>F)
period          2 292.06 146.028 16.6580 8.038e-05 ***
sequence        5 326.47  65.294  7.4484 0.0006072 ***
sequence:steer  6 118.50  19.750  2.2530 0.0849122 .
trt             2 549.06 274.528 31.3166 1.377e-06 ***
carry           2  16.43   8.215  0.9372 0.4100385
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

$`Type II`
               Df Sum Sq Mean Sq F value    Pr(>F)
period          2 172.31  86.154  9.8279 0.0013030 **
sequence        5 318.69  63.738  7.2709 0.0006954 ***
sequence:steer  6 118.50  19.750  2.2530 0.0849122 .
trt             2 440.61 220.304 25.1311 6.164e-06 ***
carry           2  16.43   8.215  0.9372 0.4100385
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

$`Type III`
               Df Sum Sq Mean Sq F value    Pr(>F)
period          2 172.31  86.154  9.8279 0.0013030 **
sequence        5 318.69  63.738  7.2709 0.0006954 ***
```

```
sequence:steer  6 118.50  19.750  2.2530 0.0849122 .
trt             2 440.61 220.304 25.1311 6.164e-06 ***
carry           2  16.43   8.215  0.9372 0.4100385
---
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)
GLM(weight ~ treatment*variety, d1)
```

```
$ANOVA
Response : weight
                Df Sum Sq Mean Sq F value Pr(>F)
MODEL            7     82  11.714  2.0918   0.14
RESIDUALS       10     56   5.600
CORRECTED TOTAL 17    138

$Fitness
 Root MSE weight Mean Coef Var  R-square  Adj R-sq
 2.366432          11 21.51302 0.5942029 0.3101449

$`Type I`
                  Df Sum Sq Mean Sq F value  Pr(>F)
treatment          2 10.500   5.250  0.9375 0.42348
variety            3 36.786  12.262  2.1896 0.15232
treatment:variety  2 34.714  17.357  3.0995 0.08965 .
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

$`Type II`
                  Df Sum Sq Mean Sq F value  Pr(>F)
treatment          2  9.486  4.7429  0.8469 0.45731
variety            3 36.786 12.2619  2.1896 0.15232
treatment:variety  2 34.714 17.3571  3.0995 0.08965 .
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

$`Type III`
```

```
                  Df Sum Sq Mean Sq F value  Pr(>F)
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 .
---
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)
GLM(percent ~ refinery*source, d2)
```

```
$ANOVA
Response : percent
                Df  Sum Sq Mean Sq F value Pr(>F)
MODEL           10  442.56  44.256  0.6361 0.7616
RESIDUALS       14  974.00  69.571
CORRECTED TOTAL 24 1416.56

$Fitness
```

```
 Root MSE percent Mean Coef Var  R-square   Adj R-sq
 8.340949        37.24 22.39782 0.3124188 -0.1787106

$`Type I`
                Df  Sum Sq Mean Sq F value Pr(>F)
refinery         2  20.963  10.481  0.1507 0.8615
source           3 266.124  88.708  1.2751 0.3212
refinery:source  5 155.474  31.095  0.4469 0.8086

$`Type II`
                Df  Sum Sq Mean Sq F value Pr(>F)
refinery         2  25.535  12.767  0.1835 0.8343
source           3 266.124  88.708  1.2751 0.3212
refinery:source  5 155.474  31.095  0.4469 0.8086

$`Type III`
                Df  Sum Sq Mean Sq F value Pr(>F)
refinery         2  10.766   5.383  0.0774 0.9259
source           3 282.633  94.211  1.3542 0.2972
refinery:source  5 155.474  31.095  0.4469 0.8086
```

```
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
```

```r
options(contrasts=c("contr.sum", "contr.poly"))
r21 = lm(babble ~ sugar*milk - 1, d21)
anova(r21) # Type I SS OK
```

```
Analysis of Variance Table

Response: babble
           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 **
Residuals  12   3.16   0.264
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```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 Sesssion Information

```
R version 4.2.2 (2022-10-31 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

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

other attached packages:
[1] car_3.1-1      carData_3.0-5  sasLM_0.9.3    mvtnorm_1.1-3  rmarkdown_2.17

loaded via a namespace (and not attached):
 [1] digest_0.6.30   MASS_7.3-58.1   magrittr_2.0.3  evaluate_0.17
 [5] rlang_1.0.6     stringi_1.7.8   cli_3.4.1       tools_4.2.2
 [9] stringr_1.4.1   tinytex_0.42    abind_1.4-5     xfun_0.34
[13] yaml_2.3.6      fastmap_1.1.0   compiler_4.2.2  htmltools_0.5.3
[17] knitr_1.40
```