# Crossover Trial

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*22 July, 2019*

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## Simulate crossover trial

```
n <- 3  # number of patients

sdB = 1  # between person SD

sdW = 1  # within person SD

beta = c(1, 1, 1, 1)  #intercept, main effect, order effect, interaction


Patient <- as.factor(rep(1:(2 * n), rep(2, 2 * n)))

Treatment <- c(rep(c("Treatment1", "Treatment2"), n), rep(c("Treatment2",
    "Treatment1"), n))

Order <- rep(c("First", "Second"), 2 * n)

Data <- data.frame(Patient, Treatment, Order)

FMat <- model.matrix(~Treatment * Order, data = Data)

RMat <- model.matrix(~0 + Patient, data = Data)

Response <- FMat %*% beta + RMat %*% rnorm(2 * n, 0, sdB) + rnorm(4 *
    n, 0, sdW)

Data$Response <- Response

FMat
```

```
   (Intercept) TreatmentTreatment2 OrderSecond
1            1                   0           0
2            1                   1           1
3            1                   0           0
4            1                   1           1
5            1                   0           0
6            1                   1           1
7            1                   1           0
8            1                   0           1
9            1                   1           0
10           1                   0           1
11           1                   1           0
12           1                   0           1
   TreatmentTreatment2:OrderSecond
1                                0
2                                1
3                                0
4                                1
5                                0
6                                1
7                                0
8                                0
9                                0
```

```
10                                0
11                                0
12                                0
attr(,"assign")
[1] 0 1 2 3
attr(,"contrasts")
attr(,"contrasts")$Treatment
[1] "contr.treatment"

attr(,"contrasts")$Order
[1] "contr.treatment"
```

```
RMat
```

```
   Patient1 Patient2 Patient3 Patient4 Patient5 Patient6
1         1        0        0        0        0        0
2         1        0        0        0        0        0
3         0        1        0        0        0        0
4         0        1        0        0        0        0
5         0        0        1        0        0        0
6         0        0        1        0        0        0
7         0        0        0        1        0        0
8         0        0        0        1        0        0
9         0        0        0        0        1        0
10        0        0        0        0        1        0
11        0        0        0        0        0        1
12        0        0        0        0        0        1
attr(,"assign")
[1] 1 1 1 1 1 1
attr(,"contrasts")
attr(,"contrasts")$Patient
[1] "contr.treatment"
```

```
Data
```

```
   Patient  Treatment  Order   Response
1        1 Treatment1  First 0.90044056
2        1 Treatment2 Second 2.17446312
3        2 Treatment1  First 0.08296966
4        2 Treatment2 Second 3.32416054
5        3 Treatment1  First 3.78279011
6        3 Treatment2 Second 5.91852214
7        4 Treatment2  First 2.47127984
8        4 Treatment1 Second 2.18119111
9        5 Treatment2  First 1.57344660
10       5 Treatment1 Second 3.91620087
11       6 Treatment2  First 4.21291547
12       6 Treatment1 Second 1.74844783
```

## Model

```
(Fit <- lme4::lmer(Response ~ (1 | Patient) + Treatment * Order,
    data = Data))
```

```
Linear mixed model fit by REML ['lmerMod']
Formula: Response ~ (1 | Patient) + Treatment * Order
   Data: Data
REML criterion at convergence: 34.3185
Random effects:
 Groups   Name        Std.Dev.
 Patient  (Intercept) 0.9754
 Residual             1.3007
Number of obs: 12, groups:  Patient, 6
Fixed Effects:
                     (Intercept)
                         1.58873
            TreatmentTreatment2
                         1.16381
                      OrderSecond
                         1.02655
TreatmentTreatment2:OrderSecond
                         0.02662
```

```
confint(Fit)
```

```
                                    2.5 %   97.5 %
.sig01                          0.0000000 2.067994
.sigma                          0.6594705 1.983156
(Intercept)                    -0.0702044 3.247671
TreatmentTreatment2            -1.1822785 3.509906
OrderSecond                    -1.3195459 3.372639
TreatmentTreatment2:OrderSecond -4.1201312 4.173371
```

## Computing Environment

```
sessionInfo()
```

```
R version 3.6.1 (2019-07-05)
Platform: x86_64-w64-mingw32/x64 (64-bit)
Running under: Windows 10 x64 (build 17134)

Matrix products: default

locale:
[1] LC_COLLATE=English_United Kingdom.1252
[2] LC_CTYPE=English_United Kingdom.1252
[3] LC_MONETARY=English_United Kingdom.1252
[4] LC_NUMERIC=C
[5] LC_TIME=English_United Kingdom.1252

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

other attached packages:
[1] knitr_1.23

loaded via a namespace (and not attached):
 [1] Rcpp_1.0.1      lattice_0.20-38 digest_0.6.20
 [4] MASS_7.3-51.4   grid_3.6.1      nlme_3.1-140
 [7] formatR_1.7     magrittr_1.5    evaluate_0.14
[10] stringi_1.4.3   minqa_1.2.4     nloptr_1.2.1
[13] Matrix_1.2-17   boot_1.3-22     rmarkdown_1.14
[16] splines_3.6.1   lme4_1.1-21     tools_3.6.1
[19] stringr_1.4.0   xfun_0.8        yaml_2.2.0
[22] compiler_3.6.1  htmltools_0.3.6
```

This took 3.03 seconds to execute.