

Example simulation code to accompany:

Timmons, A. C., & Preacher, K. J. (in press). The importance of temporal design: How do measurement intervals affect the accuracy and efficiency of parameter estimates in longitudinal research? *Multivariate Behavioral Research*.

```
#####
# Example of Simulation Code for the Linear Function
# Run all of this code, then scroll to the bottom
# This code will take approximately 40 minutes to run
# Convergence errors will print but the simulation will
# continue to run until 1,000 estimates converge
# You will need to install the packages lsr and nlme to run
# this code (see code below)
# install.packages("lsr", dependencies = T)
# install.packages("nlme", dependencies = T)
#####

library(lsr)
library(nlme)
set.seed(42596)

#####

a1 <- 3
b1 <- 5
u1 <- sqrt(225)
e1 <- sqrt(600)

#####

(even.6 <- c(0, 12, 24, 36, 48, 60))
(left.6 <- c(0, 4, 12, 21, 33, 60))
(right.6 <- c(0, 27, 39, 48, 56, 60))
(middle.6 <- c(0, 13, 26, 34, 46, 60))
(extreme.6 <- c(0, 7, 17, 43, 53, 60))

#####

out <- matrix(nrow=1000,ncol=20)
i <- 0
for (loop in 1:1000){
i <- i+1

#####

nn <- 50
u0j <- rnorm(nn, 0, u1)
```

```
#####

linear.even.6 <- vector(mode="numeric",length=nn*length(even.6))
linear.left.6 <- vector(mode="numeric",length=nn*length(left.6))
linear.right.6 <- vector(mode="numeric",length=nn*length(right.6))
linear.middle.6 <- vector(mode="numeric",length=nn*length(middle.6))
linear.extreme.6 <- vector(mode="numeric",length=nn*length(extreme.6))

#####

for (j in 1:nn) {
  for (x in even.6) {
    temp <- rnorm(length(even.6), (a1 + u0j[j]) + b1*even.6, e1)
  }
  for (x in 1:length(even.6)) {
    linear.even.6[(j-1)*length(even.6)+x] <- temp[x]
  }
}

q2 <- rep(1:nn,each = length(even.6))
q1 <- rep(1:length(even.6), times = nn)
time.even.6 <- rep(even.6,time = nn)
dataframe.linear.even.6 <- data.frame(q2, q1, time.even.6, linear.even.6)

#####

for (j in 1:nn) {
  for (x in left.6) {
    temp <- rnorm(length(left.6), (a1 + u0j[j]) + b1*left.6, e1)
  }
  for (x in 1:length(left.6)) {
    linear.left.6[(j-1)*length(left.6)+x] <- temp[x]
  }
}

q2 <- rep(1:nn,each = length(left.6))
q1 <- rep(1:length(left.6), times = nn)
time.left.6 <- rep(left.6,time = nn)
dataframe.linear.left.6 <- data.frame(q2, q1, time.left.6, linear.left.6)

#####

for (j in 1:nn) {
  for (x in right.6) {
    temp <- rnorm(length(right.6), (a1 + u0j[j]) + b1*right.6, e1)
  }
  for (x in 1:length(right.6)) {
    linear.right.6[(j-1)*length(right.6)+x] <- temp[x]
  }
}

q2 <- rep(1:nn,each = length(right.6))
```

```

q1 <- rep(1:length(right.6), times = nn)
time.right.6 <- rep(right.6,time = nn)
dataframe.linear.right.6 <- data.frame(q2, q1, time.right.6, linear.right.6)

#####

for (j in 1:nn) {
  for (x in middle.6) {
    temp <- rnorm(length(middle.6), (a1 + u0j[j]) + b1*middle.6, e1)
  }
  for (x in 1:length(middle.6)) {
    linear.middle.6[(j-1)*length(middle.6)+x] <- temp[x]
  }
}

q2 <- rep(1:nn,each = length(middle.6))
q1 <- rep(1:length(middle.6), times = nn)
time.middle.6 <- rep(middle.6,time = nn)
dataframe.linear.middle.6 <- data.frame(q2, q1, time.middle.6,
linear.middle.6)

#####

for (j in 1:nn) {
  for (x in extreme.6) {
    temp <- rnorm(length(extreme.6), (a1 + u0j[j]) + b1*extreme.6, e1)

  }
  for (x in 1:length(extreme.6)) {
    linear.extreme.6[(j-1)*length(extreme.6)+x] <- temp[x]
  }
}

q2 <- rep(1:nn,each = length(extreme.6))
q1 <- rep(1:length(extreme.6), times = nn)
time.extreme.6 <- rep(extreme.6,time = nn)
dataframe.linear.extreme.6 <- data.frame(q2, q1, time.extreme.6,
linear.extreme.6)

#####

try(fit.linear.even.6 <- nlme(linear.even.6 ~ b0 + b1*time.even.6, fixed =
list(b0 + b1 ~ 1), random = b0 ~ 1 | q2, data = dataframe.linear.even.6,
start = c(b0=a1, b1=b1)))

try(fit.linear.left.6 <- nlme(linear.left.6 ~ b0 + b1*time.left.6, fixed =
list(b0 + b1 ~ 1), random = b0 ~ 1 | q2, data = dataframe.linear.left.6,
start = c(b0=a1, b1=b1)))

try(fit.linear.right.6 <- nlme(linear.right.6 ~ b0 + b1*time.right.6, fixed
= list(b0 + b1 ~ 1), random = b0 ~ 1 | q2, data = dataframe.linear.right.6,
start = c(b0=a1, b1=b1)))

```

```

try(fit.linear.middle.6 <- nlme(linear.middle.6 ~ b0 + b1*time.middle.6,
fixed = list(b0 + b1 ~ 1), random = b0 ~ 1 | q2, data =
dataframe.linear.middle.6, start = c(b0=a1, b1=b1)))

try(fit.linear.extreme.6 <- nlme(linear.extreme.6 ~ b0 + b1*time.extreme.6,
fixed = list(b0 + b1 ~ 1), random = b0 ~ 1 | q2, data =
dataframe.linear.extreme.6, start = c(b0=a1, b1=b1)))

#####

out[i,1]=summary(fit.linear.even.6)$tTable[1]
out[i,2]=summary(fit.linear.even.6)$tTable[2]
out[i,3]=summary(fit.linear.even.6)$tTable[3]
out[i,4]=summary(fit.linear.even.6)$tTable[4]

out[i,5]=summary(fit.linear.left.6)$tTable[1]
out[i,6]=summary(fit.linear.left.6)$tTable[2]
out[i,7]=summary(fit.linear.left.6)$tTable[3]
out[i,8]=summary(fit.linear.left.6)$tTable[4]

out[i,9]=summary(fit.linear.right.6)$tTable[1]
out[i,10]=summary(fit.linear.right.6)$tTable[2]
out[i,11]=summary(fit.linear.right.6)$tTable[3]
out[i,12]=summary(fit.linear.right.6)$tTable[4]

out[i,13]=summary(fit.linear.middle.6)$tTable[1]
out[i,14]=summary(fit.linear.middle.6)$tTable[2]
out[i,15]=summary(fit.linear.middle.6)$tTable[3]
out[i,16]=summary(fit.linear.middle.6)$tTable[4]

out[i,17]=summary(fit.linear.extreme.6)$tTable[1]
out[i,18]=summary(fit.linear.extreme.6)$tTable[2]
out[i,19]=summary(fit.linear.extreme.6)$tTable[3]
out[i,20]=summary(fit.linear.extreme.6)$tTable[4]

}

outdataframe <- data.frame(out)
attach(outdataframe)

par1.fit.linear.even.6 <- X1
par2.fit.linear.even.6 <- X2
SE1.fit.linear.even.6 <- X3
SE2.fit.linear.even.6 <- X4

par1.fit.linear.left.6 <- X5
par2.fit.linear.left.6 <- X6
SE1.fit.linear.left.6 <- X7
SE2.fit.linear.left.6 <- X8

par1.fit.linear.right.6 <- X9

```

```

par2.fit.linear.right.6 <- X10
SE1.fit.linear.right.6 <- X11
SE2.fit.linear.right.6 <- X12

par1.fit.linear.middle.6 <- X13
par2.fit.linear.middle.6 <- X14
SE1.fit.linear.middle.6 <- X15
SE2.fit.linear.middle.6 <- X16

par1.fit.linear.extreme.6 <- X17
par2.fit.linear.extreme.6 <- X18
SE1.fit.linear.extreme.6 <- X19
SE2.fit.linear.extreme.6 <- X20

#####

(mean(par1.fit.linear.even.6))
(PRB.par1.even.6 <- ((mean(par1.fit.linear.even.6)-a1)/a1)*100)
(ESD.par1.even.6 <- sd(par1.fit.linear.even.6))

(mean(par2.fit.linear.even.6))
(PRB.par2.even.6 <- ((mean(par2.fit.linear.even.6)-b1)/b1)*100)
(ESD.par2.even.6 <- sd(par2.fit.linear.even.6))

SE.par1.even.6 <- mean(SE1.fit.linear.even.6)
SE.par2.even.6 <- mean(SE2.fit.linear.even.6)

####

(mean(par1.fit.linear.left.6))
(PRB.par1.left.6 <- ((mean(par1.fit.linear.left.6)-a1)/a1)*100)
(ESD.par1.left.6 <- sd(par1.fit.linear.left.6))

(mean(par2.fit.linear.left.6))
(PRB.par2.left.6 <- ((mean(par2.fit.linear.left.6)-b1)/b1)*100)
(ESD.par2.left.6 <- sd(par2.fit.linear.left.6))

SE.par1.left.6 <- mean(SE1.fit.linear.left.6)
SE.par2.left.6 <- mean(SE2.fit.linear.left.6)

####

(mean(par1.fit.linear.right.6))
(PRB.par1.right.6 <- ((mean(par1.fit.linear.right.6)-a1)/a1)*100)
(ESD.par1.right.6 <- sd(par1.fit.linear.right.6))
(mean(par2.fit.linear.right.6))
(PRB.par2.right.6 <- ((mean(par2.fit.linear.right.6)-b1)/b1)*100)
(ESD.par2.right.6 <- sd(par2.fit.linear.right.6))

SE.par1.right.6 <- mean(SE1.fit.linear.right.6)
SE.par2.right.6 <- mean(SE2.fit.linear.right.6)

```

```
#####

(mean(par1.fit.linear.middle.6))
(PRB.par1.middle.6 <- ((mean(par1.fit.linear.middle.6)-a1)/a1)*100)
(ESD.par1.middle.6 <- sd(par1.fit.linear.middle.6))

(mean(par2.fit.linear.middle.6))
(PRB.par2.middle.6 <- ((mean(par2.fit.linear.middle.6)-b1)/b1)*100)
(ESD.par2.middle.6 <- sd(par2.fit.linear.middle.6))

SE.par1.middle.6 <- mean(SE1.fit.linear.middle.6)
SE.par2.middle.6 <- mean(SE2.fit.linear.middle.6)

#####

(mean(par1.fit.linear.extreme.6))
(PRB.par1.extreme.6 <- ((mean(par1.fit.linear.extreme.6)-a1)/a1)*100)
(ESD.par1.extreme.6 <- sd(par1.fit.linear.extreme.6))

(mean(par2.fit.linear.extreme.6))
(PRB.par2.extreme.6 <- ((mean(par2.fit.linear.extreme.6)-b1)/b1)*100)
(ESD.par2.extreme.6 <- sd(par2.fit.linear.extreme.6))

SE.par1.extreme.6 <- mean(SE1.fit.linear.extreme.6)
SE.par2.extreme.6 <- mean(SE2.fit.linear.extreme.6)

#####

(even.11 <- c(0, 6, 12, 18, 24, 30, 36, 42, 48, 54, 60))
(left.11 <- c(0, 3, 6, 9, 13, 17, 22, 27, 32, 37, 60))
(right.11 <- c(0, 23, 28, 33, 38, 43, 47, 51, 54, 57, 60))
(middle.11 <- c(0, 12, 18, 23, 27, 30, 33, 37, 42, 48, 60))
(extreme.11 <- c(0, 1, 4, 7, 12, 19, 42, 49, 53, 57, 60))

#####

out <- matrix(nrow=1000,ncol=20)
i <- 0
for (loop in 1:1000){
i <- i+1

#####

nn <- 50
u0j <- rnorm(nn, 0, u1)

#####

linear.even.11 <- vector(mode="numeric",length=nn*length(even.11))
linear.left.11 <- vector(mode="numeric",length=nn*length(left.11))
linear.right.11 <- vector(mode="numeric",length=nn*length(right.11))
linear.middle.11 <- vector(mode="numeric",length=nn*length(middle.11))
```

```

linear.extreme.11 <- vector(mode="numeric",length=nn*length(extreme.11))

#####

for (j in 1:nn) {
  for (x in even.11) {
    temp <- rnorm(length(even.11), (a1 + u0j[j]) + b1*even.11, e1)
  }
  for (x in 1:length(even.11)) {
    linear.even.11[(j-1)*length(even.11)+x] <- temp[x]
  }
}

q2 <- rep(1:nn,each = length(even.11))
q1 <- rep(1:length(even.11), times = nn)
time.even.11 <- rep(even.11,time = nn)
dataframe.linear.even.11 <- data.frame(q2, q1, time.even.11, linear.even.11)

#####

for (j in 1:nn) {
  for (x in left.11) {
    temp <- rnorm(length(left.11), (a1 + u0j[j]) + b1*left.11, e1)
  }
  for (x in 1:length(left.11)) {
    linear.left.11[(j-1)*length(left.11)+x] <- temp[x]
  }
}

q2 <- rep(1:nn,each = length(left.11))
q1 <- rep(1:length(left.11), times = nn)
time.left.11 <- rep(left.11,time = nn)
dataframe.linear.left.11 <- data.frame(q2, q1, time.left.11, linear.left.11)

#####

for (j in 1:nn) {
  for (x in right.11) {
    temp <- rnorm(length(right.11), (a1 + u0j[j]) + b1*right.11, e1)
  }
  for (x in 1:length(right.11)) {
    linear.right.11[(j-1)*length(right.11)+x] <- temp[x]
  }
}

q2 <- rep(1:nn,each = length(right.11))
q1 <- rep(1:length(right.11), times = nn)
time.right.11 <- rep(right.11,time = nn)
dataframe.linear.right.11 <- data.frame(q2, q1, time.right.11,
linear.right.11)

#####

```

```

for (j in 1:nn) {
  for (x in middle.11) {
    temp <- rnorm(length(middle.11), (a1 + u0j[j]) + b1*middle.11, e1)
  }
  for (x in 1:length(middle.11)) {
    linear.middle.11[(j-1)*length(middle.11)+x] <- temp[x]
  }
}

```

```

q2 <- rep(1:nn,each = length(middle.11))
q1 <- rep(1:length(middle.11), times = nn)
time.middle.11 <- rep(middle.11,time = nn)
dataframe.linear.middle.11 <- data.frame(q2, q1, time.middle.11,
linear.middle.11)

```

```
#####
```

```

for (j in 1:nn) {
  for (x in extreme.11) {
    temp <- rnorm(length(extreme.11), (a1 + u0j[j]) + b1*extreme.11, e1)
  }
  for (x in 1:length(extreme.11)) {
    linear.extreme.11[(j-1)*length(extreme.11)+x] <- temp[x]
  }
}

```

```

q2 <- rep(1:nn,each = length(extreme.11))
q1 <- rep(1:length(extreme.11), times = nn)
time.extreme.11 <- rep(extreme.11,time = nn)
dataframe.linear.extreme.11 <- data.frame(q2, q1, time.extreme.11,
linear.extreme.11)

```

```
#####
```

```

try(fit.linear.even.11 <- nlme(linear.even.11 ~ b0 + b1*time.even.11, fixed
= list(b0 + b1 ~ 1), random = b0 ~ 1 | q2, data = dataframe.linear.even.11,
start = c(b0=a1, b1=b1)))

```

```

try(fit.linear.left.11 <- nlme(linear.left.11 ~ b0 + b1*time.left.11, fixed
= list(b0 + b1 ~ 1), random = b0 ~ 1 | q2, data = dataframe.linear.left.11,
start = c(b0=a1, b1=b1)))

```

```

try(fit.linear.right.11 <- nlme(linear.right.11 ~ b0 + b1*time.right.11,
fixed = list(b0 + b1 ~ 1), random = b0 ~ 1 | q2, data =
dataframe.linear.right.11, start = c(b0=a1, b1=b1)))

```

```

try(fit.linear.middle.11 <- nlme(linear.middle.11 ~ b0 + b1*time.middle.11,
fixed = list(b0 + b1 ~ 1), random = b0 ~ 1 | q2, data =
dataframe.linear.middle.11, start = c(b0=a1, b1=b1)))

```



```
try(fit.linear.extreme.11 <- nlme(linear.extreme.11 ~ b0 +
b1*time.extreme.11, fixed = list(b0 + b1 ~ 1), random = b0 ~ 1 | q2, data =
dataframe.linear.extreme.11, start = c(b0=a1, b1=b1))
```

```
#####
```

```
out[i,1]=summary(fit.linear.even.11)$tTable[1]
out[i,2]=summary(fit.linear.even.11)$tTable[2]
out[i,3]=summary(fit.linear.even.11)$tTable[3]
out[i,4]=summary(fit.linear.even.11)$tTable[4]
```

```
out[i,5]=summary(fit.linear.left.11)$tTable[1]
out[i,6]=summary(fit.linear.left.11)$tTable[2]
out[i,7]=summary(fit.linear.left.11)$tTable[3]
out[i,8]=summary(fit.linear.left.11)$tTable[4]
```

```
out[i,9]=summary(fit.linear.right.11)$tTable[1]
out[i,10]=summary(fit.linear.right.11)$tTable[2]
out[i,11]=summary(fit.linear.right.11)$tTable[3]
out[i,12]=summary(fit.linear.right.11)$tTable[4]
```

```
out[i,13]=summary(fit.linear.middle.11)$tTable[1]
out[i,14]=summary(fit.linear.middle.11)$tTable[2]
out[i,15]=summary(fit.linear.middle.11)$tTable[3]
out[i,16]=summary(fit.linear.middle.11)$tTable[4]
```

```
out[i,17]=summary(fit.linear.extreme.11)$tTable[1]
out[i,18]=summary(fit.linear.extreme.11)$tTable[2]
out[i,19]=summary(fit.linear.extreme.11)$tTable[3]
out[i,20]=summary(fit.linear.extreme.11)$tTable[4]
```

```
}
```

```
outdataframe <- data.frame(out)
attach(outdataframe)
```

```
par1.fit.linear.even.11 <- X1
par2.fit.linear.even.11 <- X2
SE1.fit.linear.even.11 <- X3
SE2.fit.linear.even.11 <- X4
```

```
par1.fit.linear.left.11 <- X5
par2.fit.linear.left.11 <- X6
SE1.fit.linear.left.11 <- X7
SE2.fit.linear.left.11 <- X8
```

```
par1.fit.linear.right.11 <- X9
par2.fit.linear.right.11 <- X10
SE1.fit.linear.right.11 <- X11
SE2.fit.linear.right.11 <- X12
```

```
par1.fit.linear.middle.11 <- X13
```

```

par2.fit.linear.middle.11 <- X14
SE1.fit.linear.middle.11 <- X15
SE2.fit.linear.middle.11 <- X16

par1.fit.linear.extreme.11 <- X17
par2.fit.linear.extreme.11 <- X18
SE1.fit.linear.extreme.11 <- X19
SE2.fit.linear.extreme.11 <- X20

#####

(mean(par1.fit.linear.even.11))
(PRB.par1.even.11 <- ((mean(par1.fit.linear.even.11)-a1)/a1)*100)
(ESD.par1.even.11 <- sd(par1.fit.linear.even.11))

(mean(par2.fit.linear.even.11))
(PRB.par2.even.11 <- ((mean(par2.fit.linear.even.11)-b1)/b1)*100)
(ESD.par2.even.11 <- sd(par2.fit.linear.even.11))

SE.par1.even.11 <- mean(SE1.fit.linear.even.11)
SE.par2.even.11 <- mean(SE2.fit.linear.even.11)

#####

(mean(par1.fit.linear.left.11))
(PRB.par1.left.11 <- ((mean(par1.fit.linear.left.11)-a1)/a1)*100)
(ESD.par1.left.11 <- sd(par1.fit.linear.left.11))

(mean(par2.fit.linear.left.11))
(PRB.par2.left.11 <- ((mean(par2.fit.linear.left.11)-b1)/b1)*100)
(ESD.par2.left.11 <- sd(par2.fit.linear.left.11))

SE.par1.left.11 <- mean(SE1.fit.linear.left.11)
SE.par2.left.11 <- mean(SE2.fit.linear.left.11)

#####

(mean(par1.fit.linear.right.11))
(PRB.par1.right.11 <- ((mean(par1.fit.linear.right.11)-a1)/a1)*100)
(ESD.par1.right.11 <- sd(par1.fit.linear.right.11))
(mean(par2.fit.linear.right.11))
(PRB.par2.right.11 <- ((mean(par2.fit.linear.right.11)-b1)/b1)*100)
(ESD.par2.right.11 <- sd(par2.fit.linear.right.11))

SE.par1.right.11 <- mean(SE1.fit.linear.right.11)
SE.par2.right.11 <- mean(SE2.fit.linear.right.11)

#####

(mean(par1.fit.linear.middle.11))
(PRB.par1.middle.11 <- ((mean(par1.fit.linear.middle.11)-a1)/a1)*100)
(ESD.par1.middle.11 <- sd(par1.fit.linear.middle.11))

```

```

(mean(par2.fit.linear.middle.11))
(PRB.par2.middle.11 <- ((mean(par2.fit.linear.middle.11)-b1)/b1)*100)
(ESD.par2.middle.11 <- sd(par2.fit.linear.middle.11))

SE.par1.middle.11 <- mean(SE1.fit.linear.middle.11)
SE.par2.middle.11 <- mean(SE2.fit.linear.middle.11)

#####

(mean(par1.fit.linear.extreme.11))
(PRB.par1.extreme.11 <- ((mean(par1.fit.linear.extreme.11)-a1)/a1)*100)
(ESD.par1.extreme.11 <- sd(par1.fit.linear.extreme.11))

(mean(par2.fit.linear.extreme.11))
(PRB.par2.extreme.11 <- ((mean(par2.fit.linear.extreme.11)-b1)/b1)*100)
(ESD.par2.extreme.11 <- sd(par2.fit.linear.extreme.11))

SE.par1.extreme.11 <- mean(SE1.fit.linear.extreme.11)
SE.par2.extreme.11 <- mean(SE2.fit.linear.extreme.11)

#####

(even.16 <- c(0, 4, 8, 12, 16, 20, 24, 28, 32, 36, 40, 44, 48, 52, 56, 60))
(left.16 <- c(0, 2, 4, 6, 8, 10, 12, 14, 17, 21, 25, 29, 33, 37, 41, 60))
(right.16 <- c(0, 19, 23, 27, 31, 35, 39, 43, 46, 48, 50, 52, 54, 56, 58,
60))
(middle.16 <- c(0, 10, 14, 18, 22, 25, 28, 29, 30, 31, 34, 37, 41, 45, 50,
60))
(extreme.16 <- c(0, 1, 3, 5, 7, 11, 15, 21, 40, 45, 49, 53, 55, 57, 59, 60))

#####

out <- matrix(nrow=1000,ncol=20)
i <- 0
for (loop in 1:1000){
i <- i+1

#####

nn <- 50
u0j <- rnorm(nn, 0, u1)

#####

linear.even.16 <- vector(mode="numeric",length=nn*length(even.16))
linear.left.16 <- vector(mode="numeric",length=nn*length(left.16))
linear.right.16 <- vector(mode="numeric",length=nn*length(right.16))
linear.middle.16 <- vector(mode="numeric",length=nn*length(middle.16))
linear.extreme.16 <- vector(mode="numeric",length=nn*length(extreme.16))

#####

```

```

for (j in 1:nn) {
  for (x in even.16) {
    temp <- rnorm(length(even.16), (a1 + u0j[j]) + b1*even.16, e1)
  }
  for (x in 1:length(even.16)) {
    linear.even.16[(j-1)*length(even.16)+x] <- temp[x]
  }
}

q2 <- rep(1:nn,each = length(even.16))
q1 <- rep(1:length(even.16), times = nn)
time.even.16 <- rep(even.16,time = nn)
dataframe.linear.even.16 <- data.frame(q2, q1, time.even.16, linear.even.16)

#####

for (j in 1:nn) {
  for (x in left.16) {
    temp <- rnorm(length(left.16), (a1 + u0j[j]) + b1*left.16, e1)
  }
  for (x in 1:length(left.16)) {
    linear.left.16[(j-1)*length(left.16)+x] <- temp[x]
  }
}

q2 <- rep(1:nn,each = length(left.16))
q1 <- rep(1:length(left.16), times = nn)
time.left.16 <- rep(left.16,time = nn)
dataframe.linear.left.16 <- data.frame(q2, q1, time.left.16, linear.left.16)

#####

for (j in 1:nn) {
  for (x in right.16) {
    temp <- rnorm(length(right.16), (a1 + u0j[j]) + b1*right.16, e1)
  }
  for (x in 1:length(right.16)) {
    linear.right.16[(j-1)*length(right.16)+x] <- temp[x]
  }
}

q2 <- rep(1:nn,each = length(right.16))
q1 <- rep(1:length(right.16), times = nn)
time.right.16 <- rep(right.16,time = nn)
dataframe.linear.right.16 <- data.frame(q2, q1, time.right.16,
linear.right.16)

#####

for (j in 1:nn) {
  for (x in middle.16) {

```

```

temp <- rnorm(length(middle.16), (a1 + u0j[j]) + b1*middle.16, e1)
}
for (x in 1:length(middle.16)) {
linear.middle.16[(j-1)*length(middle.16)+x] <- temp[x]
}
}

q2 <- rep(1:nn,each = length(middle.16))
q1 <- rep(1:length(middle.16), times = nn)
time.middle.16 <- rep(middle.16,time = nn)
dataframe.linear.middle.16 <- data.frame(q2, q1, time.middle.16,
linear.middle.16)

#####

for (j in 1:nn) {
for (x in extreme.16) {
temp <- rnorm(length(extreme.16), (a1 + u0j[j]) + b1*extreme.16, e1)

}
for (x in 1:length(extreme.16)) {
linear.extreme.16[(j-1)*length(extreme.16)+x] <- temp[x]
}
}

q2 <- rep(1:nn,each = length(extreme.16))
q1 <- rep(1:length(extreme.16), times = nn)
time.extreme.16 <- rep(extreme.16,time = nn)
dataframe.linear.extreme.16 <- data.frame(q2, q1, time.extreme.16,
linear.extreme.16)

#####

try(fit.linear.even.16 <- nlme(linear.even.16 ~ b0 + b1*time.even.16, fixed
= list(b0 + b1 ~ 1), random = b0 ~ 1 | q2, data = dataframe.linear.even.16,
start = c(b0=a1, b1=b1)))

try(fit.linear.left.16 <- nlme(linear.left.16 ~ b0 + b1*time.left.16, fixed
= list(b0 + b1 ~ 1), random = b0 ~ 1 | q2, data = dataframe.linear.left.16,
start = c(b0=a1, b1=b1)))

try(fit.linear.right.16 <- nlme(linear.right.16 ~ b0 + b1*time.right.16,
fixed = list(b0 + b1 ~ 1), random = b0 ~ 1 | q2, data =
dataframe.linear.right.16, start = c(b0=a1, b1=b1)))

try(fit.linear.middle.16 <- nlme(linear.middle.16 ~ b0 + b1*time.middle.16,
fixed = list(b0 + b1 ~ 1), random = b0 ~ 1 | q2, data =
dataframe.linear.middle.16, start = c(b0=a1, b1=b1)))

try(fit.linear.extreme.16 <- nlme(linear.extreme.16 ~ b0 +
b1*time.extreme.16, fixed = list(b0 + b1 ~ 1), random = b0 ~ 1 | q2, data =
dataframe.linear.extreme.16, start = c(b0=a1, b1=b1)))

```

```
#####

out[i,1]=summary(fit.linear.even.16)$tTable[1]
out[i,2]=summary(fit.linear.even.16)$tTable[2]
out[i,3]=summary(fit.linear.even.16)$tTable[3]
out[i,4]=summary(fit.linear.even.16)$tTable[4]

out[i,5]=summary(fit.linear.left.16)$tTable[1]
out[i,6]=summary(fit.linear.left.16)$tTable[2]
out[i,7]=summary(fit.linear.left.16)$tTable[3]
out[i,8]=summary(fit.linear.left.16)$tTable[4]

out[i,9]=summary(fit.linear.right.16)$tTable[1]
out[i,10]=summary(fit.linear.right.16)$tTable[2]
out[i,11]=summary(fit.linear.right.16)$tTable[3]
out[i,12]=summary(fit.linear.right.16)$tTable[4]

out[i,13]=summary(fit.linear.middle.16)$tTable[1]
out[i,14]=summary(fit.linear.middle.16)$tTable[2]
out[i,15]=summary(fit.linear.middle.16)$tTable[3]
out[i,16]=summary(fit.linear.middle.16)$tTable[4]

out[i,17]=summary(fit.linear.extreme.16)$tTable[1]
out[i,18]=summary(fit.linear.extreme.16)$tTable[2]
out[i,19]=summary(fit.linear.extreme.16)$tTable[3]
out[i,20]=summary(fit.linear.extreme.16)$tTable[4]

}

outdataframe <- data.frame(out)
attach(outdataframe)

par1.fit.linear.even.16 <- X1
par2.fit.linear.even.16 <- X2
SE1.fit.linear.even.16 <- X3
SE2.fit.linear.even.16 <- X4

par1.fit.linear.left.16 <- X5
par2.fit.linear.left.16 <- X6
SE1.fit.linear.left.16 <- X7
SE2.fit.linear.left.16 <- X8

par1.fit.linear.right.16 <- X9
par2.fit.linear.right.16 <- X10
SE1.fit.linear.right.16 <- X11
SE2.fit.linear.right.16 <- X12

par1.fit.linear.middle.16 <- X13
par2.fit.linear.middle.16 <- X14
SE1.fit.linear.middle.16 <- X15
SE2.fit.linear.middle.16 <- X16
```

```

par1.fit.linear.extreme.16 <- X17
par2.fit.linear.extreme.16 <- X18
SE1.fit.linear.extreme.16 <- X19
SE2.fit.linear.extreme.16 <- X20

#####

(mean(par1.fit.linear.even.16))
(PRB.par1.even.16 <- ((mean(par1.fit.linear.even.16)-a1)/a1)*100)
(ESD.par1.even.16 <- sd(par1.fit.linear.even.16))

(mean(par2.fit.linear.even.16))
(PRB.par2.even.16 <- ((mean(par2.fit.linear.even.16)-b1)/b1)*100)
(ESD.par2.even.16 <- sd(par2.fit.linear.even.16))

SE.par1.even.16 <- mean(SE1.fit.linear.even.16)
SE.par2.even.16 <- mean(SE2.fit.linear.even.16)

####

(mean(par1.fit.linear.left.16))
(PRB.par1.left.16 <- ((mean(par1.fit.linear.left.16)-a1)/a1)*100)
(ESD.par1.left.16 <- sd(par1.fit.linear.left.16))

(mean(par2.fit.linear.left.16))
(PRB.par2.left.16 <- ((mean(par2.fit.linear.left.16)-b1)/b1)*100)
(ESD.par2.left.16 <- sd(par2.fit.linear.left.16))

SE.par1.left.16 <- mean(SE1.fit.linear.left.16)
SE.par2.left.16 <- mean(SE2.fit.linear.left.16)

####

(mean(par1.fit.linear.right.16))
(PRB.par1.right.16 <- ((mean(par1.fit.linear.right.16)-a1)/a1)*100)
(ESD.par1.right.16 <- sd(par1.fit.linear.right.16))
(mean(par2.fit.linear.right.16))
(PRB.par2.right.16 <- ((mean(par2.fit.linear.right.16)-b1)/b1)*100)
(ESD.par2.right.16 <- sd(par2.fit.linear.right.16))

SE.par1.right.16 <- mean(SE1.fit.linear.right.16)
SE.par2.right.16 <- mean(SE2.fit.linear.right.16)

####

(mean(par1.fit.linear.middle.16))
(PRB.par1.middle.16 <- ((mean(par1.fit.linear.middle.16)-a1)/a1)*100)
(ESD.par1.middle.16 <- sd(par1.fit.linear.middle.16))

(mean(par2.fit.linear.middle.16))
(PRB.par2.middle.16 <- ((mean(par2.fit.linear.middle.16)-b1)/b1)*100)

```

```

(ESD.par2.middle.16 <- sd(par2.fit.linear.middle.16))

SE.par1.middle.16 <- mean(SE1.fit.linear.middle.16)
SE.par2.middle.16 <- mean(SE2.fit.linear.middle.16)

####

(mean(par1.fit.linear.extreme.16))
(PRB.par1.extreme.16 <- ((mean(par1.fit.linear.extreme.16)-a1)/a1)*100)
(ESD.par1.extreme.16 <- sd(par1.fit.linear.extreme.16))

(mean(par2.fit.linear.extreme.16))
(PRB.par2.extreme.16 <- ((mean(par2.fit.linear.extreme.16)-b1)/b1)*100)
(ESD.par2.extreme.16 <- sd(par2.fit.linear.extreme.16))

SE.par1.extreme.16 <- mean(SE1.fit.linear.extreme.16)
SE.par2.extreme.16 <- mean(SE2.fit.linear.extreme.16)

#####

(even.21 <- c(0, 3, 6, 9, 12, 15, 18, 21, 24, 27, 30, 33, 36, 39, 42, 45,
48, 51, 54, 57, 60))
(left.21 <- c(0, 1, 3, 5, 7, 9, 11, 13, 15, 17, 19, 21, 24, 27, 30, 33, 36,
39, 42, 45, 60))
(right.21 <- c(0, 15, 18, 21, 24, 27, 30, 33, 36, 39, 41, 43, 45, 47, 49,
51, 53, 55, 57, 59, 60))
(middle.21 <- c(0, 8, 11, 14, 17, 20, 24, 26, 28, 29, 30, 31, 32, 34, 36,
39, 42, 45, 48, 52, 60))
(extreme.21 <- c(0, 1, 2, 4, 6, 8, 10, 13, 16, 19, 23, 38, 42, 46, 49, 52,
54, 56, 58, 59, 60))

#####

out <- matrix(nrow=1000,ncol=20)
i <- 0
for (loop in 1:1000){
i <- i+1

#####

nn <- 50
u0j <- rnorm(nn, 0, u1)

#####

linear.even.21 <- vector(mode="numeric",length=nn*length(even.21))
linear.left.21 <- vector(mode="numeric",length=nn*length(left.21))
linear.right.21 <- vector(mode="numeric",length=nn*length(right.21))
linear.middle.21 <- vector(mode="numeric",length=nn*length(middle.21))
linear.extreme.21 <- vector(mode="numeric",length=nn*length(extreme.21))

#####

```



```

for (j in 1:nn) {
  for (x in even.21) {
    temp <- rnorm(length(even.21), (a1 + u0j[j]) + b1*even.21, e1)
  }
  for (x in 1:length(even.21)) {
    linear.even.21[(j-1)*length(even.21)+x] <- temp[x]
  }
}

q2 <- rep(1:nn,each = length(even.21))
q1 <- rep(1:length(even.21), times = nn)
time.even.21 <- rep(even.21,time = nn)
dataframe.linear.even.21 <- data.frame(q2, q1, time.even.21, linear.even.21)

#####

for (j in 1:nn) {
  for (x in left.21) {
    temp <- rnorm(length(left.21), (a1 + u0j[j]) + b1*left.21, e1)
  }
  for (x in 1:length(left.21)) {
    linear.left.21[(j-1)*length(left.21)+x] <- temp[x]
  }
}

q2 <- rep(1:nn,each = length(left.21))
q1 <- rep(1:length(left.21), times = nn)
time.left.21 <- rep(left.21,time = nn)
dataframe.linear.left.21 <- data.frame(q2, q1, time.left.21, linear.left.21)

#####

for (j in 1:nn) {
  for (x in right.21) {
    temp <- rnorm(length(right.21), (a1 + u0j[j]) + b1*right.21, e1)
  }
  for (x in 1:length(right.21)) {
    linear.right.21[(j-1)*length(right.21)+x] <- temp[x]
  }
}

q2 <- rep(1:nn,each = length(right.21))
q1 <- rep(1:length(right.21), times = nn)
time.right.21 <- rep(right.21,time = nn)
dataframe.linear.right.21 <- data.frame(q2, q1, time.right.21,
linear.right.21)

#####

for (j in 1:nn) {
  for (x in middle.21) {

```

```

temp <- rnorm(length(middle.21), (a1 + u0j[j]) + b1*middle.21, e1)
}
for (x in 1:length(middle.21)) {
linear.middle.21[(j-1)*length(middle.21)+x] <- temp[x]
}
}

q2 <- rep(1:nn,each = length(middle.21))
q1 <- rep(1:length(middle.21), times = nn)
time.middle.21 <- rep(middle.21,time = nn)
dataframe.linear.middle.21 <- data.frame(q2, q1, time.middle.21,
linear.middle.21)

#####

for (j in 1:nn) {
for (x in extreme.21) {
temp <- rnorm(length(extreme.21), (a1 + u0j[j]) + b1*extreme.21, e1)

}
for (x in 1:length(extreme.21)) {
linear.extreme.21[(j-1)*length(extreme.21)+x] <- temp[x]
}
}

q2 <- rep(1:nn,each = length(extreme.21))
q1 <- rep(1:length(extreme.21), times = nn)
time.extreme.21 <- rep(extreme.21,time = nn)
dataframe.linear.extreme.21 <- data.frame(q2, q1, time.extreme.21,
linear.extreme.21)

#####

try(fit.linear.even.21 <- nlme(linear.even.21 ~ b0 + b1*time.even.21, fixed
= list(b0 + b1 ~ 1), random = b0 ~ 1 | q2, data = dataframe.linear.even.21,
start = c(b0=a1, b1=b1)))

try(fit.linear.left.21 <- nlme(linear.left.21 ~ b0 + b1*time.left.21, fixed
= list(b0 + b1 ~ 1), random = b0 ~ 1 | q2, data = dataframe.linear.left.21,
start = c(b0=a1, b1=b1)))

try(fit.linear.right.21 <- nlme(linear.right.21 ~ b0 + b1*time.right.21,
fixed = list(b0 + b1 ~ 1), random = b0 ~ 1 | q2, data =
dataframe.linear.right.21, start = c(b0=a1, b1=b1)))

try(fit.linear.middle.21 <- nlme(linear.middle.21 ~ b0 + b1*time.middle.21,
fixed = list(b0 + b1 ~ 1), random = b0 ~ 1 | q2, data =
dataframe.linear.middle.21, start = c(b0=a1, b1=b1)))

try(fit.linear.extreme.21 <- nlme(linear.extreme.21 ~ b0 +
b1*time.extreme.21, fixed = list(b0 + b1 ~ 1), random = b0 ~ 1 | q2, data =
dataframe.linear.extreme.21, start = c(b0=a1, b1=b1)))

```

```
#####

out[i,1]=summary(fit.linear.even.21)$tTable[1]
out[i,2]=summary(fit.linear.even.21)$tTable[2]
out[i,3]=summary(fit.linear.even.21)$tTable[3]
out[i,4]=summary(fit.linear.even.21)$tTable[4]

out[i,5]=summary(fit.linear.left.21)$tTable[1]
out[i,6]=summary(fit.linear.left.21)$tTable[2]
out[i,7]=summary(fit.linear.left.21)$tTable[3]
out[i,8]=summary(fit.linear.left.21)$tTable[4]

out[i,9]=summary(fit.linear.right.21)$tTable[1]
out[i,10]=summary(fit.linear.right.21)$tTable[2]
out[i,11]=summary(fit.linear.right.21)$tTable[3]
out[i,12]=summary(fit.linear.right.21)$tTable[4]

out[i,13]=summary(fit.linear.middle.21)$tTable[1]
out[i,14]=summary(fit.linear.middle.21)$tTable[2]
out[i,15]=summary(fit.linear.middle.21)$tTable[3]
out[i,16]=summary(fit.linear.middle.21)$tTable[4]

out[i,17]=summary(fit.linear.extreme.21)$tTable[1]
out[i,18]=summary(fit.linear.extreme.21)$tTable[2]
out[i,19]=summary(fit.linear.extreme.21)$tTable[3]
out[i,20]=summary(fit.linear.extreme.21)$tTable[4]

}

outdataframe <- data.frame(out)
attach(outdataframe)

par1.fit.linear.even.21 <- X1
par2.fit.linear.even.21 <- X2
SE1.fit.linear.even.21 <- X3
SE2.fit.linear.even.21 <- X4

par1.fit.linear.left.21 <- X5
par2.fit.linear.left.21 <- X6
SE1.fit.linear.left.21 <- X7
SE2.fit.linear.left.21 <- X8

par1.fit.linear.right.21 <- X9
par2.fit.linear.right.21 <- X10
SE1.fit.linear.right.21 <- X11
SE2.fit.linear.right.21 <- X12

par1.fit.linear.middle.21 <- X13
par2.fit.linear.middle.21 <- X14
SE1.fit.linear.middle.21 <- X15
SE2.fit.linear.middle.21 <- X16
```

```

par1.fit.linear.extreme.21 <- X17
par2.fit.linear.extreme.21 <- X18
SE1.fit.linear.extreme.21 <- X19
SE2.fit.linear.extreme.21 <- X20

#####

(mean(par1.fit.linear.even.21))
(PRB.par1.even.21 <- ((mean(par1.fit.linear.even.21)-a1)/a1)*100)
(ESD.par1.even.21 <- sd(par1.fit.linear.even.21))

(mean(par2.fit.linear.even.21))
(PRB.par2.even.21 <- ((mean(par2.fit.linear.even.21)-b1)/b1)*100)
(ESD.par2.even.21 <- sd(par2.fit.linear.even.21))

SE.par1.even.21 <- mean(SE1.fit.linear.even.21)
SE.par2.even.21 <- mean(SE2.fit.linear.even.21)

####

(mean(par1.fit.linear.left.21))
(PRB.par1.left.21 <- ((mean(par1.fit.linear.left.21)-a1)/a1)*100)
(ESD.par1.left.21 <- sd(par1.fit.linear.left.21))

(mean(par2.fit.linear.left.21))
(PRB.par2.left.21 <- ((mean(par2.fit.linear.left.21)-b1)/b1)*100)
(ESD.par2.left.21 <- sd(par2.fit.linear.left.21))

SE.par1.left.21 <- mean(SE1.fit.linear.left.21)
SE.par2.left.21 <- mean(SE2.fit.linear.left.21)

####

(mean(par1.fit.linear.right.21))
(PRB.par1.right.21 <- ((mean(par1.fit.linear.right.21)-a1)/a1)*100)
(ESD.par1.right.21 <- sd(par1.fit.linear.right.21))
(mean(par2.fit.linear.right.21))
(PRB.par2.right.21 <- ((mean(par2.fit.linear.right.21)-b1)/b1)*100)
(ESD.par2.right.21 <- sd(par2.fit.linear.right.21))

SE.par1.right.21 <- mean(SE1.fit.linear.right.21)
SE.par2.right.21 <- mean(SE2.fit.linear.right.21)

####

(mean(par1.fit.linear.middle.21))
(PRB.par1.middle.21 <- ((mean(par1.fit.linear.middle.21)-a1)/a1)*100)
(ESD.par1.middle.21 <- sd(par1.fit.linear.middle.21))

(mean(par2.fit.linear.middle.21))
(PRB.par2.middle.21 <- ((mean(par2.fit.linear.middle.21)-b1)/b1)*100)

```

```

(ESD.par2.middle.21 <- sd(par2.fit.linear.middle.21))

SE.par1.middle.21 <- mean(SE1.fit.linear.middle.21)
SE.par2.middle.21 <- mean(SE2.fit.linear.middle.21)

####

(mean(par1.fit.linear.extreme.21))
(PRB.par1.extreme.21 <- ((mean(par1.fit.linear.extreme.21)-a1)/a1)*100)
(ESD.par1.extreme.21 <- sd(par1.fit.linear.extreme.21))

(mean(par2.fit.linear.extreme.21))
(PRB.par2.extreme.21 <- ((mean(par2.fit.linear.extreme.21)-b1)/b1)*100)
(ESD.par2.extreme.21 <- sd(par2.fit.linear.extreme.21))

SE.par1.extreme.21 <- mean(SE1.fit.linear.extreme.21)
SE.par2.extreme.21 <- mean(SE2.fit.linear.extreme.21)

#####

linear.results1a <- data.frame(PRB.par1.even.6)
linear.results2a <- data.frame(PRB.par1.left.6)
linear.results3a <- data.frame(PRB.par1.right.6)
linear.results4a <- data.frame(PRB.par1.middle.6)
linear.results5a <- data.frame(PRB.par1.extreme.6)
linear.results6a <- data.frame(PRB.par1.even.11)
linear.results7a <- data.frame(PRB.par1.left.11)
linear.results8a <- data.frame(PRB.par1.right.11)
linear.results9a <- data.frame(PRB.par1.middle.11)
linear.results10a <- data.frame(PRB.par1.extreme.11)
linear.results11a <- data.frame(PRB.par1.even.16)
linear.results12a <- data.frame(PRB.par1.left.16)
linear.results13a <- data.frame(PRB.par1.right.16)
linear.results14a <- data.frame(PRB.par1.middle.16)
linear.results15a <- data.frame(PRB.par1.extreme.16)
linear.results16a <- data.frame(PRB.par1.even.21)
linear.results17a <- data.frame(PRB.par1.left.21)
linear.results18a <- data.frame(PRB.par1.right.21)
linear.results19a <- data.frame(PRB.par1.middle.21)
linear.results20a <- data.frame(PRB.par1.extreme.21)

linear.results.PRB.par1 <- matrix(c(PRB.par1.even.6,
PRB.par1.left.6, PRB.par1.right.6, PRB.par1.middle.6,
PRB.par1.extreme.6, PRB.par1.even.11, PRB.par1.left.11,
PRB.par1.right.11, PRB.par1.middle.11, PRB.par1.extreme.11, PRB.par1.even.16,
PRB.par1.left.16, PRB.par1.right.16,
PRB.par1.middle.16, PRB.par1.extreme.16, PRB.par1.even.21,
PRB.par1.left.21, PRB.par1.right.21, PRB.par1.middle.21,
PRB.par1.extreme.21), ncol=5, byrow=TRUE)

colnames(linear.results.PRB.par1) <- c("even", "left", "right", "middle",
"extreme")

```

```

rownames(linear.results.PRB.par1) <- c("6", "11", "16", "21")
linear.results.PRB.par1.table <- as.table(linear.results.PRB.par1)
linear.results.PRB.par1.table

write.table(linear.results.PRB.par1.table, file="LinearPRBPar1Example.xls",
sep=", ")

#####

linear.results1b <- data.frame(PRB.par2.even.6)
linear.results2b <- data.frame(PRB.par2.left.6)
linear.results3b <- data.frame(PRB.par2.right.6)
linear.results4b <- data.frame(PRB.par2.middle.6)
linear.results5b <- data.frame(PRB.par2.extreme.6)
linear.results6b <- data.frame(PRB.par2.even.11)
linear.results7b <- data.frame(PRB.par2.left.11)
linear.results8b <- data.frame(PRB.par2.right.11)
linear.results9b <- data.frame(PRB.par2.middle.11)
linear.results10b <- data.frame(PRB.par2.extreme.11)
linear.results11b <- data.frame(PRB.par2.even.16)
linear.results12b <- data.frame(PRB.par2.left.16)
linear.results13b <- data.frame(PRB.par2.right.16)
linear.results14b <- data.frame(PRB.par2.middle.16)
linear.results15b <- data.frame(PRB.par2.extreme.16)
linear.results16b <- data.frame(PRB.par2.even.21)
linear.results17b <- data.frame(PRB.par2.left.21)
linear.results18b <- data.frame(PRB.par2.right.21)
linear.results19b <- data.frame(PRB.par2.middle.21)
linear.results20b <- data.frame(PRB.par2.extreme.21)

linear.results.PRB.par2 <- matrix(c(PRB.par2.even.6,
PRB.par2.left.6, PRB.par2.right.6, PRB.par2.middle.6,
PRB.par2.extreme.6, PRB.par2.even.11, PRB.par2.left.11,
PRB.par2.right.11, PRB.par2.middle.11, PRB.par2.extreme.11, PRB.par2.even.16,
PRB.par2.left.16, PRB.par2.right.16, PRB.par2.middle.16,
PRB.par2.extreme.16, PRB.par2.even.21,
PRB.par2.left.21, PRB.par2.right.21, PRB.par2.middle.21,
PRB.par2.extreme.21), ncol=5, byrow=TRUE)

colnames(linear.results.PRB.par2) <- c("even", "left", "right", "middle",
"extreme")
rownames(linear.results.PRB.par2) <- c("6", "11", "16", "21")
linear.results.PRB.par2.table <- as.table(linear.results.PRB.par2)
linear.results.PRB.par2.table

write.table(linear.results.PRB.par2.table, file="LinearPRBPar2Example.xls",
sep=", ")

#####

linear.results1c <- data.frame(ESD.par1.even.6)
linear.results2c <- data.frame(ESD.par1.left.6)

```

```

linear.results3c <- data.frame(ESD.par1.right.6)
linear.results4c <- data.frame(ESD.par1.middle.6)
linear.results5c <- data.frame(ESD.par1.extreme.6)
linear.results6c <- data.frame(ESD.par1.even.11)
linear.results7c <- data.frame(ESD.par1.left.11)
linear.results8c <- data.frame(ESD.par1.right.11)
linear.results9c <- data.frame(ESD.par1.middle.11)
linear.results10c <- data.frame(ESD.par1.extreme.11)
linear.results11c <- data.frame(ESD.par1.even.16)
linear.results12c <- data.frame(ESD.par1.left.16)
linear.results13c <- data.frame(ESD.par1.right.16)
linear.results14c <- data.frame(ESD.par1.middle.16)
linear.results15c <- data.frame(ESD.par1.extreme.16)
linear.results16c <- data.frame(ESD.par1.even.21)
linear.results17c <- data.frame(ESD.par1.left.21)
linear.results18c <- data.frame(ESD.par1.right.21)
linear.results19c <- data.frame(ESD.par1.middle.21)
linear.results20c <- data.frame(ESD.par1.extreme.21)

linear.results.ESD.par1 <- matrix(c(ESD.par1.even.6,
ESD.par1.left.6, ESD.par1.right.6, ESD.par1.middle.6,
ESD.par1.extreme.6, ESD.par1.even.11,
ESD.par1.left.11, ESD.par1.right.11, ESD.par1.middle.11,
ESD.par1.extreme.11, ESD.par1.even.16,
ESD.par1.left.16, ESD.par1.right.16, ESD.par1.middle.16,
ESD.par1.extreme.16, ESD.par1.even.21,
ESD.par1.left.21, ESD.par1.right.21, ESD.par1.middle.21,
ESD.par1.extreme.21),
  ncol=5, byrow=TRUE)

  colnames(linear.results.ESD.par1) <- c("even", "left", "right", "middle",
"extreme")
  rownames(linear.results.ESD.par1) <- c("6", "11", "16", "21")
linear.results.ESD.par1.table <- as.table(linear.results.ESD.par1)
linear.results.ESD.par1.table

write.table(linear.results.ESD.par1.table, file="LinearESDPar1Example.xls",
sep=", ")

#####

linear.results1d <- data.frame(ESD.par2.even.6)
linear.results2d <- data.frame(ESD.par2.left.6)
linear.results3d <- data.frame(ESD.par2.right.6)
linear.results4d <- data.frame(ESD.par2.middle.6)
linear.results5d <- data.frame(ESD.par2.extreme.6)
linear.results6d <- data.frame(ESD.par2.even.11)
linear.results7d <- data.frame(ESD.par2.left.11)
linear.results8d <- data.frame(ESD.par2.right.11)
linear.results9d <- data.frame(ESD.par2.middle.11)
linear.results10d <- data.frame(ESD.par2.extreme.11)
linear.results11d <- data.frame(ESD.par2.even.16)

```

```

linear.results12d <- data.frame(ESD.par2.left.16)
linear.results13d <- data.frame(ESD.par2.right.16)
linear.results14d <- data.frame(ESD.par2.middle.16)
linear.results15d <- data.frame(ESD.par2.extreme.16)
linear.results16d <- data.frame(ESD.par2.even.21)
linear.results17d <- data.frame(ESD.par2.left.21)
linear.results18d <- data.frame(ESD.par2.right.21)
linear.results19d <- data.frame(ESD.par2.middle.21)
linear.results20d <- data.frame(ESD.par2.extreme.21)

linear.results.ESD.par2 <- matrix(c(ESD.par2.even.6,
ESD.par2.left.6, ESD.par2.right.6, ESD.par2.middle.6,
ESD.par2.extreme.6, ESD.par2.even.11,
ESD.par2.left.11, ESD.par2.right.11, ESD.par2.middle.11,
ESD.par2.extreme.11, ESD.par2.even.16,
ESD.par2.left.16, ESD.par2.right.16, ESD.par2.middle.16,
ESD.par2.extreme.16, ESD.par2.even.21,
ESD.par2.left.21, ESD.par2.right.21, ESD.par2.middle.21,
ESD.par2.extreme.21),
  ncol=5, byrow=TRUE)

  colnames(linear.results.ESD.par2) <- c("even", "left", "right", "middle",
"extreme")
rownames(linear.results.ESD.par2) <- c("6", "11", "16", "21")
linear.results.ESD.par2.table <- as.table(linear.results.ESD.par2)
linear.results.ESD.par2.table

write.table(linear.results.ESD.par2.table, file="LinearESDPar2Example.xls",
sep=", ")

#####

linear.results1e <- data.frame(SE.par1.even.6)
linear.results2e <- data.frame(SE.par1.left.6)
linear.results3e <- data.frame(SE.par1.right.6)
linear.results4e <- data.frame(SE.par1.middle.6)
linear.results5e <- data.frame(SE.par1.extreme.6)
linear.results6e <- data.frame(SE.par1.even.11)
linear.results7e <- data.frame(SE.par1.left.11)
linear.results8e <- data.frame(SE.par1.right.11)
linear.results9e <- data.frame(SE.par1.middle.11)
linear.results10e <- data.frame(SE.par1.extreme.11)
linear.results11e <- data.frame(SE.par1.even.16)
linear.results12e <- data.frame(SE.par1.left.16)
linear.results13e <- data.frame(SE.par1.right.16)
linear.results14e <- data.frame(SE.par1.middle.16)
linear.results15e <- data.frame(SE.par1.extreme.16)
linear.results16e <- data.frame(SE.par1.even.21)
linear.results17e <- data.frame(SE.par1.left.21)
linear.results18e <- data.frame(SE.par1.right.21)
linear.results19e <- data.frame(SE.par1.middle.21)
linear.results20e <- data.frame(SE.par1.extreme.21)

```



```

linear.results.SE.par1 <- matrix(c(SE.par1.even.6,
SE.par1.left.6, SE.par1.right.6, SE.par1.middle.6,
SE.par1.extreme.6, SE.par1.even.11, SE.par1.left.11,
SE.par1.right.11, SE.par1.middle.11, SE.par1.extreme.11, SE.par1.even.16,
SE.par1.left.16, SE.par1.right.16,
SE.par1.middle.16, SE.par1.extreme.16, SE.par1.even.21,
SE.par1.left.21, SE.par1.right.21, SE.par1.middle.21,
SE.par1.extreme.21), ncol=5, byrow=TRUE)

colnames(linear.results.SE.par1) <- c("even", "left", "right", "middle",
"extreme")
rownames(linear.results.SE.par1) <- c("6", "11", "16", "21")
linear.results.SE.par1.table <- as.table(linear.results.SE.par1)
linear.results.SE.par1.table

write.table(linear.results.SE.par1.table, file="LinearSEPar1Example.xls",
sep=",")

#####

linear.results1f <- data.frame(SE.par2.even.6)
linear.results2f <- data.frame(SE.par2.left.6)
linear.results3f <- data.frame(SE.par2.right.6)
linear.results4f <- data.frame(SE.par2.middle.6)
linear.results5f <- data.frame(SE.par2.extreme.6)
linear.results6f <- data.frame(SE.par2.even.11)
linear.results7f <- data.frame(SE.par2.left.11)
linear.results8f <- data.frame(SE.par2.right.11)
linear.results9f <- data.frame(SE.par2.middle.11)
linear.results10f <- data.frame(SE.par2.extreme.11)
linear.results11f <- data.frame(SE.par2.even.16)
linear.results12f <- data.frame(SE.par2.left.16)
linear.results13f <- data.frame(SE.par2.right.16)
linear.results14f <- data.frame(SE.par2.middle.16)
linear.results15f <- data.frame(SE.par2.extreme.16)
linear.results16f <- data.frame(SE.par2.even.21)
linear.results17f <- data.frame(SE.par2.left.21)
linear.results18f <- data.frame(SE.par2.right.21)
linear.results19f <- data.frame(SE.par2.middle.21)
linear.results20f <- data.frame(SE.par2.extreme.21)

linear.results.SE.par2 <- matrix(c(SE.par2.even.6,
SE.par2.left.6, SE.par2.right.6, SE.par2.middle.6,
SE.par2.extreme.6, SE.par2.even.11, SE.par2.left.11,
SE.par2.right.11, SE.par2.middle.11, SE.par2.extreme.11, SE.par2.even.16,
SE.par2.left.16, SE.par2.right.16,
SE.par2.middle.16, SE.par2.extreme.16, SE.par2.even.21,
SE.par2.left.21, SE.par2.right.21, SE.par2.middle.21,
SE.par2.extreme.21), ncol=5, byrow=TRUE)

colnames(linear.results.SE.par2) <- c("even", "left", "right", "middle",

```

```

"extreme")
rownames(linear.results.SE.par2) <- c("6", "11", "16", "21")
linear.results.SE.par2.table <- as.table(linear.results.SE.par2)
linear.results.SE.par2.table

write.table(linear.results.SE.par2.table, file="LinearSEPar2Example.xls",
sep=",")

#####

for (loop in 1:1000){
xPRB.par1.even.6 <- ((par1.fit.linear.even.6 - a1)/a1)*100
}
for (loop in 1:1000){
xPRB.par1.even.11 <- ((par1.fit.linear.even.11 - a1)/a1)*100
}
for (loop in 1:1000){
xPRB.par1.even.16 <- ((par1.fit.linear.even.16 - a1)/a1)*100
}
for (loop in 1:1000){
xPRB.par1.even.21 <- ((par1.fit.linear.even.21 - a1)/a1)*100
}

#####

for (loop in 1:1000){
xPRB.par1.left.6 <- ((par1.fit.linear.left.6 - a1)/a1)*100
}
for (loop in 1:1000){
xPRB.par1.left.11 <- ((par1.fit.linear.left.11 - a1)/a1)*100
}
for (loop in 1:1000){
xPRB.par1.left.16 <- ((par1.fit.linear.left.16 - a1)/a1)*100
}
for (loop in 1:1000){
xPRB.par1.left.21 <- ((par1.fit.linear.left.21 - a1)/a1)*100
}

for (loop in 1:1000){
xPRB.par1.right.6 <- ((par1.fit.linear.right.6 - a1)/a1)*100
}
for (loop in 1:1000){
xPRB.par1.right.11 <- ((par1.fit.linear.right.11 - a1)/a1)*100
}
for (loop in 1:1000){
xPRB.par1.right.16 <- ((par1.fit.linear.right.16 - a1)/a1)*100
}
for (loop in 1:1000){
xPRB.par1.right.21 <- ((par1.fit.linear.right.21 - a1)/a1)*100
}

```

```
#####

for (loop in 1:1000){
xPRB.par1.middle.6 <- ((par1.fit.linear.middle.6 - a1)/a1)*100
}
for (loop in 1:1000){
xPRB.par1.middle.11 <- ((par1.fit.linear.middle.11 - a1)/a1)*100
}
for (loop in 1:1000){
xPRB.par1.middle.16 <- ((par1.fit.linear.middle.16 - a1)/a1)*100
}
for (loop in 1:1000){
xPRB.par1.middle.21 <- ((par1.fit.linear.middle.21 - a1)/a1)*100
}

#####

for (loop in 1:1000){
xPRB.par1.extreme.6 <- ((par1.fit.linear.extreme.6 - a1)/a1)*100
}
for (loop in 1:1000){
xPRB.par1.extreme.11 <- ((par1.fit.linear.extreme.11 - a1)/a1)*100
}
for (loop in 1:1000){
xPRB.par1.extreme.16 <- ((par1.fit.linear.extreme.16 - a1)/a1)*100
}
for (loop in 1:1000){
xPRB.par1.extreme.21 <- ((par1.fit.linear.extreme.21 - a1)/a1)*100
}

#####

PRBparlest <- c(xPRB.par1.even.6, xPRB.par1.even.11, xPRB.par1.even.16,
xPRB.par1.even.21, xPRB.par1.left.6, xPRB.par1.left.11, xPRB.par1.left.16,
xPRB.par1.left.21,
xPRB.par1.right.6, xPRB.par1.right.11, xPRB.par1.right.16,
xPRB.par1.right.21,
xPRB.par1.middle.6, xPRB.par1.middle.11, xPRB.par1.middle.16,
xPRB.par1.middle.21,
xPRB.par1.extreme.6, xPRB.par1.extreme.11, xPRB.par1.extreme.16,
xPRB.par1.extreme.21)

PRBparlspacing <- c(rep("even", 4000), rep("left", 4000), rep("right",
4000), rep("middle", 4000), rep("extreme", 4000))

PRBparltimepoints <- c(rep("six", 1000), rep("eleven", 1000), rep("sixteen",
1000), rep("twentyone", 1000), rep("six", 1000), rep("eleven", 1000),
rep("sixteen", 1000), rep("twentyone", 1000), rep("six", 1000),
rep("eleven", 1000), rep("sixteen", 1000), rep("twentyone", 1000),
rep("six", 1000), rep("eleven", 1000), rep("sixteen", 1000),
rep("twentyone", 1000), rep("six", 1000), rep("eleven", 1000),
```

```

rep("sixteen", 1000), rep("twentyone", 1000))

PRBparlanovadata <- cbind(PRBparlest, PRBparlspacing, PRBparltimepoints)
head(PRBparlanovadata)

PRBparlanova <- anova(lm(PRBparlest ~ factor(PRBparlspacing) +
factor(PRBparltimepoints) +
factor(PRBparlspacing)*factor(PRBparltimepoints)))
PRBparlanova

#####

for (loop in 1:1000){
xPRB.par2.even.6 <- ((par2.fit.linear.even.6 - b1)/b1)*100
}
for (loop in 1:1000){
xPRB.par2.even.11 <- ((par2.fit.linear.even.11 - b1)/b1)*100
}
for (loop in 1:1000){
xPRB.par2.even.16 <- ((par2.fit.linear.even.16 - b1)/b1)*100
}
for (loop in 1:1000){
xPRB.par2.even.21 <- ((par2.fit.linear.even.21 - b1)/b1)*100
}

#####

for (loop in 1:1000){
xPRB.par2.left.6 <- ((par2.fit.linear.left.6 - b1)/b1)*100
}
for (loop in 1:1000){
xPRB.par2.left.11 <- ((par2.fit.linear.left.11 - b1)/b1)*100
}
for (loop in 1:1000){
xPRB.par2.left.16 <- ((par2.fit.linear.left.16 - b1)/b1)*100
}
for (loop in 1:1000){
xPRB.par2.left.21 <- ((par2.fit.linear.left.21 - b1)/b1)*100
}

#####

for (loop in 1:1000){
xPRB.par2.right.6 <- ((par2.fit.linear.right.6 - b1)/b1)*100
}
for (loop in 1:1000){
xPRB.par2.right.11 <- ((par2.fit.linear.right.11 - b1)/b1)*100
}
for (loop in 1:1000){
xPRB.par2.right.16 <- ((par2.fit.linear.right.16 - b1)/b1)*100
}
for (loop in 1:1000){

```

```

xPRB.par2.right.21 <- ((par2.fit.linear.right.21 - b1)/b1)*100
}

#####

for (loop in 1:1000){
xPRB.par2.middle.6 <- ((par2.fit.linear.middle.6 - b1)/b1)*100
}
for (loop in 1:1000){
xPRB.par2.middle.11 <- ((par2.fit.linear.middle.11 - b1)/b1)*100
}
for (loop in 1:1000){
xPRB.par2.middle.16 <- ((par2.fit.linear.middle.16 - b1)/b1)*100
}
for (loop in 1:1000){
xPRB.par2.middle.21 <- ((par2.fit.linear.middle.21 - b1)/b1)*100
}

####

for (loop in 1:1000){
xPRB.par2.extreme.6 <- ((par2.fit.linear.extreme.6 - b1)/b1)*100
}
for (loop in 1:1000){
xPRB.par2.extreme.11 <- ((par2.fit.linear.extreme.11 - b1)/b1)*100
}
for (loop in 1:1000){
xPRB.par2.extreme.16 <- ((par2.fit.linear.extreme.16 - b1)/b1)*100
}
for (loop in 1:1000){
xPRB.par2.extreme.21 <- ((par2.fit.linear.extreme.21 - b1)/b1)*100
}

#####

PRBpar2est <- c(xPRB.par2.even.6, xPRB.par2.even.11, xPRB.par2.even.16,
xPRB.par2.even.21, xPRB.par2.left.6, xPRB.par2.left.11, xPRB.par2.left.16,
xPRB.par2.left.21,
xPRB.par2.right.6, xPRB.par2.right.11, xPRB.par2.right.16,
xPRB.par2.right.21,
xPRB.par2.middle.6, xPRB.par2.middle.11, xPRB.par2.middle.16,
xPRB.par2.middle.21,
xPRB.par2.extreme.6, xPRB.par2.extreme.11, xPRB.par2.extreme.16,
xPRB.par2.extreme.21)

PRBpar2spacing <- c(rep("even", 4000), rep("left", 4000), rep("right",
4000), rep("middle", 4000), rep("extreme", 4000))

PRBpar2timepoints <- c(rep("six", 1000), rep("eleven", 1000), rep("sixteen",
1000), rep("twentyone", 1000), rep("six", 1000), rep("eleven", 1000),
rep("sixteen", 1000), rep("twentyone", 1000), rep("six", 1000),
rep("eleven", 1000), rep("sixteen", 1000), rep("twentyone", 1000),

```

```

rep("six", 1000), rep("eleven", 1000), rep("sixteen", 1000),
rep("twentyone", 1000), rep("six", 1000), rep("eleven", 1000),
rep("sixteen", 1000), rep("twentyone", 1000))

PRBpar2anovadata <- cbind(PRBpar2est, PRBpar2spacing, PRBpar2timepoints)

head(PRBpar2anovadata)

PRBpar2anova <- anova(lm(PRBpar2est ~ factor(PRBpar2spacing) +
factor(PRBpar2timepoints) +
factor(PRBpar2spacing)*factor(PRBpar2timepoints)))

PRBpar2anova

#####

SEparlest <- c(SE1.fit.linear.even.6, SE1.fit.linear.even.11,
SE1.fit.linear.even.16, SE1.fit.linear.even.21, SE1.fit.linear.left.6,
SE1.fit.linear.left.11, SE1.fit.linear.left.16, SE1.fit.linear.left.21,
SE1.fit.linear.right.6, SE1.fit.linear.right.11, SE1.fit.linear.right.16,
SE1.fit.linear.right.21,
SE1.fit.linear.middle.6, SE1.fit.linear.middle.11, SE1.fit.linear.middle.16,
SE1.fit.linear.middle.21,
SE1.fit.linear.extreme.6, SE1.fit.linear.extreme.11,
SE1.fit.linear.extreme.16, SE1.fit.linear.extreme.21)

SEparlspacing <- c(rep("even", 4000), rep("left", 4000), rep("right", 4000),
rep("middle", 4000), rep("extreme", 4000))

SEparltimepoints <-c(rep("six", 1000), rep("eleven", 1000), rep("sixteen",
1000), rep("twentyone", 1000), rep("six", 1000), rep("eleven", 1000),
rep("sixteen", 1000), rep("twentyone", 1000), rep("six", 1000),
rep("eleven", 1000), rep("sixteen", 1000), rep("twentyone", 1000),
rep("six", 1000), rep("eleven", 1000), rep("sixteen", 1000),
rep("twentyone", 1000), rep("six", 1000), rep("eleven", 1000),
rep("sixteen", 1000), rep("twentyone", 1000))

SEparlanovadata <- cbind(SEparlest, SEparlspacing, SEparltimepoints)
head(SEparlanovadata)

SEparlanova <- anova(lm(SEparlest ~ factor(SEparlspacing) +
factor(SEparltimepoints) + factor(SEparlspacing)*factor(SEparltimepoints)))
SEparlanova

#####

SEpar2est <- c(SE2.fit.linear.even.6, SE2.fit.linear.even.11,
SE2.fit.linear.even.16, SE2.fit.linear.even.21, SE2.fit.linear.left.6,
SE2.fit.linear.left.11, SE2.fit.linear.left.16, SE2.fit.linear.left.21,
SE2.fit.linear.right.6, SE2.fit.linear.right.11, SE2.fit.linear.right.16,
SE2.fit.linear.right.21,
SE2.fit.linear.middle.6, SE2.fit.linear.middle.11, SE2.fit.linear.middle.16,

```

```

SE2.fit.linear.middle.21,
SE2.fit.linear.extreme.6, SE2.fit.linear.extreme.11,
SE2.fit.linear.extreme.16, SE2.fit.linear.extreme.21)

SEpar2spacing <- c(rep("even", 4000), rep("left", 4000), rep("right", 4000),
rep("middle", 4000), rep("extreme", 4000))

SEpar2timepoints <-c(rep("six", 1000), rep("eleven", 1000), rep("sixteen",
1000), rep("twentyone", 1000), rep("six", 1000), rep("eleven", 1000),
rep("sixteen", 1000), rep("twentyone", 1000), rep("six", 1000),
rep("eleven", 1000), rep("sixteen", 1000), rep("twentyone", 1000),
rep("six", 1000), rep("eleven", 1000), rep("sixteen", 1000),
rep("twentyone", 1000), rep("six", 1000), rep("eleven", 1000),
rep("sixteen", 1000), rep("twentyone", 1000))

SEpar2anovadata <- cbind(SEpar2est, SEpar2spacing, SEpar2timepoints)
head(SEpar2anovadata)

SEpar2anova <- anova(lm(SEpar2est ~ factor(SEpar2spacing) +
factor(SEpar2timepoints) + factor(SEpar2spacing)*factor(SEpar2timepoints)))
SEpar2anova

#####

PRBpar1pariwise <- TukeyHSD(aov(PRBpar1est ~ factor(PRBpar1spacing) +
factor(PRBpar1timepoints) +
factor(PRBpar1spacing)*factor(PRBpar1timepoints)))

PRBpar2pariwise <- TukeyHSD(aov(PRBpar2est ~ factor(PRBpar2spacing) +
factor(PRBpar2timepoints) +
factor(PRBpar2spacing)*factor(PRBpar2timepoints)))

SEpar1pariwise <- TukeyHSD(aov(SEpar1est ~ factor(SEpar1spacing) +
factor(SEpar1timepoints) + factor(SEpar1spacing)*factor(SEpar1timepoints)))

SEpar2pariwise <- TukeyHSD(aov(SEpar2est ~ factor(SEpar2spacing) +
factor(SEpar2timepoints) + factor(SEpar2spacing)*factor(SEpar2timepoints)))

#####

library(lsr)

PRBparlanovaa <- aov(PRBpar1est ~ factor(PRBpar1spacing))

PRBparlanovab <- aov(PRBpar1est ~ factor(PRBpar1timepoints))

PRBparlanovac <- aov(PRBpar1est ~ factor(PRBpar1spacing) +
factor(PRBpar1timepoints) +
factor(PRBpar1spacing)*factor(PRBpar1timepoints))

PRBpar2anovaa <- aov(PRBpar2est ~ factor(PRBpar2spacing))

```

```

PRBpar2anovab <- aov(PRBpar2est ~ factor(PRBpar2timepoints))

PRBpar2anovac <- aov(PRBpar2est ~ factor(PRBpar2spacing) +
factor(PRBpar2timepoints) +
factor(PRBpar2spacing)*factor(PRBpar2timepoints))

SEparlanovaa <- aov(SEparlest ~ factor(SEpar1spacing))

SEparlanovab <- aov(SEparlest ~ factor(SEpar1timepoints))

SEparlanovac <- aov(SEparlest ~ factor(SEpar1spacing) +
factor(SEpar1timepoints) + factor(SEpar1spacing)*factor(SEpar1timepoints))

SEpar2anovaa <- aov(SEpar2est ~ factor(SEpar2spacing))

SEpar2anovab <- aov(SEpar2est ~ factor(SEpar2timepoints))

SEpar2anovac <- aov(SEpar2est ~ factor(SEpar2spacing) +
factor(SEpar2timepoints) + factor(SEpar2spacing)*factor(SEpar2timepoints))

#####

# Output

#####

PRBpar1anova
PRBpar2anova
SEparlanova
SEpar2anova

etaSquared(PRBpar1anovaa)
etaSquared(PRBpar1anovab)
etaSquared(PRBpar1anovac)

etaSquared(PRBpar2anovaa)
etaSquared(PRBpar2anovab)
etaSquared(PRBpar2anovac)

etaSquared(SEparlanovaa)
etaSquared(SEparlanovab)
etaSquared(SEparlanovac)

etaSquared(SEpar2anovaa)
etaSquared(SEpar2anovab)
etaSquared(SEpar2anovac)

# If you would like pairwise comparisons, run the following code:

# PRBpar1pairwise
# PRBpar2pairwise
# SEpar1pairwise

```



```
# SEparlpairwise
```

```
#####
```