[STAT 4400] HW-5

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Problem - 1

```
library(lme4)
library(ggplot2)

df <- read.table(file = "/Users/Home/Documents/Michael_Ghattas/School/
CU_Boulder/2022/Spring 2022/STAT - 4400/Data/apt.txt", header = TRUE)
head(df)

##   y    defects      poor race floor dist bldg
## 1 1 0.0000000 2.000000    4     2    1    1
## 2 0 1.0000000 4.000000    4     2    1    1
## 3 0 0.0000000 1.000000    3     2    1    1
## 4 0 1.0000000 2.000000    4     2    1    1
## 5 0 0.2320124 2.325472    2     3    1    2
## 6 1 1.0000000 3.000000    2     2    1    3
```

(a)

```
m1 <- lmer(y ~ dist + (0 + dist | race), data = df)
summary(m1)

## Linear mixed model fit by REML ['lmerMod']
## Formula: y ~ dist + (0 + dist | race)
##    Data: df
##
## REML criterion at convergence: 14577.2
##
## Scaled residuals:
##     Min      1Q  Median      3Q     Max
## -0.91090 -0.75478 -0.38006  0.07048  2.52334
##
## Random effects:
```

```
##  Groups    Name Variance  Std.Dev.
##  race      dist 5.638e-06 0.002375
##  Residual       1.662e-01 0.407688
## Number of obs: 13931, groups:  race, 7
##
## Fixed effects:
##                 Estimate Std. Error t value
## (Intercept)  0.3723157  0.0075180  49.523
## dist        -0.0036107  0.0009787  -3.689
##
## Correlation of Fixed Effects:
##      (Intr)
## dist -0.210
```

(b)

```
m2 <- lmer(y ~ dist + (1 + dist | race), data = df)

## Warning in checkConv(attr(opt, "derivs"), opt$par, ctrl =
## control$checkConv, :
## unable to evaluate scaled gradient

## Warning in checkConv(attr(opt, "derivs"), opt$par, ctrl =
## control$checkConv, :
## Model failed to converge: degenerate Hessian with 1 negative eigenvalues

summary(m2)

## Linear mixed model fit by REML ['lmerMod']
## Formula: y ~ dist + (1 + dist | race)
##    Data: df
##
## REML criterion at convergence: 14238.4
##
## Scaled residuals:
##     Min      1Q  Median      3Q     Max
## -1.3293 -0.7025 -0.2874 -0.1619  2.3229
##
## Random effects:
```

```
##  Groups   Name         Variance  Std.Dev. Corr
##  race     (Intercept) 2.729e-01 0.522387
##           dist        2.453e-05 0.004953 -1.00
##  Residual             1.620e-01 0.402447
## Number of obs: 13931, groups:  race, 7
##
## Fixed effects:
##              Estimate Std. Error t value
## (Intercept)  0.388548   0.198228   1.960
## dist        -0.003893   0.001898  -2.052
##
## Correlation of Fixed Effects:
##      (Intr)
## dist -0.991
## optimizer (nloptwrap) convergence code: 0 (OK)
## unable to evaluate scaled gradient
## Model failed to converge: degenerate  Hessian with 1 negative eigenvalues
```

Problem - 2

```r
library(reshape)
```

```
##
## Attaching package: 'reshape'

## The following object is masked from 'package:data.table':
##
##     melt

## The following object is masked from 'package:Matrix':
##
##     expand
```

```r
library("stringr")
library(zoo)

filename <- "/Users/Home/Documents/Michael_Ghattas/School/CU_Boulder/2022/
Spring 2022/STAT - 4400/Data/olympics1932.txt"
```

```
olympics1932_na <- read.fwf(filename, widths = c(2, 14, 9, 9, 9, 9, 9, 9, 9),
skip = 21, header = FALSE)
colnames(olympics1932_na)<- c("pair", "criterion", "judge_1",  "judge_2",
"judge_3", "judge_4",  "judge_5" , "judge_6",  "judge_7")
olympics1932 <- na.locf(olympics1932_na)
olympics1932$criterion <- str_trim(olympics1932_na$criterion)
```

(a)

```
arr_olym <- melt(data = olympics1932, id.vars = c("pair", "criterion"),
measure.vars=c(colnames(olympics1932)[3:9]))
arr_olym
```

```
##    pair   criterion variable value
## 1     1      Program  judge_1   5.6
## 2     1  Performance  judge_1   5.6
## 3     2      Program  judge_1   5.5
## 4     2  Performance  judge_1   5.5
## 5     3      Program  judge_1   6.0
## 6     3  Performance  judge_1   6.0
## 7     4      Program  judge_1   5.6
## 8     4  Performance  judge_1   5.6
## 9     5      Program  judge_1   5.4
## 10    5  Performance  judge_1   4.8
## 11    6      Program  judge_1   5.2
## 12    6  Performance  judge_1   4.8
## 13    7      Program  judge_1   4.8
## 14    7  Performance  judge_1   4.3
## 15    1      Program  judge_2   5.5
## 16    1  Performance  judge_2   5.5
## 17    2      Program  judge_2   5.2
## 18    2  Performance  judge_2   5.7
## 19    3      Program  judge_2   5.3
## 20    3  Performance  judge_2   5.5
## 21    4      Program  judge_2   5.3
## 22    4  Performance  judge_2   5.3
## 23    5      Program  judge_2   4.5
## 24    5  Performance  judge_2   4.8
```

```
## 25    6     Program   judge_2    5.1
## 26    6 Performance   judge_2    5.6
## 27    7     Program   judge_2    4.0
## 28    7 Performance   judge_2    4.6
## 29    1     Program   judge_3    5.8
## 30    1 Performance   judge_3    5.8
## 31    2     Program   judge_3    5.8
## 32    2 Performance   judge_3    5.6
## 33    3     Program   judge_3    5.8
## 34    3 Performance   judge_3    5.7
## 35    4     Program   judge_3    5.8
## 36    4 Performance   judge_3    5.8
## 37    5     Program   judge_3    5.8
## 38    5 Performance   judge_3    5.5
## 39    6     Program   judge_3    5.3
## 40    6 Performance   judge_3    5.0
## 41    7     Program   judge_3    4.7
## 42    7 Performance   judge_3    4.5
## 43    1     Program   judge_4    5.3
## 44    1 Performance   judge_4    4.7
## 45    2     Program   judge_4    5.8
## 46    2 Performance   judge_4    5.4
## 47    3     Program   judge_4    5.0
## 48    3 Performance   judge_4    4.9
## 49    4     Program   judge_4    4.4
## 50    4 Performance   judge_4    4.8
## 51    5     Program   judge_4    4.0
## 52    5 Performance   judge_4    4.4
## 53    6     Program   judge_4    5.4
## 54    6 Performance   judge_4    4.7
## 55    7     Program   judge_4    4.0
## 56    7 Performance   judge_4    4.0
## 57    1     Program   judge_5    5.6
## 58    1 Performance   judge_5    5.7
## 59    2     Program   judge_5    5.6
```

```
## 60     2 Performance   judge_5    5.5
## 61     3     Program   judge_5    5.4
## 62     3 Performance   judge_5    5.5
## 63     4     Program   judge_5    4.5
## 64     4 Performance   judge_5    4.5
## 65     5     Program   judge_5    5.5
## 66     5 Performance   judge_5    4.6
## 67     6     Program   judge_5    4.5
## 68     6 Performance   judge_5    4.0
## 69     7     Program   judge_5    3.7
## 70     7 Performance   judge_5    3.6
## 71     1     Program   judge_6    5.2
## 72     1 Performance   judge_6    5.3
## 73     2     Program   judge_6    5.1
## 74     2 Performance   judge_6    5.3
## 75     3     Program   judge_6    5.1
## 76     3 Performance   judge_6    5.2
## 77     4     Program   judge_6    5.0
## 78     4 Performance   judge_6    5.0
## 79     5     Program   judge_6    4.8
## 80     5 Performance   judge_6    4.8
## 81     6     Program   judge_6    4.5
## 82     6 Performance   judge_6    4.6
## 83     7     Program   judge_6    4.0
## 84     7 Performance   judge_6    4.0
## 85     1     Program   judge_7    5.7
## 86     1 Performance   judge_7    5.4
## 87     2     Program   judge_7    5.8
## 88     2 Performance   judge_7    5.7
## 89     3     Program   judge_7    5.3
## 90     3 Performance   judge_7    5.7
## 91     4     Program   judge_7    5.1
## 92     4 Performance   judge_7    5.5
## 93     5     Program   judge_7    5.5
## 94     5 Performance   judge_7    5.2
```

```
## 95    6     Program  judge_7   5.0
## 96    6 Performance  judge_7   5.2
## 97    7     Program  judge_7   4.8
## 98    7 Performance  judge_7   4.8
```

(b)

```r
olym_984 <- arr_olym[order(arr_olym$variable), ]
olym_984 <- olym_984[c("criterion", "value", "pair", "variable")]

olym_984
```

```
##       criterion value pair variable
## 1       Program   5.6    1  judge_1
## 2   Performance   5.6    1  judge_1
## 3       Program   5.5    2  judge_1
## 4   Performance   5.5    2  judge_1
## 5       Program   6.0    3  judge_1
## 6   Performance   6.0    3  judge_1
## 7       Program   5.6    4  judge_1
## 8   Performance   5.6    4  judge_1
## 9       Program   5.4    5  judge_1
## 10  Performance   4.8    5  judge_1
## 11      Program   5.2    6  judge_1
## 12  Performance   4.8    6  judge_1
## 13      Program   4.8    7  judge_1
## 14  Performance   4.3    7  judge_1
## 15      Program   5.5    1  judge_2
## 16  Performance   5.5    1  judge_2
## 17      Program   5.2    2  judge_2
## 18  Performance   5.7    2  judge_2
## 19      Program   5.3    3  judge_2
## 20  Performance   5.5    3  judge_2
## 21      Program   5.3    4  judge_2
## 22  Performance   5.3    4  judge_2
## 23      Program   4.5    5  judge_2
## 24  Performance   4.8    5  judge_2
```

```
## 25        Program    5.1    6    judge_2
## 26 Performance    5.6    6    judge_2
## 27        Program    4.0    7    judge_2
## 28 Performance    4.6    7    judge_2
## 29        Program    5.8    1    judge_3
## 30 Performance    5.8    1    judge_3
## 31        Program    5.8    2    judge_3
## 32 Performance    5.6    2    judge_3
## 33        Program    5.8    3    judge_3
## 34 Performance    5.7    3    judge_3
## 35        Program    5.8    4    judge_3
## 36 Performance    5.8    4    judge_3
## 37        Program    5.8    5    judge_3
## 38 Performance    5.5    5    judge_3
## 39        Program    5.3    6    judge_3
## 40 Performance    5.0    6    judge_3
## 41        Program    4.7    7    judge_3
## 42 Performance    4.5    7    judge_3
## 43        Program    5.3    1    judge_4
## 44 Performance    4.7    1    judge_4
## 45        Program    5.8    2    judge_4
## 46 Performance    5.4    2    judge_4
## 47        Program    5.0    3    judge_4
## 48 Performance    4.9    3    judge_4
## 49        Program    4.4    4    judge_4
## 50 Performance    4.8    4    judge_4
## 51        Program    4.0    5    judge_4
## 52 Performance    4.4    5    judge_4
## 53        Program    5.4    6    judge_4
## 54 Performance    4.7    6    judge_4
## 55        Program    4.0    7    judge_4
## 56 Performance    4.0    7    judge_4
## 57        Program    5.6    1    judge_5
## 58 Performance    5.7    1    judge_5
## 59        Program    5.6    2    judge_5
```

```
## 60 Performance   5.5   2   judge_5
## 61      Program   5.4   3   judge_5
## 62 Performance   5.5   3   judge_5
## 63      Program   4.5   4   judge_5
## 64 Performance   4.5   4   judge_5
## 65      Program   5.5   5   judge_5
## 66 Performance   4.6   5   judge_5
## 67      Program   4.5   6   judge_5
## 68 Performance   4.0   6   judge_5
## 69      Program   3.7   7   judge_5
## 70 Performance   3.6   7   judge_5
## 71      Program   5.2   1   judge_6
## 72 Performance   5.3   1   judge_6
## 73      Program   5.1   2   judge_6
## 74 Performance   5.3   2   judge_6
## 75      Program   5.1   3   judge_6
## 76 Performance   5.2   3   judge_6
## 77      Program   5.0   4   judge_6
## 78 Performance   5.0   4   judge_6
## 79      Program   4.8   5   judge_6
## 80 Performance   4.8   5   judge_6
## 81      Program   4.5   6   judge_6
## 82 Performance   4.6   6   judge_6
## 83      Program   4.0   7   judge_6
## 84 Performance   4.0   7   judge_6
## 85      Program   5.7   1   judge_7
## 86 Performance   5.4   1   judge_7
## 87      Program   5.8   2   judge_7
## 88 Performance   5.7   2   judge_7
## 89      Program   5.3   3   judge_7
## 90 Performance   5.7   3   judge_7
## 91      Program   5.1   4   judge_7
## 92 Performance   5.5   4   judge_7
## 93      Program   5.5   5   judge_7
## 94 Performance   5.2   5   judge_7
```

```
## 95       Program   5.0    6   judge_7
## 96 Performance   5.2    6   judge_7
## 97       Program   4.8    7   judge_7
## 98 Performance   4.8    7   judge_7
```

(c)

```
olym_984$SameCountry <- ifelse(olym_984[, 3] == " 1"&olym_984[, 4] ==
"judge_5", 1, ifelse(olym_984[, 3] == " 2"&olym_984[, 4] == "judge_7", 1,
  ifelse(olym_984[, 3] == " 3"&olym_984[, 4] == "judge_1", 1,
ifelse(olym_984[, 3] == " 4"&olym_984[, 4] == "judge_1", 1,
  ifelse(olym_984[, 3] == " 7"&olym_984[, 4] == "judge_7", 1, 0)))))

olym_984
```

```
##       criterion value pair variable SameCountry
## 1       Program   5.6    1  judge_1           0
## 2   Performance   5.6    1  judge_1           0
## 3       Program   5.5    2  judge_1           0
## 4   Performance   5.5    2  judge_1           0
## 5       Program   6.0    3  judge_1           0
## 6   Performance   6.0    3  judge_1           0
## 7       Program   5.6    4  judge_1           0
## 8   Performance   5.6    4  judge_1           0
## 9       Program   5.4    5  judge_1           0
## 10  Performance   4.8    5  judge_1           0
## 11      Program   5.2    6  judge_1           0
## 12  Performance   4.8    6  judge_1           0
## 13      Program   4.8    7  judge_1           0
## 14  Performance   4.3    7  judge_1           0
## 15      Program   5.5    1  judge_2           0
## 16  Performance   5.5    1  judge_2           0
## 17      Program   5.2    2  judge_2           0
## 18  Performance   5.7    2  judge_2           0
## 19      Program   5.3    3  judge_2           0
## 20  Performance   5.5    3  judge_2           0
## 21      Program   5.3    4  judge_2           0
## 22  Performance   5.3    4  judge_2           0
```

```
## 23        Program   4.5   5   judge_2            0
## 24 Performance   4.8   5   judge_2            0
## 25        Program   5.1   6   judge_2            0
## 26 Performance   5.6   6   judge_2            0
## 27        Program   4.0   7   judge_2            0
## 28 Performance   4.6   7   judge_2            0
## 29        Program   5.8   1   judge_3            0
## 30 Performance   5.8   1   judge_3            0
## 31        Program   5.8   2   judge_3            0
## 32 Performance   5.6   2   judge_3            0
## 33        Program   5.8   3   judge_3            0
## 34 Performance   5.7   3   judge_3            0
## 35        Program   5.8   4   judge_3            0
## 36 Performance   5.8   4   judge_3            0
## 37        Program   5.8   5   judge_3            0
## 38 Performance   5.5   5   judge_3            0
## 39        Program   5.3   6   judge_3            0
## 40 Performance   5.0   6   judge_3            0
## 41        Program   4.7   7   judge_3            0
## 42 Performance   4.5   7   judge_3            0
## 43        Program   5.3   1   judge_4            0
## 44 Performance   4.7   1   judge_4            0
## 45        Program   5.8   2   judge_4            0
## 46 Performance   5.4   2   judge_4            0
## 47        Program   5.0   3   judge_4            0
## 48 Performance   4.9   3   judge_4            0
## 49        Program   4.4   4   judge_4            0
## 50 Performance   4.8   4   judge_4            0
## 51        Program   4.0   5   judge_4            0
## 52 Performance   4.4   5   judge_4            0
## 53        Program   5.4   6   judge_4            0
## 54 Performance   4.7   6   judge_4            0
## 55        Program   4.0   7   judge_4            0
## 56 Performance   4.0   7   judge_4            0
## 57        Program   5.6   1   judge_5            0
```

```
## 58 Performance   5.7   1   judge_5        0
## 59      Program   5.6   2   judge_5        0
## 60 Performance   5.5   2   judge_5        0
## 61      Program   5.4   3   judge_5        0
## 62 Performance   5.5   3   judge_5        0
## 63      Program   4.5   4   judge_5        0
## 64 Performance   4.5   4   judge_5        0
## 65      Program   5.5   5   judge_5        0
## 66 Performance   4.6   5   judge_5        0
## 67      Program   4.5   6   judge_5        0
## 68 Performance   4.0   6   judge_5        0
## 69      Program   3.7   7   judge_5        0
## 70 Performance   3.6   7   judge_5        0
## 71      Program   5.2   1   judge_6        0
## 72 Performance   5.3   1   judge_6        0
## 73      Program   5.1   2   judge_6        0
## 74 Performance   5.3   2   judge_6        0
## 75      Program   5.1   3   judge_6        0
## 76 Performance   5.2   3   judge_6        0
## 77      Program   5.0   4   judge_6        0
## 78 Performance   5.0   4   judge_6        0
## 79      Program   4.8   5   judge_6        0
## 80 Performance   4.8   5   judge_6        0
## 81      Program   4.5   6   judge_6        0
## 82 Performance   4.6   6   judge_6        0
## 83      Program   4.0   7   judge_6        0
## 84 Performance   4.0   7   judge_6        0
## 85      Program   5.7   1   judge_7        0
## 86 Performance   5.4   1   judge_7        0
## 87      Program   5.8   2   judge_7        0
## 88 Performance   5.7   2   judge_7        0
## 89      Program   5.3   3   judge_7        0
## 90 Performance   5.7   3   judge_7        0
## 91      Program   5.1   4   judge_7        0
## 92 Performance   5.5   4   judge_7        0
```

```
## 93      Program    5.5     5   judge_7              0
## 94 Performance    5.2     5   judge_7              0
## 95      Program    5.0     6   judge_7              0
## 96 Performance    5.2     6   judge_7              0
## 97      Program    4.8     7   judge_7              0
## 98 Performance    4.8     7   judge_7              0
```

Problem - 3

```
library(tidyverse)

## ── Attaching packages ─────────────────────────────── tidyverse
1.3.1 ──

## ✓ tibble  3.1.6          ✓ purrr    0.3.4
## ✓ tidyr   1.2.0.9000     ✓ dplyr    1.0.8
## ✓ readr   2.1.2          ✓ forcats 0.5.1

## Warning: package 'readr' was built under R version 4.1.2

## Warning: package 'dplyr' was built under R version 4.1.2

## ── Conflicts ───────────────────────────────────────
tidyverse_conflicts() ──
## x dplyr::between()   masks data.table::between()
## x dplyr::combine()   masks gridExtra::combine()
## x tidyr::expand()    masks reshape::expand(), Matrix::expand()
## x tidyr::extract()   masks rstan::extract()
## x dplyr::filter()    masks stats::filter()
## x dplyr::first()     masks data.table::first()
## x dplyr::lag()       masks stats::lag()
## x dplyr::last()      masks data.table::last()
## x tidyr::pack()      masks Matrix::pack()
## x dplyr::recode()    masks car::recode()
## x dplyr::rename()    masks reshape::rename()
## x dplyr::select()    masks MASS::select()
## x purrr::some()      masks car::some()
## x purrr::transpose() masks data.table::transpose()
## x tidyr::unpack()    masks Matrix::unpack()
```

```r
library(ggvis)

##
## Attaching package: 'ggvis'

## The following object is masked from 'package:Matrix':
##
##      band

## The following object is masked from 'package:ggplot2':
##
##      resolution

library(data.table)

hiv.data.raw <- fread("/Users/Home/Documents/Michael_Ghattas/School/
CU_Boulder/2022/Spring 2022/STAT - 4400/Data/allvar.csv")

invisible(hiv.data.raw[,ok := !is.na(CD4PCT) ])
hiv.data<-hiv.data.raw[ok==TRUE]
invisible(hiv.data[,y :=sqrt (CD4PCT)])
 # kid's age (yrs) at the beginning of the study
invisible(hiv.data[,age.baseline := baseage ]  )
# kids age (yrs) at the time of measurement
invisible(hiv.data[,age.measurement := visage ] )
invisible(hiv.data[,time := visage - baseage ] )
setnames(hiv.data,"treatmnt","treatment")
hiv.data<-
hiv.data[complete.cases(hiv.data[,list(y,time,age.baseline,treatment)])]
```
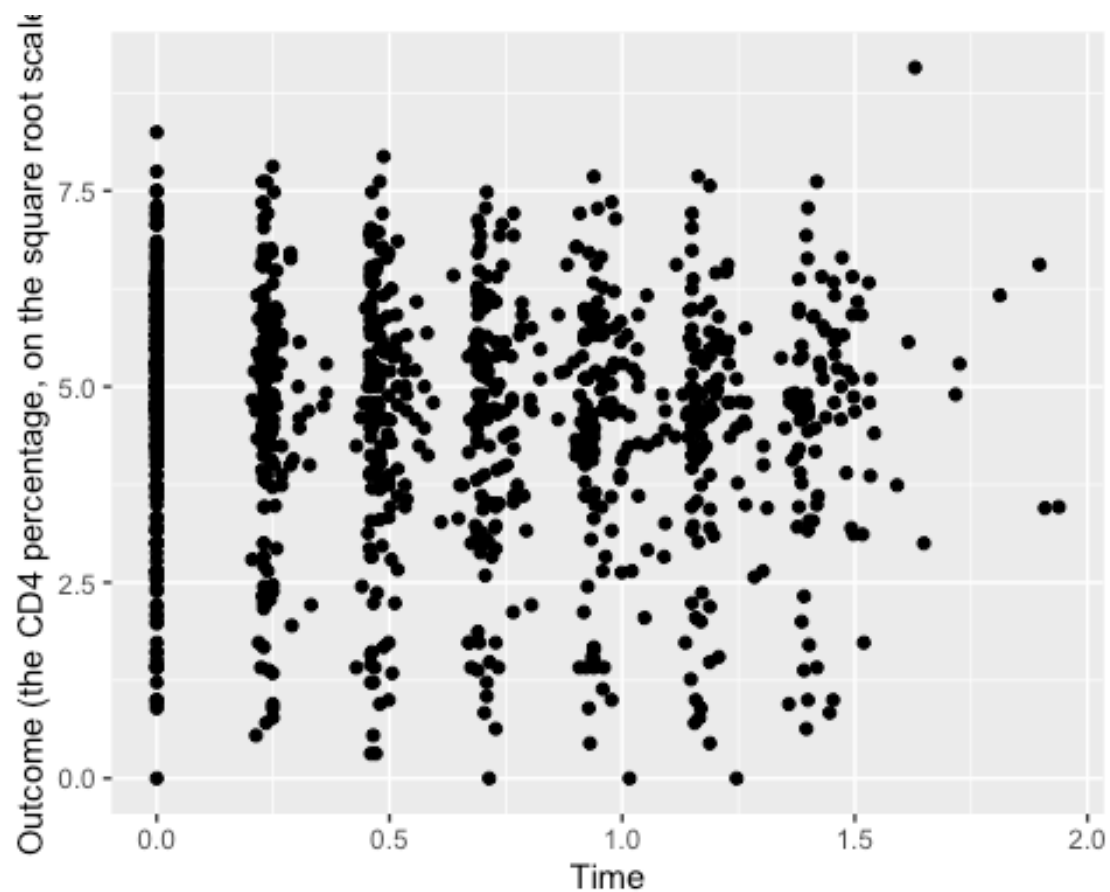
(a)
```r
ggplot(hiv.data) + geom_point(aes(x = time, y = y)) + xlab("Time") +
ylab("Outcome (the CD4 percentage, on the square root scale)")
```

(b)

```
r_np <- lm(y ~ time + factor(newpid) - 1, data = hiv.data)
summary(r_np)

## 
## Call:
## lm(formula = y ~ time + factor(newpid) - 1, data = hiv.data)
## 
## Residuals:
##     Min      1Q  Median      3Q     Max
## -3.6595 -0.3293  0.0000  0.3347  4.0036
## 
## Coefficients:
##                   Estimate Std. Error t value Pr(>|t|)
```

```
## time              -0.38629    0.05455   -7.081 3.07e-12 ***
## factor(newpid)1     4.56368    0.34896   13.078  < 2e-16 ***
## factor(newpid)2     0.81507    0.54578    1.493 0.135716
## factor(newpid)3     5.95004    0.29534   20.146  < 2e-16 ***
## factor(newpid)4     5.61374    0.31677   17.722  < 2e-16 ***
## factor(newpid)5     4.00000    0.77180    5.183 2.76e-07 ***
## factor(newpid)6     5.36947    0.31738   16.918  < 2e-16 ***
## factor(newpid)7     5.61896    0.29436   19.088  < 2e-16 ***
## factor(newpid)8     5.14703    0.38791   13.268  < 2e-16 ***
## factor(newpid)9     6.21645    0.34732   17.898  < 2e-16 ***
## factor(newpid)10    5.71848    0.31739   18.017  < 2e-16 ***
## factor(newpid)11    2.44507    0.29417    8.312 3.89e-16 ***
## factor(newpid)12    4.36330    0.31699   13.765  < 2e-16 ***
## factor(newpid)13    5.33903    0.44635   11.962  < 2e-16 ***
## factor(newpid)14    3.00000    0.77180    3.887 0.000110 ***
## factor(newpid)15    5.24008    0.31759   16.499  < 2e-16 ***
## factor(newpid)16    2.39908    0.38705    6.198 9.03e-10 ***
## factor(newpid)17    6.10066    0.31839   19.161  < 2e-16 ***
## factor(newpid)18    6.02588    0.34608   17.412  < 2e-16 ***
## factor(newpid)19    4.10797    0.38783   10.592  < 2e-16 ***
## factor(newpid)20    5.00962    0.44580   11.237  < 2e-16 ***
## factor(newpid)21    5.00000    0.77180    6.478 1.60e-10 ***
## factor(newpid)22    6.16441    0.77180    7.987 4.66e-15 ***
## factor(newpid)23    1.59920    0.34723    4.606 4.76e-06 ***
## factor(newpid)24    4.81823    0.44728   10.772  < 2e-16 ***
## factor(newpid)25    4.76132    0.31717   15.012  < 2e-16 ***
## factor(newpid)26    4.63303    0.31656   14.636  < 2e-16 ***
## factor(newpid)27    4.38498    0.31672   13.845  < 2e-16 ***
## factor(newpid)28    5.65959    0.54590   10.367  < 2e-16 ***
## factor(newpid)29    4.52845    0.38717   11.696  < 2e-16 ***
## factor(newpid)30    1.00000    0.77180    1.296 0.195454
## factor(newpid)31    4.45824    0.54608    8.164 1.22e-15 ***
## factor(newpid)32    4.64821    0.34892   13.322  < 2e-16 ***
## factor(newpid)33    5.03494    0.29431   17.108  < 2e-16 ***
## factor(newpid)34    6.49167    0.54579   11.894  < 2e-16 ***
```

```
## factor(newpid)35    4.93661    0.38757   12.737   < 2e-16 ***
## factor(newpid)37    3.98526    0.54579    7.302 6.72e-13 ***
## factor(newpid)38    6.15939    0.44617   13.805   < 2e-16 ***
## factor(newpid)39    4.84721    0.34613   14.004   < 2e-16 ***
## factor(newpid)40    3.60555    0.77180    4.672 3.49e-06 ***
## factor(newpid)41    5.00000    0.77180    6.478 1.60e-10 ***
## factor(newpid)42    3.26132    0.29446   11.076   < 2e-16 ***
## factor(newpid)43    4.93493    0.29446   16.759   < 2e-16 ***
## factor(newpid)44    2.49104    0.44579    5.588 3.13e-08 ***
## factor(newpid)45    5.16288    0.31782   16.245   < 2e-16 ***
## factor(newpid)46    3.50085    0.31798   11.010   < 2e-16 ***
## factor(newpid)47    4.85968    0.31796   15.284   < 2e-16 ***
## factor(newpid)48    4.45407    0.38739   11.498   < 2e-16 ***
## factor(newpid)49    5.39827    0.29437   18.339   < 2e-16 ***
## factor(newpid)50    4.32745    0.29426   14.706   < 2e-16 ***
## factor(newpid)51    3.94551    0.34618   11.397   < 2e-16 ***
## factor(newpid)52    1.79719    0.29417    6.109 1.54e-09 ***
## factor(newpid)53    4.81554    0.29411   16.373   < 2e-16 ***
## factor(newpid)54    4.46903    0.29419   15.191   < 2e-16 ***
## factor(newpid)55    2.37752    0.29410    8.084 2.24e-15 ***
## factor(newpid)56    2.79201    0.54578    5.116 3.90e-07 ***
## factor(newpid)57    2.14991    0.31692    6.784 2.24e-11 ***
## factor(newpid)58    2.01600    0.31692    6.361 3.32e-10 ***
## factor(newpid)59    5.12724    0.29440   17.416   < 2e-16 ***
## factor(newpid)60    2.04462    0.54578    3.746 0.000192 ***
## factor(newpid)61    5.23903    0.31671   16.542   < 2e-16 ***
## factor(newpid)62    5.65826    0.29448   19.215   < 2e-16 ***
## factor(newpid)63    1.92512    0.29426    6.542 1.07e-10 ***
## factor(newpid)64    5.42219    0.29418   18.431   < 2e-16 ***
## factor(newpid)65    1.42126    0.34611    4.106 4.42e-05 ***
## factor(newpid)66    6.46556    0.44592   14.499   < 2e-16 ***
## factor(newpid)67    2.50677    0.54579    4.593 5.06e-06 ***
## factor(newpid)68    5.87367    0.77180    7.610 7.50e-14 ***
## factor(newpid)69    5.37708    0.39062   13.766   < 2e-16 ***
## factor(newpid)70    5.04789    0.38676   13.052   < 2e-16 ***
```

```
## factor(newpid)71    2.64575    0.77180    3.428 0.000638 ***
## factor(newpid)72    3.79504    0.38672    9.813  < 2e-16 ***
## factor(newpid)73    6.85565    0.77180    8.883  < 2e-16 ***
## factor(newpid)74    5.15287    0.29412   17.519  < 2e-16 ***
## factor(newpid)75    5.83766    0.29416   19.845  < 2e-16 ***
## factor(newpid)76    4.92242    0.34748   14.166  < 2e-16 ***
## factor(newpid)77    4.01660    0.38672   10.386  < 2e-16 ***
## factor(newpid)78    5.99278    0.29415   20.373  < 2e-16 ***
## factor(newpid)79    4.90326    0.44575   11.000  < 2e-16 ***
## factor(newpid)81    0.97153    0.54589    1.780 0.075492 .
## factor(newpid)82    3.25905    0.34636    9.409  < 2e-16 ***
## factor(newpid)83    0.94868    0.77180    1.229 0.219356
## factor(newpid)84    2.25870    0.34701    6.509 1.32e-10 ***
## factor(newpid)85    1.58969    0.34705    4.581 5.36e-06 ***
## factor(newpid)86    6.44121    0.34644   18.593  < 2e-16 ***
## factor(newpid)87    6.09731    0.29421   20.724  < 2e-16 ***
## factor(newpid)88    4.83296    0.54579    8.855  < 2e-16 ***
## factor(newpid)89    5.02052    0.34621   14.501  < 2e-16 ***
## factor(newpid)90    5.84808    0.77180    7.577 9.53e-14 ***
## factor(newpid)91    2.54897    0.38706    6.586 8.09e-11 ***
## factor(newpid)92    2.68623    0.54579    4.922 1.04e-06 ***
## factor(newpid)93    1.52443    0.38637    3.945 8.64e-05 ***
## factor(newpid)94    4.94328    0.44775   11.040  < 2e-16 ***
## factor(newpid)95    2.78151    0.54578    5.096 4.30e-07 ***
## factor(newpid)96    4.89898    0.77180    6.347 3.62e-10 ***
## factor(newpid)97    7.70878    0.44671   17.257  < 2e-16 ***
## factor(newpid)98    4.79583    0.77180    6.214 8.22e-10 ***
## factor(newpid)99    6.58753    0.38674   17.033  < 2e-16 ***
## factor(newpid)100   6.54584    0.34609   18.914  < 2e-16 ***
## factor(newpid)101   5.65685    0.77180    7.329 5.54e-13 ***
## factor(newpid)103   6.11117    0.29512   20.708  < 2e-16 ***
## factor(newpid)104   3.55877    0.31688   11.230  < 2e-16 ***
## factor(newpid)105   4.66845    0.29461   15.846  < 2e-16 ***
## factor(newpid)106   3.79964    0.38686    9.822  < 2e-16 ***
## factor(newpid)107   5.79041    0.38686   14.968  < 2e-16 ***
```

```
## factor(newpid)108   1.17737      0.38739    3.039 0.002447 **
## factor(newpid)109   4.04447      0.54579    7.410 3.13e-13 ***
## factor(newpid)110   5.32304      0.29448   18.076  < 2e-16 ***
## factor(newpid)111   2.13749      0.54580    3.916 9.74e-05 ***
## factor(newpid)112   4.04681      0.29465   13.734  < 2e-16 ***
## factor(newpid)113   6.34488      0.31739   19.991  < 2e-16 ***
## factor(newpid)114   4.95064      0.29459   16.805  < 2e-16 ***
## factor(newpid)115   5.62952      0.29454   19.113  < 2e-16 ***
## factor(newpid)116   4.25683      0.54612    7.795 1.95e-14 ***
## factor(newpid)117   4.41240      0.34852   12.660  < 2e-16 ***
## factor(newpid)118   5.31355      0.34636   15.341  < 2e-16 ***
## factor(newpid)119   1.92914      0.54582    3.534 0.000432 ***
## factor(newpid)120   6.83535      0.31712   21.555  < 2e-16 ***
## factor(newpid)121   6.12904      0.44703   13.711  < 2e-16 ***
## factor(newpid)122   5.43379      0.44651   12.169  < 2e-16 ***
## factor(newpid)123   2.96695      0.54578    5.436 7.18e-08 ***
## factor(newpid)124   3.16228      0.77180    4.097 4.60e-05 ***
## factor(newpid)126   4.48243      0.38753   11.567  < 2e-16 ***
## factor(newpid)127   5.25547      0.34628   15.177  < 2e-16 ***
## factor(newpid)128   4.75350      0.54668    8.695  < 2e-16 ***
## factor(newpid)129   0.97864      0.34636    2.825 0.004836 **
## factor(newpid)130   3.70472      0.38672    9.580  < 2e-16 ***
## factor(newpid)131   4.25708      0.38711   10.997  < 2e-16 ***
## factor(newpid)132   4.73853      0.38778   12.220  < 2e-16 ***
## factor(newpid)133   3.77490      0.31673   11.918  < 2e-16 ***
## factor(newpid)134   6.72519      0.29422   22.858  < 2e-16 ***
## factor(newpid)135   5.60776      0.29440   19.048  < 2e-16 ***
## factor(newpid)136   6.64977      0.29433   22.593  < 2e-16 ***
## factor(newpid)137   5.67273      0.29452   19.261  < 2e-16 ***
## factor(newpid)138   7.48331      0.77180    9.696  < 2e-16 ***
## factor(newpid)139   4.85189      0.29479   16.459  < 2e-16 ***
## factor(newpid)140   5.47249      0.29452   18.581  < 2e-16 ***
## factor(newpid)141   7.16773      0.29440   24.347  < 2e-16 ***
## factor(newpid)142   2.82420      0.31707    8.907  < 2e-16 ***
## factor(newpid)143   2.88106      0.29437    9.787  < 2e-16 ***
```

```
## factor(newpid)144  6.04833    0.29423  20.556   < 2e-16 ***
## factor(newpid)145  5.55106    0.31688  17.518   < 2e-16 ***
## factor(newpid)146  5.46320    0.31677  17.246   < 2e-16 ***
## factor(newpid)147  6.18166    0.34655  17.838   < 2e-16 ***
## factor(newpid)148  5.34407    0.44578  11.988   < 2e-16 ***
## factor(newpid)149  5.67007    0.34615  16.381   < 2e-16 ***
## factor(newpid)150  4.39422    0.38642  11.372   < 2e-16 ***
## factor(newpid)151  5.68779    0.38640  14.720   < 2e-16 ***
## factor(newpid)152  4.61519    0.77180   5.980 3.33e-09 ***
## factor(newpid)153  7.21403    0.44577  16.183   < 2e-16 ***
## factor(newpid)154  5.71394    0.44580  12.817   < 2e-16 ***
## factor(newpid)155  6.27073    0.44579  14.067   < 2e-16 ***
## factor(newpid)156  6.34439    0.54578  11.624   < 2e-16 ***
## factor(newpid)157  6.41098    0.44609  14.371   < 2e-16 ***
## factor(newpid)158  6.08632    0.34692  17.544   < 2e-16 ***
## factor(newpid)159  5.29916    0.54594   9.706   < 2e-16 ***
## factor(newpid)160  5.04712    0.54579   9.247   < 2e-16 ***
## factor(newpid)161  5.14072    0.38657  13.298   < 2e-16 ***
## factor(newpid)162  4.69277    0.44588  10.525   < 2e-16 ***
## factor(newpid)163  7.42011    0.38647  19.200   < 2e-16 ***
## factor(newpid)164  7.07418    0.34873  20.286   < 2e-16 ***
## factor(newpid)165  4.40042    0.34744  12.665   < 2e-16 ***
## factor(newpid)166  5.63845    0.54812  10.287   < 2e-16 ***
## factor(newpid)167  4.93276    0.38713  12.742   < 2e-16 ***
## factor(newpid)168  5.79989    0.29425  19.711   < 2e-16 ***
## factor(newpid)169  2.83271    0.54605   5.188 2.69e-07 ***
## factor(newpid)170  4.52041    0.34670  13.039   < 2e-16 ***
## factor(newpid)171  6.70820    0.77180   8.692   < 2e-16 ***
## factor(newpid)172  5.26891    0.34643  15.209   < 2e-16 ***
## factor(newpid)173  1.59625    0.54592   2.924 0.003551 **
## factor(newpid)174  3.80765    0.34709  10.970   < 2e-16 ***
## factor(newpid)175  5.86770    0.34640  16.939   < 2e-16 ***
## factor(newpid)176  5.71388    0.44591  12.814   < 2e-16 ***
## factor(newpid)177  4.65448    0.38715  12.022   < 2e-16 ***
## factor(newpid)178  6.64100    0.34712  19.132   < 2e-16 ***
```

```
## factor(newpid)179   5.42868      0.44577   12.178   < 2e-16 ***
## factor(newpid)180   5.38254      0.29417   18.297   < 2e-16 ***
## factor(newpid)181   7.58231      0.31737   23.891   < 2e-16 ***
## factor(newpid)182   6.87445      0.44674   15.388   < 2e-16 ***
## factor(newpid)183   4.73226      0.54591    8.669   < 2e-16 ***
## factor(newpid)184   4.69042      0.77180    6.077 1.87e-09 ***
## factor(newpid)185   5.32106      0.31790   16.738   < 2e-16 ***
## factor(newpid)186   2.26637      0.34754    6.521 1.22e-10 ***
## factor(newpid)187   5.96108      0.31804   18.743   < 2e-16 ***
## factor(newpid)188   5.64729      0.34676   16.286   < 2e-16 ***
## factor(newpid)189   0.89556      0.54589    1.641 0.101277
## factor(newpid)190   3.93221      0.54593    7.203 1.34e-12 ***
## factor(newpid)191   4.73072      0.44582   10.611   < 2e-16 ***
## factor(newpid)192   4.63493      0.29415   15.757   < 2e-16 ***
## factor(newpid)193   3.51569      0.29414   11.952   < 2e-16 ***
## factor(newpid)194   1.67399      0.31665    5.286 1.60e-07 ***
## factor(newpid)195   6.57259      0.44708   14.701   < 2e-16 ***
## factor(newpid)196   4.28686      0.38778   11.055   < 2e-16 ***
## factor(newpid)197   4.52015      0.38659   11.692   < 2e-16 ***
## factor(newpid)198   6.11686      0.34677   17.640   < 2e-16 ***
## factor(newpid)199   3.58154      0.38734    9.247   < 2e-16 ***
## factor(newpid)200   6.33062      0.31871   19.863   < 2e-16 ***
## factor(newpid)201   4.88817      0.38837   12.586   < 2e-16 ***
## factor(newpid)202   6.08433      0.54598   11.144   < 2e-16 ***
## factor(newpid)203   6.31594      0.38792   16.282   < 2e-16 ***
## factor(newpid)204   5.44066      0.38672   14.069   < 2e-16 ***
## factor(newpid)205   3.66210      0.34771   10.532   < 2e-16 ***
## factor(newpid)206   5.98915      0.29415   20.361   < 2e-16 ***
## factor(newpid)207   6.08204      0.31761   19.149   < 2e-16 ***
## factor(newpid)208   4.17020      0.34723   12.010   < 2e-16 ***
## factor(newpid)209   6.43027      0.31684   20.295   < 2e-16 ***
## factor(newpid)210   5.21148      0.29412   17.719   < 2e-16 ***
## factor(newpid)211   5.34459      0.29419   18.167   < 2e-16 ***
## factor(newpid)212   5.21535      0.31670   16.468   < 2e-16 ***
## factor(newpid)213   4.67607      0.44578   10.490   < 2e-16 ***
```

```
## factor(newpid)214   6.54179      0.29428   22.230   < 2e-16 ***
## factor(newpid)215   5.04463      0.31666   15.931   < 2e-16 ***
## factor(newpid)216   3.74901      0.34628   10.827   < 2e-16 ***
## factor(newpid)217   3.09943      0.54578    5.679 1.88e-08 ***
## factor(newpid)218   4.76821      0.29420   16.207   < 2e-16 ***
## factor(newpid)219   5.47723      0.77180    7.097 2.76e-12 ***
## factor(newpid)220   6.34478      0.29424   21.564   < 2e-16 ***
## factor(newpid)221   5.78464      0.31662   18.270   < 2e-16 ***
## factor(newpid)222   5.27235      0.31785   16.587   < 2e-16 ***
## factor(newpid)223   5.34864      0.31661   16.894   < 2e-16 ***
## factor(newpid)224   3.80821      0.54578    6.978 6.19e-12 ***
## factor(newpid)225   6.47400      0.29413   22.010   < 2e-16 ***
## factor(newpid)226   6.85178      0.34695   19.748   < 2e-16 ***
## factor(newpid)227   6.21616      0.31664   19.631   < 2e-16 ***
## factor(newpid)228   4.67312      0.31665   14.758   < 2e-16 ***
## factor(newpid)229   5.25787      0.34628   15.184   < 2e-16 ***
## factor(newpid)230   5.96217      0.34628   17.218   < 2e-16 ***
## factor(newpid)231   5.95432      0.38653   15.405   < 2e-16 ***
## factor(newpid)232   6.17519      0.44620   13.840   < 2e-16 ***
## factor(newpid)233   4.36377      0.38636   11.295   < 2e-16 ***
## factor(newpid)234   6.22240      0.54578   11.401   < 2e-16 ***
## factor(newpid)235   3.21066      0.44635    7.193 1.43e-12 ***
## factor(newpid)236   2.83698      0.34674    8.182 1.06e-15 ***
## factor(newpid)237   5.43365      0.31707   17.137   < 2e-16 ***
## factor(newpid)238   5.05647      0.38660   13.079   < 2e-16 ***
## factor(newpid)239   5.54035      0.44593   12.424   < 2e-16 ***
## factor(newpid)240   3.51138      0.34603   10.148   < 2e-16 ***
## factor(newpid)241   6.11555      0.77180    7.924 7.49e-15 ***
## factor(newpid)242   5.16910      0.44592   11.592   < 2e-16 ***
## factor(newpid)243   5.89800      0.44636   13.213   < 2e-16 ***
## factor(newpid)244   5.94175      0.54578   10.887   < 2e-16 ***
## factor(newpid)245   4.92484      0.38641   12.745   < 2e-16 ***
## factor(newpid)246   5.05558      0.54579    9.263   < 2e-16 ***
## factor(newpid)247   4.78539      0.77180    6.200 8.92e-10 ***
## factor(newpid)248   5.64132      0.54579   10.336   < 2e-16 ***
```

```
## factor(newpid)249   5.59464      0.77180    7.249 9.71e-13 ***
## factor(newpid)250   5.83524      0.54579   10.691  < 2e-16 ***
## factor(newpid)251   3.74166      0.77180    4.848 1.49e-06 ***
## factor(newpid)252   4.51291      0.54582    8.268 5.45e-16 ***
## factor(newpid)253   3.60555      0.77180    4.672 3.49e-06 ***
## factor(newpid)254   3.75520      0.54598    6.878 1.20e-11 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.7718 on 821 degrees of freedom
## Multiple R-squared:  0.9809, Adjusted R-squared:  0.9751
## F-statistic: 168.1 on 251 and 821 DF,  p-value: < 2.2e-16
```

```r
ggplot(aes(x = time, y = y), data = hiv.data) + geom_point() +
geom_abline(intercept = coef(r_np)[1], slope = coef(r_np)
[2:length(coef(r_np))]) +
  xlab("Time") + ylab("Outcome (the CD4 percentage, on the square root
scale)")
```
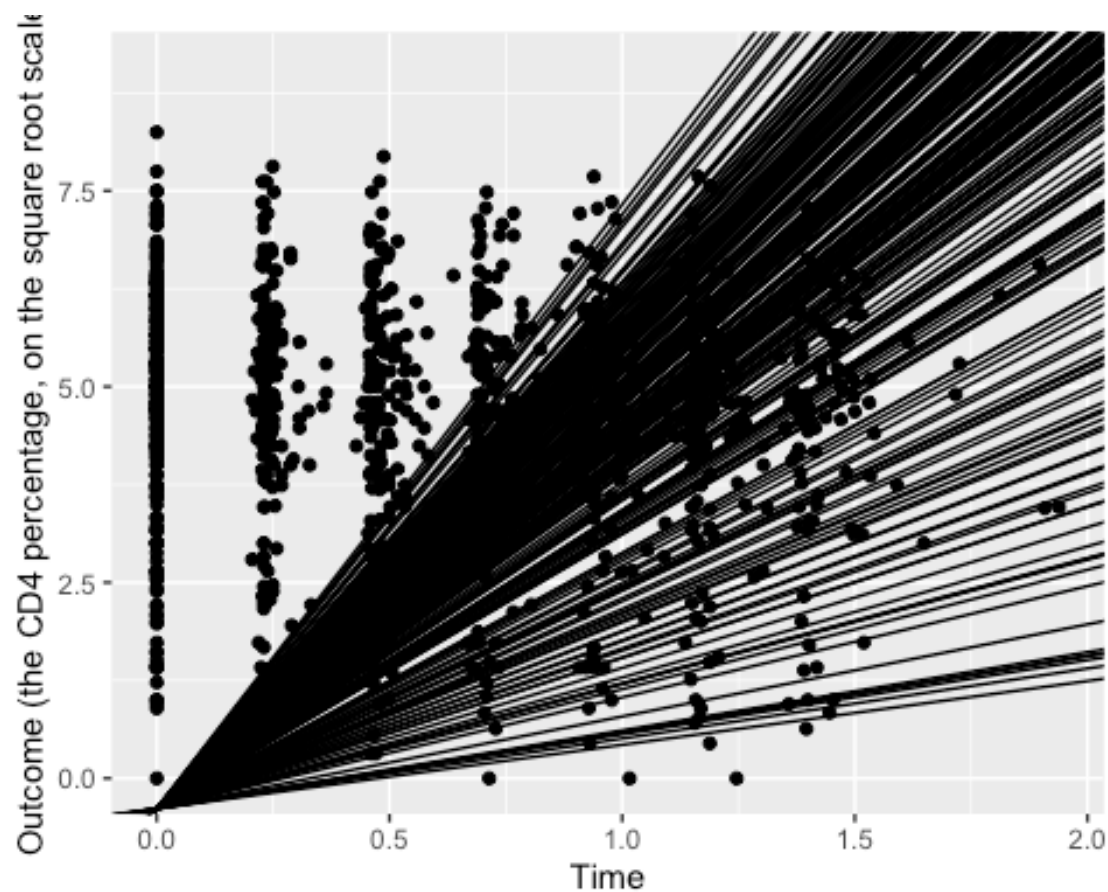
(c)

```
r1 <- lm(y ~ time + factor(newpid) - 1, data = hiv.data)
summary(r1)

##
## Call:
## lm(formula = y ~ time + factor(newpid) - 1, data = hiv.data)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -3.6595 -0.3293  0.0000  0.3347  4.0036
##
## Coefficients:
##                    Estimate Std. Error t value Pr(>|t|)
```

```
## time              -0.38629    0.05455  -7.081 3.07e-12 ***
## factor(newpid)1     4.56368    0.34896  13.078  < 2e-16 ***
## factor(newpid)2     0.81507    0.54578   1.493 0.135716
## factor(newpid)3     5.95004    0.29534  20.146  < 2e-16 ***
## factor(newpid)4     5.61374    0.31677  17.722  < 2e-16 ***
## factor(newpid)5     4.00000    0.77180   5.183 2.76e-07 ***
## factor(newpid)6     5.36947    0.31738  16.918  < 2e-16 ***
## factor(newpid)7     5.61896    0.29436  19.088  < 2e-16 ***
## factor(newpid)8     5.14703    0.38791  13.268  < 2e-16 ***
## factor(newpid)9     6.21645    0.34732  17.898  < 2e-16 ***
## factor(newpid)10    5.71848    0.31739  18.017  < 2e-16 ***
## factor(newpid)11    2.44507    0.29417   8.312 3.89e-16 ***
## factor(newpid)12    4.36330    0.31699  13.765  < 2e-16 ***
## factor(newpid)13    5.33903    0.44635  11.962  < 2e-16 ***
## factor(newpid)14    3.00000    0.77180   3.887 0.000110 ***
## factor(newpid)15    5.24008    0.31759  16.499  < 2e-16 ***
## factor(newpid)16    2.39908    0.38705   6.198 9.03e-10 ***
## factor(newpid)17    6.10066    0.31839  19.161  < 2e-16 ***
## factor(newpid)18    6.02588    0.34608  17.412  < 2e-16 ***
## factor(newpid)19    4.10797    0.38783  10.592  < 2e-16 ***
## factor(newpid)20    5.00962    0.44580  11.237  < 2e-16 ***
## factor(newpid)21    5.00000    0.77180   6.478 1.60e-10 ***
## factor(newpid)22    6.16441    0.77180   7.987 4.66e-15 ***
## factor(newpid)23    1.59920    0.34723   4.606 4.76e-06 ***
## factor(newpid)24    4.81823    0.44728  10.772  < 2e-16 ***
## factor(newpid)25    4.76132    0.31717  15.012  < 2e-16 ***
## factor(newpid)26    4.63303    0.31656  14.636  < 2e-16 ***
## factor(newpid)27    4.38498    0.31672  13.845  < 2e-16 ***
## factor(newpid)28    5.65959    0.54590  10.367  < 2e-16 ***
## factor(newpid)29    4.52845    0.38717  11.696  < 2e-16 ***
## factor(newpid)30    1.00000    0.77180   1.296 0.195454
## factor(newpid)31    4.45824    0.54608   8.164 1.22e-15 ***
## factor(newpid)32    4.64821    0.34892  13.322  < 2e-16 ***
## factor(newpid)33    5.03494    0.29431  17.108  < 2e-16 ***
## factor(newpid)34    6.49167    0.54579  11.894  < 2e-16 ***
```

```
## factor(newpid)35   4.93661      0.38757   12.737   < 2e-16 ***
## factor(newpid)37   3.98526      0.54579    7.302 6.72e-13 ***
## factor(newpid)38   6.15939      0.44617   13.805   < 2e-16 ***
## factor(newpid)39   4.84721      0.34613   14.004   < 2e-16 ***
## factor(newpid)40   3.60555      0.77180    4.672 3.49e-06 ***
## factor(newpid)41   5.00000      0.77180    6.478 1.60e-10 ***
## factor(newpid)42   3.26132      0.29446   11.076   < 2e-16 ***
## factor(newpid)43   4.93493      0.29446   16.759   < 2e-16 ***
## factor(newpid)44   2.49104      0.44579    5.588 3.13e-08 ***
## factor(newpid)45   5.16288      0.31782   16.245   < 2e-16 ***
## factor(newpid)46   3.50085      0.31798   11.010   < 2e-16 ***
## factor(newpid)47   4.85968      0.31796   15.284   < 2e-16 ***
## factor(newpid)48   4.45407      0.38739   11.498   < 2e-16 ***
## factor(newpid)49   5.39827      0.29437   18.339   < 2e-16 ***
## factor(newpid)50   4.32745      0.29426   14.706   < 2e-16 ***
## factor(newpid)51   3.94551      0.34618   11.397   < 2e-16 ***
## factor(newpid)52   1.79719      0.29417    6.109 1.54e-09 ***
## factor(newpid)53   4.81554      0.29411   16.373   < 2e-16 ***
## factor(newpid)54   4.46903      0.29419   15.191   < 2e-16 ***
## factor(newpid)55   2.37752      0.29410    8.084 2.24e-15 ***
## factor(newpid)56   2.79201      0.54578    5.116 3.90e-07 ***
## factor(newpid)57   2.14991      0.31692    6.784 2.24e-11 ***
## factor(newpid)58   2.01600      0.31692    6.361 3.32e-10 ***
## factor(newpid)59   5.12724      0.29440   17.416   < 2e-16 ***
## factor(newpid)60   2.04462      0.54578    3.746 0.000192 ***
## factor(newpid)61   5.23903      0.31671   16.542   < 2e-16 ***
## factor(newpid)62   5.65826      0.29448   19.215   < 2e-16 ***
## factor(newpid)63   1.92512      0.29426    6.542 1.07e-10 ***
## factor(newpid)64   5.42219      0.29418   18.431   < 2e-16 ***
## factor(newpid)65   1.42126      0.34611    4.106 4.42e-05 ***
## factor(newpid)66   6.46556      0.44592   14.499   < 2e-16 ***
## factor(newpid)67   2.50677      0.54579    4.593 5.06e-06 ***
## factor(newpid)68   5.87367      0.77180    7.610 7.50e-14 ***
## factor(newpid)69   5.37708      0.39062   13.766   < 2e-16 ***
## factor(newpid)70   5.04789      0.38676   13.052   < 2e-16 ***
```

```
## factor(newpid)71    2.64575     0.77180     3.428 0.000638 ***
## factor(newpid)72    3.79504     0.38672     9.813  < 2e-16 ***
## factor(newpid)73    6.85565     0.77180     8.883  < 2e-16 ***
## factor(newpid)74    5.15287     0.29412    17.519  < 2e-16 ***
## factor(newpid)75    5.83766     0.29416    19.845  < 2e-16 ***
## factor(newpid)76    4.92242     0.34748    14.166  < 2e-16 ***
## factor(newpid)77    4.01660     0.38672    10.386  < 2e-16 ***
## factor(newpid)78    5.99278     0.29415    20.373  < 2e-16 ***
## factor(newpid)79    4.90326     0.44575    11.000  < 2e-16 ***
## factor(newpid)81    0.97153     0.54589     1.780 0.075492 .
## factor(newpid)82    3.25905     0.34636     9.409  < 2e-16 ***
## factor(newpid)83    0.94868     0.77180     1.229 0.219356
## factor(newpid)84    2.25870     0.34701     6.509 1.32e-10 ***
## factor(newpid)85    1.58969     0.34705     4.581 5.36e-06 ***
## factor(newpid)86    6.44121     0.34644    18.593  < 2e-16 ***
## factor(newpid)87    6.09731     0.29421    20.724  < 2e-16 ***
## factor(newpid)88    4.83296     0.54579     8.855  < 2e-16 ***
## factor(newpid)89    5.02052     0.34621    14.501  < 2e-16 ***
## factor(newpid)90    5.84808     0.77180     7.577 9.53e-14 ***
## factor(newpid)91    2.54897     0.38706     6.586 8.09e-11 ***
## factor(newpid)92    2.68623     0.54579     4.922 1.04e-06 ***
## factor(newpid)93    1.52443     0.38637     3.945 8.64e-05 ***
## factor(newpid)94    4.94328     0.44775    11.040  < 2e-16 ***
## factor(newpid)95    2.78151     0.54578     5.096 4.30e-07 ***
## factor(newpid)96    4.89898     0.77180     6.347 3.62e-10 ***
## factor(newpid)97    7.70878     0.44671    17.257  < 2e-16 ***
## factor(newpid)98    4.79583     0.77180     6.214 8.22e-10 ***
## factor(newpid)99    6.58753     0.38674    17.033  < 2e-16 ***
## factor(newpid)100   6.54584     0.34609    18.914  < 2e-16 ***
## factor(newpid)101   5.65685     0.77180     7.329 5.54e-13 ***
## factor(newpid)103   6.11117     0.29512    20.708  < 2e-16 ***
## factor(newpid)104   3.55877     0.31688    11.230  < 2e-16 ***
## factor(newpid)105   4.66845     0.29461    15.846  < 2e-16 ***
## factor(newpid)106   3.79964     0.38686     9.822  < 2e-16 ***
## factor(newpid)107   5.79041     0.38686    14.968  < 2e-16 ***
```

```
## factor(newpid)108   1.17737      0.38739    3.039 0.002447  **
## factor(newpid)109   4.04447      0.54579    7.410 3.13e-13  ***
## factor(newpid)110   5.32304      0.29448   18.076  < 2e-16  ***
## factor(newpid)111   2.13749      0.54580    3.916 9.74e-05  ***
## factor(newpid)112   4.04681      0.29465   13.734  < 2e-16  ***
## factor(newpid)113   6.34488      0.31739   19.991  < 2e-16  ***
## factor(newpid)114   4.95064      0.29459   16.805  < 2e-16  ***
## factor(newpid)115   5.62952      0.29454   19.113  < 2e-16  ***
## factor(newpid)116   4.25683      0.54612    7.795 1.95e-14  ***
## factor(newpid)117   4.41240      0.34852   12.660  < 2e-16  ***
## factor(newpid)118   5.31355      0.34636   15.341  < 2e-16  ***
## factor(newpid)119   1.92914      0.54582    3.534 0.000432  ***
## factor(newpid)120   6.83535      0.31712   21.555  < 2e-16  ***
## factor(newpid)121   6.12904      0.44703   13.711  < 2e-16  ***
## factor(newpid)122   5.43379      0.44651   12.169  < 2e-16  ***
## factor(newpid)123   2.96695      0.54578    5.436 7.18e-08  ***
## factor(newpid)124   3.16228      0.77180    4.097 4.60e-05  ***
## factor(newpid)126   4.48243      0.38753   11.567  < 2e-16  ***
## factor(newpid)127   5.25547      0.34628   15.177  < 2e-16  ***
## factor(newpid)128   4.75350      0.54668    8.695  < 2e-16  ***
## factor(newpid)129   0.97864      0.34636    2.825 0.004836  **
## factor(newpid)130   3.70472      0.38672    9.580  < 2e-16  ***
## factor(newpid)131   4.25708      0.38711   10.997  < 2e-16  ***
## factor(newpid)132   4.73853      0.38778   12.220  < 2e-16  ***
## factor(newpid)133   3.77490      0.31673   11.918  < 2e-16  ***
## factor(newpid)134   6.72519      0.29422   22.858  < 2e-16  ***
## factor(newpid)135   5.60776      0.29440   19.048  < 2e-16  ***
## factor(newpid)136   6.64977      0.29433   22.593  < 2e-16  ***
## factor(newpid)137   5.67273      0.29452   19.261  < 2e-16  ***
## factor(newpid)138   7.48331      0.77180    9.696  < 2e-16  ***
## factor(newpid)139   4.85189      0.29479   16.459  < 2e-16  ***
## factor(newpid)140   5.47249      0.29452   18.581  < 2e-16  ***
## factor(newpid)141   7.16773      0.29440   24.347  < 2e-16  ***
## factor(newpid)142   2.82420      0.31707    8.907  < 2e-16  ***
## factor(newpid)143   2.88106      0.29437    9.787  < 2e-16  ***
```

```
## factor(newpid)144   6.04833      0.29423   20.556   < 2e-16 ***
## factor(newpid)145   5.55106      0.31688   17.518   < 2e-16 ***
## factor(newpid)146   5.46320      0.31677   17.246   < 2e-16 ***
## factor(newpid)147   6.18166      0.34655   17.838   < 2e-16 ***
## factor(newpid)148   5.34407      0.44578   11.988   < 2e-16 ***
## factor(newpid)149   5.67007      0.34615   16.381   < 2e-16 ***
## factor(newpid)150   4.39422      0.38642   11.372   < 2e-16 ***
## factor(newpid)151   5.68779      0.38640   14.720   < 2e-16 ***
## factor(newpid)152   4.61519      0.77180    5.980 3.33e-09 ***
## factor(newpid)153   7.21403      0.44577   16.183   < 2e-16 ***
## factor(newpid)154   5.71394      0.44580   12.817   < 2e-16 ***
## factor(newpid)155   6.27073      0.44579   14.067   < 2e-16 ***
## factor(newpid)156   6.34439      0.54578   11.624   < 2e-16 ***
## factor(newpid)157   6.41098      0.44609   14.371   < 2e-16 ***
## factor(newpid)158   6.08632      0.34692   17.544   < 2e-16 ***
## factor(newpid)159   5.29916      0.54594    9.706   < 2e-16 ***
## factor(newpid)160   5.04712      0.54579    9.247   < 2e-16 ***
## factor(newpid)161   5.14072      0.38657   13.298   < 2e-16 ***
## factor(newpid)162   4.69277      0.44588   10.525   < 2e-16 ***
## factor(newpid)163   7.42011      0.38647   19.200   < 2e-16 ***
## factor(newpid)164   7.07418      0.34873   20.286   < 2e-16 ***
## factor(newpid)165   4.40042      0.34744   12.665   < 2e-16 ***
## factor(newpid)166   5.63845      0.54812   10.287   < 2e-16 ***
## factor(newpid)167   4.93276      0.38713   12.742   < 2e-16 ***
## factor(newpid)168   5.79989      0.29425   19.711   < 2e-16 ***
## factor(newpid)169   2.83271      0.54605    5.188 2.69e-07 ***
## factor(newpid)170   4.52041      0.34670   13.039   < 2e-16 ***
## factor(newpid)171   6.70820      0.77180    8.692   < 2e-16 ***
## factor(newpid)172   5.26891      0.34643   15.209   < 2e-16 ***
## factor(newpid)173   1.59625      0.54592    2.924 0.003551 **
## factor(newpid)174   3.80765      0.34709   10.970   < 2e-16 ***
## factor(newpid)175   5.86770      0.34640   16.939   < 2e-16 ***
## factor(newpid)176   5.71388      0.44591   12.814   < 2e-16 ***
## factor(newpid)177   4.65448      0.38715   12.022   < 2e-16 ***
## factor(newpid)178   6.64100      0.34712   19.132   < 2e-16 ***
```

```
## factor(newpid)179   5.42868      0.44577   12.178   < 2e-16 ***
## factor(newpid)180   5.38254      0.29417   18.297   < 2e-16 ***
## factor(newpid)181   7.58231      0.31737   23.891   < 2e-16 ***
## factor(newpid)182   6.87445      0.44674   15.388   < 2e-16 ***
## factor(newpid)183   4.73226      0.54591    8.669   < 2e-16 ***
## factor(newpid)184   4.69042      0.77180    6.077 1.87e-09 ***
## factor(newpid)185   5.32106      0.31790   16.738   < 2e-16 ***
## factor(newpid)186   2.26637      0.34754    6.521 1.22e-10 ***
## factor(newpid)187   5.96108      0.31804   18.743   < 2e-16 ***
## factor(newpid)188   5.64729      0.34676   16.286   < 2e-16 ***
## factor(newpid)189   0.89556      0.54589    1.641 0.101277
## factor(newpid)190   3.93221      0.54593    7.203 1.34e-12 ***
## factor(newpid)191   4.73072      0.44582   10.611   < 2e-16 ***
## factor(newpid)192   4.63493      0.29415   15.757   < 2e-16 ***
## factor(newpid)193   3.51569      0.29414   11.952   < 2e-16 ***
## factor(newpid)194   1.67399      0.31665    5.286 1.60e-07 ***
## factor(newpid)195   6.57259      0.44708   14.701   < 2e-16 ***
## factor(newpid)196   4.28686      0.38778   11.055   < 2e-16 ***
## factor(newpid)197   4.52015      0.38659   11.692   < 2e-16 ***
## factor(newpid)198   6.11686      0.34677   17.640   < 2e-16 ***
## factor(newpid)199   3.58154      0.38734    9.247   < 2e-16 ***
## factor(newpid)200   6.33062      0.31871   19.863   < 2e-16 ***
## factor(newpid)201   4.88817      0.38837   12.586   < 2e-16 ***
## factor(newpid)202   6.08433      0.54598   11.144   < 2e-16 ***
## factor(newpid)203   6.31594      0.38792   16.282   < 2e-16 ***
## factor(newpid)204   5.44066      0.38672   14.069   < 2e-16 ***
## factor(newpid)205   3.66210      0.34771   10.532   < 2e-16 ***
## factor(newpid)206   5.98915      0.29415   20.361   < 2e-16 ***
## factor(newpid)207   6.08204      0.31761   19.149   < 2e-16 ***
## factor(newpid)208   4.17020      0.34723   12.010   < 2e-16 ***
## factor(newpid)209   6.43027      0.31684   20.295   < 2e-16 ***
## factor(newpid)210   5.21148      0.29412   17.719   < 2e-16 ***
## factor(newpid)211   5.34459      0.29419   18.167   < 2e-16 ***
## factor(newpid)212   5.21535      0.31670   16.468   < 2e-16 ***
## factor(newpid)213   4.67607      0.44578   10.490   < 2e-16 ***
```

```
## factor(newpid)214   6.54179      0.29428   22.230   < 2e-16 ***
## factor(newpid)215   5.04463      0.31666   15.931   < 2e-16 ***
## factor(newpid)216   3.74901      0.34628   10.827   < 2e-16 ***
## factor(newpid)217   3.09943      0.54578    5.679 1.88e-08 ***
## factor(newpid)218   4.76821      0.29420   16.207   < 2e-16 ***
## factor(newpid)219   5.47723      0.77180    7.097 2.76e-12 ***
## factor(newpid)220   6.34478      0.29424   21.564   < 2e-16 ***
## factor(newpid)221   5.78464      0.31662   18.270   < 2e-16 ***
## factor(newpid)222   5.27235      0.31785   16.587   < 2e-16 ***
## factor(newpid)223   5.34864      0.31661   16.894   < 2e-16 ***
## factor(newpid)224   3.80821      0.54578    6.978 6.19e-12 ***
## factor(newpid)225   6.47400      0.29413   22.010   < 2e-16 ***
## factor(newpid)226   6.85178      0.34695   19.748   < 2e-16 ***
## factor(newpid)227   6.21616      0.31664   19.631   < 2e-16 ***
## factor(newpid)228   4.67312      0.31665   14.758   < 2e-16 ***
## factor(newpid)229   5.25787      0.34628   15.184   < 2e-16 ***
## factor(newpid)230   5.96217      0.34628   17.218   < 2e-16 ***
## factor(newpid)231   5.95432      0.38653   15.405   < 2e-16 ***
## factor(newpid)232   6.17519      0.44620   13.840   < 2e-16 ***
## factor(newpid)233   4.36377      0.38636   11.295   < 2e-16 ***
## factor(newpid)234   6.22240      0.54578   11.401   < 2e-16 ***
## factor(newpid)235   3.21066      0.44635    7.193 1.43e-12 ***
## factor(newpid)236   2.83698      0.34674    8.182 1.06e-15 ***
## factor(newpid)237   5.43365      0.31707   17.137   < 2e-16 ***
## factor(newpid)238   5.05647      0.38660   13.079   < 2e-16 ***
## factor(newpid)239   5.54035      0.44593   12.424   < 2e-16 ***
## factor(newpid)240   3.51138      0.34603   10.148   < 2e-16 ***
## factor(newpid)241   6.11555      0.77180    7.924 7.49e-15 ***
## factor(newpid)242   5.16910      0.44592   11.592   < 2e-16 ***
## factor(newpid)243   5.89800      0.44636   13.213   < 2e-16 ***
## factor(newpid)244   5.94175      0.54578   10.887   < 2e-16 ***
## factor(newpid)245   4.92484      0.38641   12.745   < 2e-16 ***
## factor(newpid)246   5.05558      0.54579    9.263   < 2e-16 ***
## factor(newpid)247   4.78539      0.77180    6.200 8.92e-10 ***
## factor(newpid)248   5.64132      0.54579   10.336   < 2e-16 ***
```

```
## factor(newpid)249  5.59464      0.77180    7.249 9.71e-13 ***
## factor(newpid)250  5.83524      0.54579   10.691  < 2e-16 ***
## factor(newpid)251  3.74166      0.77180    4.848 1.49e-06 ***
## factor(newpid)252  4.51291      0.54582    8.268 5.45e-16 ***
## factor(newpid)253  3.60555      0.77180    4.672 3.49e-06 ***
## factor(newpid)254  3.75520      0.54598    6.878 1.20e-11 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.7718 on 821 degrees of freedom
## Multiple R-squared:  0.9809, Adjusted R-squared:  0.9751
## F-statistic: 168.1 on 251 and 821 DF,  p-value: < 2.2e-16

child <- hiv.data %>% select(newpid, age.baseline, treatment)
child <- unique(child)

r1.coef <- data.frame(child, r1$coefficients[2:length(r1$coefficients)])
colnames(r1.coef) <- c("newpid", "age.baseline", "treatment","coef.id")
rownames(r1.coef) <- 1:250
r1_coef.id <- lm(coef.id ~ age.baseline + factor(treatment), data = r1.coef)

summary(r1_coef.id)

##
## Call:
## lm(formula = coef.id ~ age.baseline + factor(treatment), data = r1.coef)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -4.1594 -0.7039  0.2265  1.1215  2.7256
##
## Coefficients:
##                    Estimate Std. Error t value Pr(>|t|)
## (Intercept)         5.10627    0.18728  27.265  < 2e-16 ***
## age.baseline       -0.12088    0.04023  -3.005  0.00293 **
## factor(treatment)2  0.14558    0.18421   0.790  0.43012
```

```
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 1.455 on 247 degrees of freedom
## Multiple R-squared:  0.03753,    Adjusted R-squared:  0.02974
## F-statistic: 4.816 on 2 and 247 DF,  p-value: 0.008875
```

Problem - 4

(a)

```
M0 <- lmer (y ~ time + (1 | newpid), data = hiv.data)
display(M0)

## lmer(formula = y ~ time + (1 | newpid), data = hiv.data)
##             coef.est coef.se
## (Intercept)  4.76     0.10
## time        -0.37     0.05
##
## Error terms:
##  Groups    Name        Std.Dev.
##  newpid    (Intercept) 1.40
##  Residual              0.77
## ---
## number of obs: 1072, groups: newpid, 250
## AIC = 3148.8, DIC = 3126.9
## deviance = 3133.9

M0.coef <- data.frame(unique(hiv.data$newpid),coef(M0)$newpid)
colnames(M0.coef) <- c("newpid", "intercept", "time")
head(coef(M0)$newpid)

##   (Intercept)       time
## 1    4.557250 -0.3660932
## 2    1.335566 -0.3660932
## 3    5.884129 -0.3660932
## 4    5.561130 -0.3660932
```

```
## 5    4.178397 -0.3660932
## 6    5.326751 -0.3660932
```

The coefficient for time is ~(-0.3661), constant across the children. Thus if the time increases by 1 unit, then the CD4 percentage on the square root scale will decrease by ~(0.3661) units.

(b)
```
M1 <- lmer (y ~ time + factor(treatment) + age.baseline + (1 | newpid), data
= hiv.data)
display(M1)

## lmer(formula = y ~ time + factor(treatment) + age.baseline +
##     (1 | newpid), data = hiv.data)
##                        coef.est coef.se
## (Intercept)            5.09     0.19
## time                  -0.36     0.05
## factor(treatment)2     0.18     0.18
## age.baseline          -0.12     0.04
##
## Error terms:
##  Groups   Name        Std.Dev.
##  newpid   (Intercept) 1.37
##  Residual             0.77
## ---
## number of obs: 1072, groups: newpid, 250
## AIC = 3149.2, DIC = 3110.9
## deviance = 3124.1

head(coef(M1)$newpid)

##   (Intercept)       time factor(treatment)2 age.baseline
## 1    5.012677 -0.3621573          0.1800822   -0.1194538
## 2    1.607624 -0.3621573          0.1800822   -0.1194538
## 3    6.593175 -0.3621573          0.1800822   -0.1194538
## 4    5.834945 -0.3621573          0.1800822   -0.1194538
## 5    4.320103 -0.3621573          0.1800822   -0.1194538
## 6    5.499405 -0.3621573          0.1800822   -0.1194538
```

1. The coefficients for time, treatment and age.baseline are all constant across the children
2. The coefficient for time is ~(-0.36216), thus if the time increases by 1 unit, then CD4 percentage on the square root scale will decrease by ~(0.36216) units
3. The coefficient for treatment is ~(0.18008), thus the CD4 percentage on the square root scale for children under treatment 2 is ~(0.18008) more than treatment 1
4. The coefficient for time is ~(-0.11945), thus if the age.baseline increases by 1 unit, CD4 percentage on the square root scale will decrease by ~(0.11945) units

(c)
```
data_plot <- as.data.frame(cbind(unlist(ranef(M0)), unlist(ranef(M1))))
colnames(data_plot) <- c("M0", "M1")
ggplot(data = data_plot,aes(x = M0,y = M1)) + geom_point() + geom_smooth() +
xlab("Random effcts of M0") +  ylab("Random effects of M1")

## `geom_smooth()` using method = 'loess' and formula 'y ~ x'
```
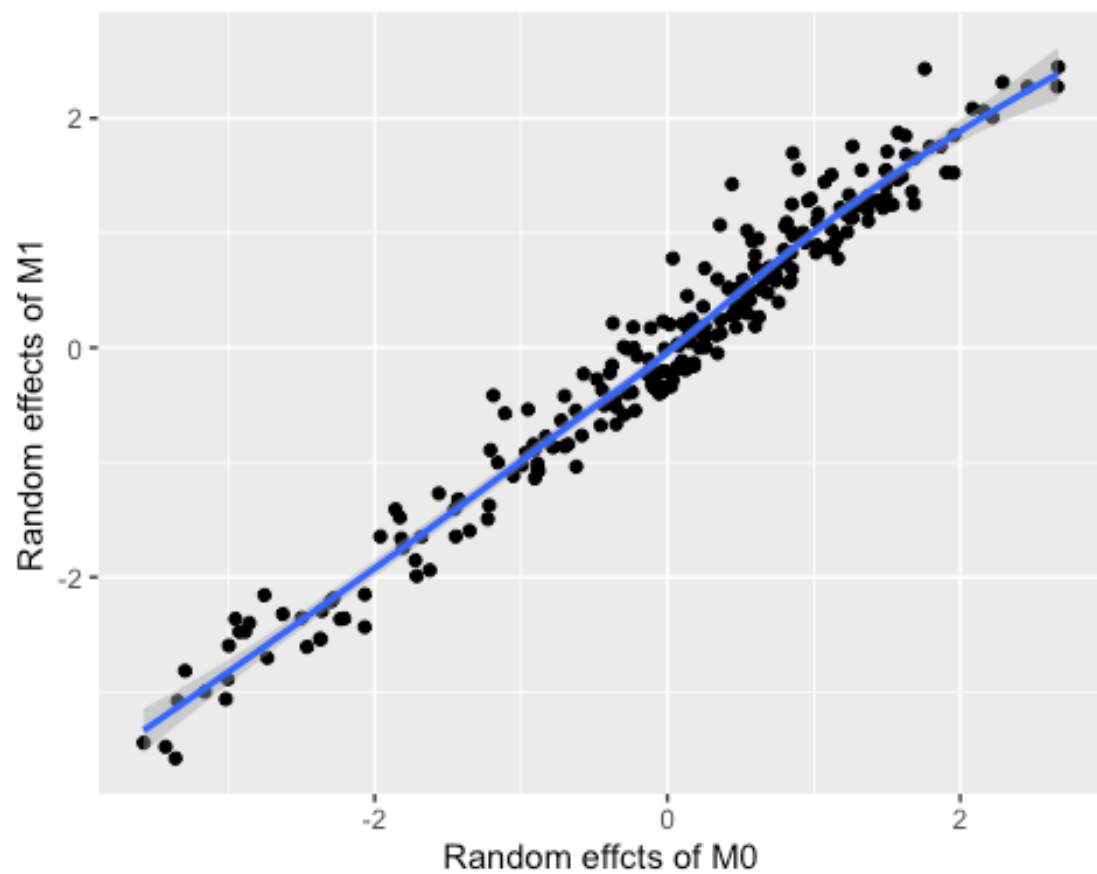
```
display(M0)

## lmer(formula = y ~ time + (1 | newpid), data = hiv.data)
##             coef.est coef.se
## (Intercept)  4.76     0.10
## time        -0.37     0.05
##
## Error terms:
##  Groups   Name        Std.Dev.
##  newpid   (Intercept) 1.40
##  Residual             0.77
## ---
## number of obs: 1072, groups: newpid, 250
```

```
## AIC = 3148.8, DIC = 3126.9
## deviance = 3133.9

display(M1)

## lmer(formula = y ~ time + factor(treatment) + age.baseline +
##     (1 | newpid), data = hiv.data)
##                       coef.est coef.se
## (Intercept)            5.09     0.19
## time                  -0.36     0.05
## factor(treatment)2     0.18     0.18
## age.baseline          -0.12     0.04
##
## Error terms:
##  Groups    Name        Std.Dev.
##  newpid    (Intercept) 1.37
##  Residual              0.77
## ---
## number of obs: 1072, groups: newpid, 250
## AIC = 3149.2, DIC = 3110.9
## deviance = 3124.1
```
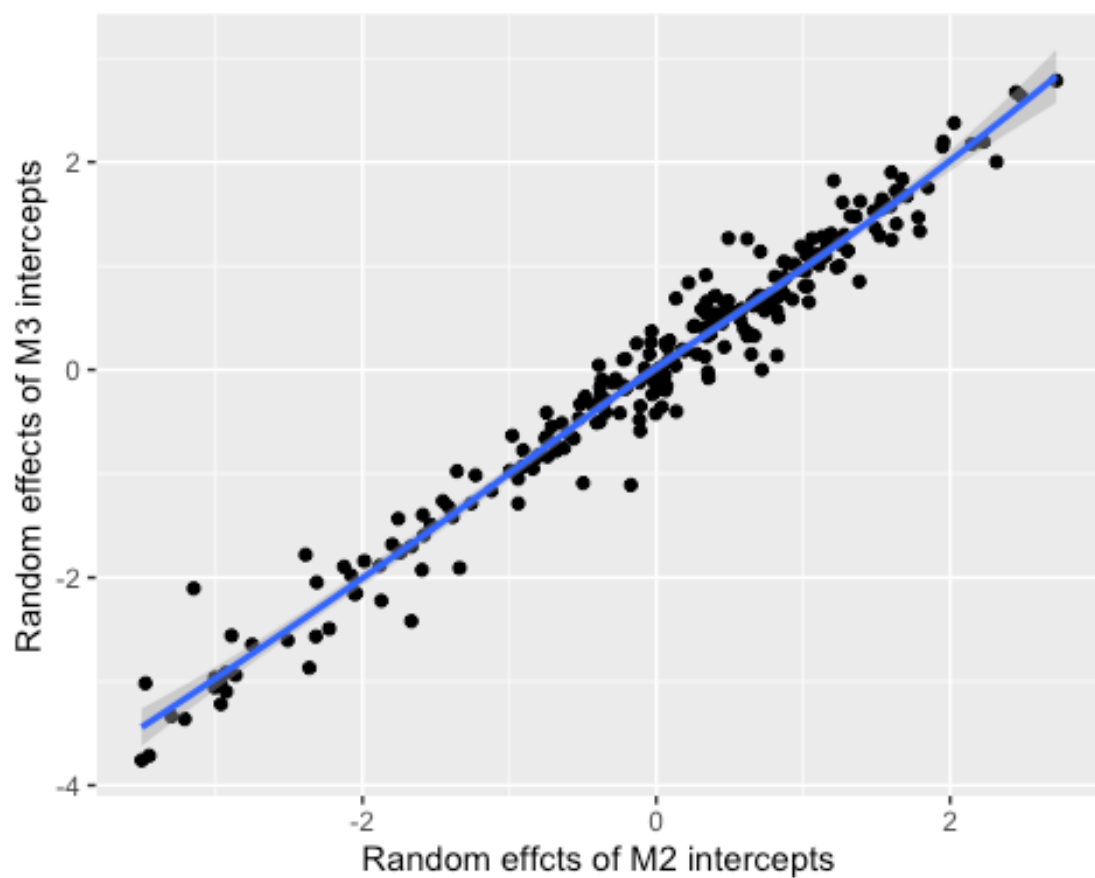
```
M2<-lmer(hiv.data$y ~ hiv.data$time + (1 + hiv.data$time | hiv.data$newpid))
M3<-lmer(hiv.data$y ~ factor(hiv.data$time) + (1 | hiv.data$newpid))

data_plot2_inter <- as.data.frame(cbind(unlist(ranef(M2))[1:250],
unlist(ranef(M3))[1:250]))
colnames(data_plot2_inter) <- c("M2", "M3")
ggplot(data = data_plot2_inter, aes(x = M2,y = M3)) + geom_point() +
geom_smooth() +
  xlab("Random effcts of M2 intercepts") + ylab("Random effects of M3
intercepts")

## `geom_smooth()` using method = 'loess' and formula 'y ~ x'
```

```
display(M2)

## lmer(formula = hiv.data$y ~ hiv.data$time + (1 + hiv.data$time |
##     hiv.data$newpid))
##               coef.est coef.se
## (Intercept)     4.76     0.09
## hiv.data$time  -0.36     0.07
##
## Error terms:
##  Groups          Name          Std.Dev. Corr
##  hiv.data$newpid (Intercept)   1.39
##                  hiv.data$time 0.58     -0.05
##  Residual                      0.72
## ---
```

```
## number of obs: 1072, groups: hiv.data$newpid, 250
## AIC = 3123.2, DIC = 3098.2
## deviance = 3104.7

display(M3)

## lmer(formula = hiv.data$y ~ factor(hiv.data$time) + (1 | hiv.data$newpid))
##                                          coef.est coef.se
## (Intercept)                               4.77     0.10
## factor(hiv.data$time)0.205               -1.23     0.67
## factor(hiv.data$time)0.209999999999999    0.21     0.89
## factor(hiv.data$time)0.213333333333333    0.16     0.94
## factor(hiv.data$time)0.213333333333334   -1.20     0.94
## factor(hiv.data$time)0.215833333333332    1.47     0.90
## factor(hiv.data$time)0.215833333333334   -0.25     0.84
## factor(hiv.data$time)0.216666666666667   -0.35     0.80
## factor(hiv.data$time)0.218333333333334    0.07     0.90
## factor(hiv.data$time)0.219166666666667   -0.48     0.85
## factor(hiv.data$time)0.221666666666667    0.19     0.94
## factor(hiv.data$time)0.224166666666666    1.65     0.86
## factor(hiv.data$time)0.224166666666667   -1.53     0.63
## factor(hiv.data$time)0.226666666666667    1.42     0.59
## factor(hiv.data$time)0.227499999999999   -1.56     0.89
## factor(hiv.data$time)0.2275               0.07     0.46
## factor(hiv.data$time)0.229999999999999   -0.36     0.59
## factor(hiv.data$time)0.23                -0.11     0.12
## factor(hiv.data$time)0.2325              -0.59     0.40
## factor(hiv.data$time)0.233333333333333    0.02     0.84
## factor(hiv.data$time)0.235000000000001   -1.96     0.80
## factor(hiv.data$time)0.235833333333333    0.04     0.29
## factor(hiv.data$time)0.235833333333334    0.18     0.62
## factor(hiv.data$time)0.2375               1.44     0.89
## factor(hiv.data$time)0.238333333333333   -0.27     0.49
## factor(hiv.data$time)0.238333333333334    0.85     0.82
## factor(hiv.data$time)0.240833333333333   -0.21     0.78
## factor(hiv.data$time)0.240833333333334    0.34     0.59
```

```
## factor(hiv.data$time)0.243333333333333 -0.51    0.89
## factor(hiv.data$time)0.244166666666667  0.09    0.48
## factor(hiv.data$time)0.245833333333333  0.09    0.43
## factor(hiv.data$time)0.245833333333334 -0.25    0.60
## factor(hiv.data$time)0.246666666666666 -0.51    0.65
## factor(hiv.data$time)0.246666666666667  0.38    0.85
## factor(hiv.data$time)0.249166666666666  0.15    0.39
## factor(hiv.data$time)0.249166666666667 -0.48    0.19
## factor(hiv.data$time)0.251666666666667  0.25    0.43
## factor(hiv.data$time)0.251666666666668  0.31    0.80
## factor(hiv.data$time)0.2525            -0.05    0.94
## factor(hiv.data$time)0.254166666666667 -0.63    0.84
## factor(hiv.data$time)0.255              0.33    0.80
## factor(hiv.data$time)0.256666666666667  0.29    0.63
## factor(hiv.data$time)0.257499999999999  0.09    0.84
## factor(hiv.data$time)0.2575             0.45    0.63
## factor(hiv.data$time)0.2625            -0.04    0.84
## factor(hiv.data$time)0.265             -0.16    0.85
## factor(hiv.data$time)0.265833333333333 -0.36    0.84
## factor(hiv.data$time)0.268333333333333 -0.34    0.59
## factor(hiv.data$time)0.268333333333334  0.07    0.49
## factor(hiv.data$time)0.2875             0.50    0.53
## factor(hiv.data$time)0.289999999999999 -0.77    0.94
## factor(hiv.data$time)0.293333333333333 -0.28    0.94
## factor(hiv.data$time)0.304166666666667  0.31    0.89
## factor(hiv.data$time)0.306666666666666 -0.28    0.89
## factor(hiv.data$time)0.306666666666667  0.22    0.59
## factor(hiv.data$time)0.325833333333334 -0.16    0.89
## factor(hiv.data$time)0.328333333333333 -0.87    0.94
## factor(hiv.data$time)0.331666666666667  0.05    0.94
## factor(hiv.data$time)0.358333333333333  0.57    0.86
## factor(hiv.data$time)0.364166666666667 -0.07    0.61
## factor(hiv.data$time)0.429166666666666 -0.29    0.94
## factor(hiv.data$time)0.429166666666667 -0.44    0.90
## factor(hiv.data$time)0.438333333333333 -0.85    0.90
```

```
## factor(hiv.data$time)0.440833333333333 -0.10      0.77
## factor(hiv.data$time)0.443333333333332  0.15      0.85
## factor(hiv.data$time)0.449166666666667 -0.08      0.79
## factor(hiv.data$time)0.454166666666666  0.27      0.90
## factor(hiv.data$time)0.454166666666667  0.09      0.86
## factor(hiv.data$time)0.455             -1.45      0.89
## factor(hiv.data$time)0.456666666666667  0.24      0.94
## factor(hiv.data$time)0.4575            -0.14      0.49
## factor(hiv.data$time)0.459166666666667  0.27      0.62
## factor(hiv.data$time)0.459999999999999 -0.19      0.46
## factor(hiv.data$time)0.46              -0.27      0.17
## factor(hiv.data$time)0.460000000000001 -0.27      0.31
## factor(hiv.data$time)0.462499999999999 -0.77      0.48
## factor(hiv.data$time)0.4625             0.43      0.41
## factor(hiv.data$time)0.463333333333333 -0.70      0.81
## factor(hiv.data$time)0.465             -0.88      0.48
## factor(hiv.data$time)0.465833333333333  0.32      0.59
## factor(hiv.data$time)0.465833333333334 -0.60      0.83
## factor(hiv.data$time)0.4675             1.61      0.61
## factor(hiv.data$time)0.468333333333335 -0.80      0.85
## factor(hiv.data$time)0.470833333333333 -0.36      0.46
## factor(hiv.data$time)0.470833333333334 -0.46      0.61
## factor(hiv.data$time)0.473333333333333 -0.17      0.62
## factor(hiv.data$time)0.473333333333334  0.45      0.79
## factor(hiv.data$time)0.474166666666666 -0.67      0.82
## factor(hiv.data$time)0.474166666666667 -0.81      0.80
## factor(hiv.data$time)0.475833333333333 -0.46      0.80
## factor(hiv.data$time)0.475833333333334 -1.41      0.58
## factor(hiv.data$time)0.476666666666667  0.61      0.40
## factor(hiv.data$time)0.479166666666666 -0.24      0.58
## factor(hiv.data$time)0.479166666666667 -0.03      0.25
## factor(hiv.data$time)0.481666666666666  0.11      0.59
## factor(hiv.data$time)0.481666666666667  0.22      0.43
## factor(hiv.data$time)0.484166666666667 -2.71      0.81
## factor(hiv.data$time)0.485              0.90      0.62
```

```
## factor(hiv.data$time)0.487499999999999 -0.23     0.77
## factor(hiv.data$time)0.4875               1.80     0.82
## factor(hiv.data$time)0.487500000000001   1.76     0.80
## factor(hiv.data$time)0.489999999999999   0.09     0.85
## factor(hiv.data$time)0.495              -0.14     0.60
## factor(hiv.data$time)0.495833333333333  -0.47     0.86
## factor(hiv.data$time)0.495833333333334  -0.12     0.94
## factor(hiv.data$time)0.498333333333333  -0.59     0.39
## factor(hiv.data$time)0.498333333333334  -0.58     0.38
## factor(hiv.data$time)0.500833333333333  -0.26     0.79
## factor(hiv.data$time)0.500833333333334   0.05     0.81
## factor(hiv.data$time)0.501666666666667  -1.18     0.61
## factor(hiv.data$time)0.503333333333334   0.59     0.84
## factor(hiv.data$time)0.504166666666666   0.24     0.52
## factor(hiv.data$time)0.505833333333333  -1.53     0.82
## factor(hiv.data$time)0.509166666666666  -0.42     0.90
## factor(hiv.data$time)0.511666666666667  -1.10     0.87
## factor(hiv.data$time)0.514166666666666   0.12     0.62
## factor(hiv.data$time)0.515               0.16     0.94
## factor(hiv.data$time)0.5175             -0.42     0.38
## factor(hiv.data$time)0.517500000000001  -1.13     0.82
## factor(hiv.data$time)0.533333333333333  -0.27     0.64
## factor(hiv.data$time)0.533333333333334  -1.07     0.87
## factor(hiv.data$time)0.534166666666667   0.22     0.62
## factor(hiv.data$time)0.536666666666667  -0.48     0.44
## factor(hiv.data$time)0.555833333333333  -0.22     0.62
## factor(hiv.data$time)0.558333333333333   1.74     0.94
## factor(hiv.data$time)0.564166666666667  -0.77     0.89
## factor(hiv.data$time)0.575              -0.35     0.63
## factor(hiv.data$time)0.580833333333333  -0.28     0.94
## factor(hiv.data$time)0.5825              0.64     0.94
## factor(hiv.data$time)0.594166666666667  -0.48     0.89
## factor(hiv.data$time)0.610833333333333  -1.09     0.94
## factor(hiv.data$time)0.6375              1.80     0.90
## factor(hiv.data$time)0.648333333333333  -2.11     0.89
```

```
## factor(hiv.data$time)0.651666666666666 -1.28     0.87
## factor(hiv.data$time)0.6575              -1.01     0.94
## factor(hiv.data$time)0.67                -0.43     0.85
## factor(hiv.data$time)0.670833333333333 -0.99     0.49
## factor(hiv.data$time)0.673333333333333  0.05     0.94
## factor(hiv.data$time)0.675833333333333 -0.15     0.67
## factor(hiv.data$time)0.684166666666667  0.53     0.63
## factor(hiv.data$time)0.685               0.61     0.84
## factor(hiv.data$time)0.6875             -1.59     0.61
## factor(hiv.data$time)0.689166666666666 -0.09     0.89
## factor(hiv.data$time)0.689166666666667  0.16     0.81
## factor(hiv.data$time)0.69               -0.18     0.16
## factor(hiv.data$time)0.6925              0.52     0.55
## factor(hiv.data$time)0.692500000000001  0.90     0.84
## factor(hiv.data$time)0.693333333333334 -0.48     0.85
## factor(hiv.data$time)0.695               0.37     0.84
## factor(hiv.data$time)0.695833333333333 -0.32     0.86
## factor(hiv.data$time)0.695833333333334 -1.68     0.83
## factor(hiv.data$time)0.695833333333335  0.82     0.59
## factor(hiv.data$time)0.697500000000001 -1.49     0.79
## factor(hiv.data$time)0.698333333333332  0.05     0.84
## factor(hiv.data$time)0.698333333333333 -0.61     0.59
## factor(hiv.data$time)0.700833333333333  1.56     0.49
## factor(hiv.data$time)0.703333333333333 -0.89     0.58
## factor(hiv.data$time)0.703333333333334 -1.07     0.82
## factor(hiv.data$time)0.704166666666667 -4.77     0.80
## factor(hiv.data$time)0.705833333333333 -0.48     0.49
## factor(hiv.data$time)0.705833333333334 -0.45     0.77
## factor(hiv.data$time)0.706666666666667  2.36     0.80
## factor(hiv.data$time)0.709166666666666 -0.11     0.80
## factor(hiv.data$time)0.709166666666667  0.23     0.28
## factor(hiv.data$time)0.711666666666666  0.10     0.84
## factor(hiv.data$time)0.711666666666667 -0.47     0.81
## factor(hiv.data$time)0.711666666666668 -0.88     0.57
## factor(hiv.data$time)0.714166666666667 -1.43     0.58
```

```
## factor(hiv.data$time)0.714999999999999 -0.72    0.79
## factor(hiv.data$time)0.715000000000001 -0.62    0.86
## factor(hiv.data$time)0.7175               -1.01    0.81
## factor(hiv.data$time)0.72                 -4.32    0.78
## factor(hiv.data$time)0.725                -0.65    0.60
## factor(hiv.data$time)0.725833333333332  0.35    0.84
## factor(hiv.data$time)0.725833333333333  0.72    0.83
## factor(hiv.data$time)0.725833333333334  0.33    0.94
## factor(hiv.data$time)0.728333333333333 -0.26    0.29
## factor(hiv.data$time)0.730833333333333  0.08    0.51
## factor(hiv.data$time)0.733333333333333 -0.74    0.84
## factor(hiv.data$time)0.734166666666666 -2.81    0.81
## factor(hiv.data$time)0.735833333333333 -0.93    0.67
## factor(hiv.data$time)0.736666666666666  0.05    0.85
## factor(hiv.data$time)0.736666666666667  1.51    0.84
## factor(hiv.data$time)0.7425               -0.48    0.94
## factor(hiv.data$time)0.744166666666667  0.15    0.57
## factor(hiv.data$time)0.745                -0.39    0.82
## factor(hiv.data$time)0.7475               -0.36    0.37
## factor(hiv.data$time)0.752500000000001 -1.65    0.84
## factor(hiv.data$time)0.758333333333334  0.22    0.86
## factor(hiv.data$time)0.761666666666667 -0.59    0.81
## factor(hiv.data$time)0.763333333333333 -0.13    0.81
## factor(hiv.data$time)0.763333333333335 -0.02    0.87
## factor(hiv.data$time)0.764166666666666 -0.45    0.86
## factor(hiv.data$time)0.765833333333333 -1.22    0.87
## factor(hiv.data$time)0.766666666666667 -0.44    0.39
## factor(hiv.data$time)0.775                -1.57    0.81
## factor(hiv.data$time)0.78                  0.89    1.58
## factor(hiv.data$time)0.783333333333333  1.05    0.89
## factor(hiv.data$time)0.785                -0.23    0.83
## factor(hiv.data$time)0.785833333333333  0.44    0.80
## factor(hiv.data$time)0.788333333333333 -0.74    0.94
## factor(hiv.data$time)0.794166666666667 -0.66    0.82
## factor(hiv.data$time)0.8025               -0.56    0.58
```

```
## factor(hiv.data$time)0.805                 -1.58      0.82
## factor(hiv.data$time)0.805000000000001   0.08      0.79
## factor(hiv.data$time)0.807500000000001  -0.32      0.89
## factor(hiv.data$time)0.824166666666667  -0.01      0.63
## factor(hiv.data$time)0.8625              -0.45      0.61
## factor(hiv.data$time)0.8675               0.56      0.90
## factor(hiv.data$time)0.878333333333334  -0.23      0.89
## factor(hiv.data$time)0.881666666666666   0.94      0.94
## factor(hiv.data$time)0.895833333333333  -0.73      0.89
## factor(hiv.data$time)0.900833333333333  -0.49      0.85
## factor(hiv.data$time)0.900833333333334   0.30      0.58
## factor(hiv.data$time)0.903333333333333  -1.03      0.76
## factor(hiv.data$time)0.903333333333334   2.25      0.94
## factor(hiv.data$time)0.905833333333334   1.26      0.90
## factor(hiv.data$time)0.908333333333334  -0.44      0.90
## factor(hiv.data$time)0.909166666666666   2.46      0.94
## factor(hiv.data$time)0.909166666666667  -0.30      0.81
## factor(hiv.data$time)0.911666666666667  -0.26      0.79
## factor(hiv.data$time)0.914166666666667   0.58      0.59
## factor(hiv.data$time)0.9175              -0.49      0.84
## factor(hiv.data$time)0.919166666666667   0.05      0.48
## factor(hiv.data$time)0.919999999999998  -0.94      0.79
## factor(hiv.data$time)0.92                -0.95      0.27
## factor(hiv.data$time)0.920000000000001  -0.15      0.46
## factor(hiv.data$time)0.9225              -0.53      0.59
## factor(hiv.data$time)0.925833333333333  -1.74      0.59
## factor(hiv.data$time)0.925833333333334   0.34      0.84
## factor(hiv.data$time)0.928333333333333   0.04      0.79
## factor(hiv.data$time)0.928333333333334  -0.94      0.83
## factor(hiv.data$time)0.930833333333333  -0.72      0.56
## factor(hiv.data$time)0.930833333333334  -1.97      0.81
## factor(hiv.data$time)0.933333333333332   0.43      0.82
## factor(hiv.data$time)0.933333333333333   0.01      0.59
## factor(hiv.data$time)0.934166666666664  -0.82      0.84
## factor(hiv.data$time)0.934166666666667  -1.03      0.80
```

```
## factor(hiv.data$time)0.935833333333333 -0.52    0.59
## factor(hiv.data$time)0.935833333333334 -0.73    0.83
## factor(hiv.data$time)0.936666666666667  0.14    0.79
## factor(hiv.data$time)0.938333333333334  0.03    0.80
## factor(hiv.data$time)0.939166666666666 -0.19    0.33
## factor(hiv.data$time)0.939166666666667  0.04    0.33
## factor(hiv.data$time)0.939166666666668 -1.72    0.82
## factor(hiv.data$time)0.941666666666666 -0.30    0.41
## factor(hiv.data$time)0.941666666666667 -0.49    0.81
## factor(hiv.data$time)0.944166666666667  0.12    0.59
## factor(hiv.data$time)0.9475             0.66    0.59
## factor(hiv.data$time)0.952500000000001 -0.45    0.79
## factor(hiv.data$time)0.955              1.56    0.84
## factor(hiv.data$time)0.955000000000001 -0.47    0.81
## factor(hiv.data$time)0.955833333333333 -1.06    0.85
## factor(hiv.data$time)0.9575             0.39    0.79
## factor(hiv.data$time)0.958333333333333  0.11    0.36
## factor(hiv.data$time)0.958333333333334 -0.14    0.46
## factor(hiv.data$time)0.960833333333333 -1.47    0.82
## factor(hiv.data$time)0.964166666666666 -0.01    0.84
## factor(hiv.data$time)0.964166666666667  0.50    0.83
## factor(hiv.data$time)0.965833333333333  0.05    0.85
## factor(hiv.data$time)0.976666666666667 -0.51    0.84
## factor(hiv.data$time)0.977499999999999 -3.22    0.81
## factor(hiv.data$time)0.9775            -0.39    0.36
## factor(hiv.data$time)0.977500000000001  0.58    0.86
## factor(hiv.data$time)0.982499999999999 -0.31    0.82
## factor(hiv.data$time)0.9825            -0.08    0.84
## factor(hiv.data$time)0.983333333333333 -0.02    0.88
## factor(hiv.data$time)0.985833333333333 -0.41    0.94
## factor(hiv.data$time)0.996666666666666 -0.61    0.57
## factor(hiv.data$time)0.996666666666667 -0.95    0.42
## factor(hiv.data$time)0.999166666666667 -0.98    0.78
## factor(hiv.data$time)1                 -0.99    0.84
## factor(hiv.data$time)1.00166666666667  -0.36    0.84
```

```
## factor(hiv.data$time)1.0025                  -1.30      0.84
## factor(hiv.data$time)1.01083333333333        -0.32      0.81
## factor(hiv.data$time)1.0125                  -0.75      0.81
## factor(hiv.data$time)1.01583333333333        -0.96      0.61
## factor(hiv.data$time)1.02083333333333        -1.29      0.85
## factor(hiv.data$time)1.02333333333333        -0.57      0.90
## factor(hiv.data$time)1.0325                   0.79      0.89
## factor(hiv.data$time)1.035                    -0.37      0.39
## factor(hiv.data$time)1.04833333333333        -1.29      0.87
## factor(hiv.data$time)1.05333333333333        -0.13      0.83
## factor(hiv.data$time)1.05416666666667        -0.54      0.58
## factor(hiv.data$time)1.07583333333333        -1.00      0.85
## factor(hiv.data$time)1.08666666666667         0.13      1.58
## factor(hiv.data$time)1.09                     -1.53      0.94
## factor(hiv.data$time)1.0925                   -0.63      0.50
## factor(hiv.data$time)1.11416666666667         0.10      0.85
## factor(hiv.data$time)1.11666666666667         0.94      0.94
## factor(hiv.data$time)1.13083333333333         0.28      0.85
## factor(hiv.data$time)1.13583333333333        -2.80      0.94
## factor(hiv.data$time)1.13916666666667         0.11      0.79
## factor(hiv.data$time)1.14166666666667        -0.48      0.57
## factor(hiv.data$time)1.14416666666667         1.06      0.86
## factor(hiv.data$time)1.145                    -0.42      0.89
## factor(hiv.data$time)1.1475                   -1.35      0.84
## factor(hiv.data$time)1.14916666666667        -0.67      0.57
## factor(hiv.data$time)1.15                     -0.41      0.22
## factor(hiv.data$time)1.1525                   -0.92      0.46
## factor(hiv.data$time)1.15583333333333        -1.17      0.49
## factor(hiv.data$time)1.1575                   -0.14      0.46
## factor(hiv.data$time)1.15833333333333        -1.63      0.59
## factor(hiv.data$time)1.16083333333333        -1.02      0.41
## factor(hiv.data$time)1.16333333333333         0.86      0.59
## factor(hiv.data$time)1.16416666666667         0.31      0.84
## factor(hiv.data$time)1.16583333333333        -1.58      0.83
## factor(hiv.data$time)1.16833333333333        -0.32      0.80
```

```
## factor(hiv.data$time)1.16916666666667  -0.52    0.31
## factor(hiv.data$time)1.17166666666667  -1.39    0.57
## factor(hiv.data$time)1.17666666666667  -1.31    0.83
## factor(hiv.data$time)1.1775            -0.10    0.80
## factor(hiv.data$time)1.18              -0.45    0.80
## factor(hiv.data$time)1.18833333333333  -0.10    0.22
## factor(hiv.data$time)1.19666666666667   0.32    0.63
## factor(hiv.data$time)1.20166666666667   0.09    0.48
## factor(hiv.data$time)1.20416666666667  -0.62    0.59
## factor(hiv.data$time)1.20666666666667   0.30    0.79
## factor(hiv.data$time)1.2075            -1.07    0.47
## factor(hiv.data$time)1.2125             0.10    0.84
## factor(hiv.data$time)1.22416666666667  -0.31    0.86
## factor(hiv.data$time)1.22583333333333   0.02    0.86
## factor(hiv.data$time)1.22666666666667  -0.02    0.59
## factor(hiv.data$time)1.22916666666667  -0.12    0.59
## factor(hiv.data$time)1.23166666666667  -1.42    0.80
## factor(hiv.data$time)1.2325            -0.12    0.80
## factor(hiv.data$time)1.24583333333333  -1.10    0.48
## factor(hiv.data$time)1.24833333333333  -1.65    0.84
## factor(hiv.data$time)1.25333333333333  -0.99    0.90
## factor(hiv.data$time)1.26166666666667  -0.42    0.81
## factor(hiv.data$time)1.265             -0.19    0.47
## factor(hiv.data$time)1.2675            -0.26    0.84
## factor(hiv.data$time)1.28416666666667  -2.30    0.86
## factor(hiv.data$time)1.3025            -0.69    0.87
## factor(hiv.data$time)1.30333333333333  -0.34    0.57
## factor(hiv.data$time)1.31166666666667  -1.86    0.81
## factor(hiv.data$time)1.34166666666667  -1.11    0.79
## factor(hiv.data$time)1.35              -0.55    0.87
## factor(hiv.data$time)1.35833333333333  -1.66    0.84
## factor(hiv.data$time)1.36              -0.09    0.89
## factor(hiv.data$time)1.36083333333333  -0.05    0.89
## factor(hiv.data$time)1.36583333333333  -0.75    0.79
## factor(hiv.data$time)1.37166666666667  -0.35    0.57
```

```
## factor(hiv.data$time)1.37416666666667   -0.69      0.79
## factor(hiv.data$time)1.375              -0.83      0.79
## factor(hiv.data$time)1.37666666666667   -3.03      0.76
## factor(hiv.data$time)1.37916666666667    0.03      0.78
## factor(hiv.data$time)1.38               -0.42      0.32
## factor(hiv.data$time)1.3825             -1.52      0.55
## factor(hiv.data$time)1.38583333333333   -0.78      0.59
## factor(hiv.data$time)1.38583333333334    0.17      0.83
## factor(hiv.data$time)1.3875             -0.22      0.57
## factor(hiv.data$time)1.38833333333333   -1.47      0.80
## factor(hiv.data$time)1.39083333333333   -0.58      0.57
## factor(hiv.data$time)1.39583333333333   -0.57      0.60
## factor(hiv.data$time)1.39666666666667    0.32      0.77
## factor(hiv.data$time)1.39833333333333   -0.33      0.82
## factor(hiv.data$time)1.39916666666667   -0.47      0.31
## factor(hiv.data$time)1.40166666666667   -2.16      0.60
## factor(hiv.data$time)1.41               -1.28      0.55
## factor(hiv.data$time)1.4125             -0.69      0.83
## factor(hiv.data$time)1.415              -0.18      0.57
## factor(hiv.data$time)1.41833333333333   -0.14      0.46
## factor(hiv.data$time)1.42083333333333   -0.74      0.94
## factor(hiv.data$time)1.42416666666667    0.39      0.79
## factor(hiv.data$time)1.42583333333333   -0.19      0.81
## factor(hiv.data$time)1.42916666666667    0.67      0.87
## factor(hiv.data$time)1.43166666666667   -0.13      0.58
## factor(hiv.data$time)1.43666666666667    0.45      0.81
## factor(hiv.data$time)1.4375             -0.88      0.79
## factor(hiv.data$time)1.44583333333333   -3.39      0.81
## factor(hiv.data$time)1.45333333333333   -0.85      0.90
## factor(hiv.data$time)1.45416666666667   -0.44      0.86
## factor(hiv.data$time)1.45583333333333   -0.56      0.79
## factor(hiv.data$time)1.45666666666667   -0.19      0.41
## factor(hiv.data$time)1.4625              0.31      0.80
## factor(hiv.data$time)1.47                0.18      0.58
## factor(hiv.data$time)1.4725              0.13      0.82
```

```
## factor(hiv.data$time)1.475                    0.27    0.84
## factor(hiv.data$time)1.48166666666667  -1.52    0.84
## factor(hiv.data$time)1.48333333333333  -0.60    0.90
## factor(hiv.data$time)1.4925            -2.59    0.80
## factor(hiv.data$time)1.495              0.20    0.48
## factor(hiv.data$time)1.4975             0.43    0.63
## factor(hiv.data$time)1.5               -0.30    0.81
## factor(hiv.data$time)1.50583333333333  -0.83    0.89
## factor(hiv.data$time)1.51416666666667   0.25    0.79
## factor(hiv.data$time)1.51666666666667  -1.94    0.84
## factor(hiv.data$time)1.51916666666667  -3.13    0.86
## factor(hiv.data$time)1.53               0.51    0.85
## factor(hiv.data$time)1.53083333333333   0.11    0.89
## factor(hiv.data$time)1.53333333333333  -0.13    0.58
## factor(hiv.data$time)1.54166666666667  -0.91    0.81
## factor(hiv.data$time)1.59083333333333  -1.28    0.87
## factor(hiv.data$time)1.615             -0.73    0.83
## factor(hiv.data$time)1.62916666666667   3.59    0.80
## factor(hiv.data$time)1.64833333333333  -1.52    0.85
## factor(hiv.data$time)1.71666666666667   0.00    0.84
## factor(hiv.data$time)1.725             -0.38    0.79
## factor(hiv.data$time)1.81166666666667   0.35    0.85
## factor(hiv.data$time)1.89666666666667  -0.41    0.82
## factor(hiv.data$time)1.90833333333333  -0.73    0.86
## factor(hiv.data$time)1.93833333333333  -0.88    0.94
##
## Error terms:
##  Groups            Name         Std.Dev.
##  hiv.data$newpid (Intercept) 1.41
##  Residual                     0.70
## ---
## number of obs: 1072, groups: hiv.data$newpid, 250
## AIC = 2980.5, DIC = 2698.6
## deviance = 2434.5
```

Problem - 5

```
one <- lmer(formula = hiv.data$y ~ hiv.data$time + hiv.data$age.baseline +
hiv.data$treatment + (1 | hiv.data$newpid))

summary(one)

## Linear mixed model fit by REML ['lmerMod']
## Formula:
## hiv.data$y ~ hiv.data$time + hiv.data$age.baseline + hiv.data$treatment +
##      (1 | hiv.data$newpid)
##
## REML criterion at convergence: 3137.2
##
## Scaled residuals:
##     Min      1Q  Median      3Q     Max
## -4.7490 -0.4392  0.0097  0.4282  5.0141
##
## Random effects:
##  Groups          Name        Variance Std.Dev.
##  hiv.data$newpid (Intercept) 1.8897   1.3747
##  Residual                    0.5969   0.7726
## Number of obs: 1072, groups:  hiv.data$newpid, 250
##
## Fixed effects:
##                       Estimate Std. Error t value
## (Intercept)            4.90606    0.31684  15.485
## hiv.data$time         -0.36216    0.05399  -6.708
## hiv.data$age.baseline -0.11945    0.04000  -2.986
## hiv.data$treatment     0.18008    0.18262   0.986
##
## Correlation of Fixed Effects:
##             (Intr) hv.dt$tm hv.d$.
## hiv.data$tm -0.086
## hv.dt$g.bsl -0.430 -0.017
## hv.dt$trtmn -0.850  0.010    -0.003
```

```
plot(one)
```
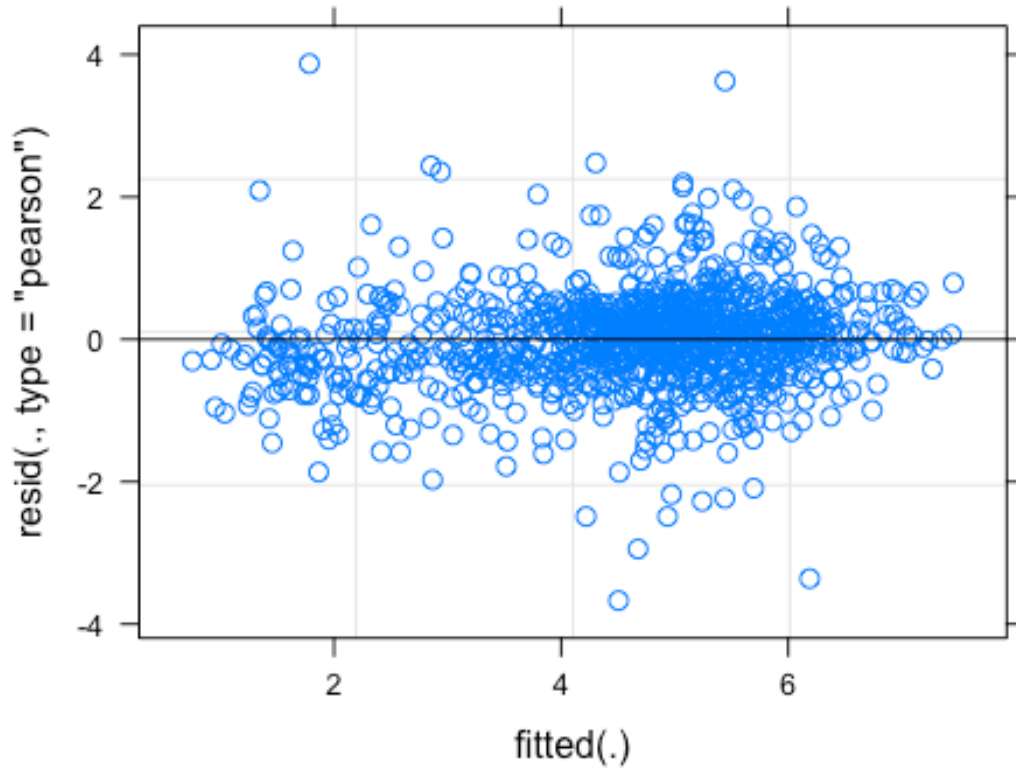

Original formula of the multilevel model:

$$y = \beta_{0[j]i} + X_{i1}{}^*\beta_{1[j]i} + X_{i2}{}^*\beta_{2[j]i} + X_{i3}{}^*\beta_{3[j]i} + \epsilon_i$$

$$y = \alpha_{j[i]} + \beta_1 X_{i1} + \beta_2 X_{i2} + \beta_3 X_{i3} + \epsilon_i$$

$$\alpha_j \sim N(\mu_i, \sigma_i^2)$$

$$X1 = time, \; X2 = age.baseline, \; X3 = treatment$$

.

Method1: Allowing regression coefficients to vary accross groups

$$y = 4.91 + X_{i1}{}^*(-0.36) + X_{i2}{}^*(-0.12) + X_{i3}{}^*0.18 + 0.77 \;, \; for \; i = 1, \ldots, n_{250}$$

$$\alpha_j\sim\ \mathrm{N}(0,1.37^2)\\$$

Method2: Combining separate local regressions

$$y \sim\ N(4.91 + X_{i1}*(-0.36) + X_{i2}*(-0.12) + X_{i3}*0.18,\ 0.77^2)\ ,\ for\ i = 1,\ldots,n_{250}$$

$$\alpha_j\sim\ \mathrm{N}(random\ intercept,1.37^2)\\$$

Method3: Modeling the coefficients of a large regression model

$$y_i \sim\ N(4.91 + X_{i1}*(-0.36) + X_{i2}*(-0.12) + X_{i3}*0.18,\ 0.77^2)$$

$$\beta_j \sim\ N(0, 1.37^2)$$

Method4: Regression with multiple error terms

$$y_i \sim\ N(4.91 + X_{i1}*(-0.36) + X_{i2}*(-0.12) + X_{i3}*0.18 + 1.37^2,\ 0.77^2)$$

Method5: Large regression with correlated errors

$$y_i \sim\ N(4.91 + X_{i1}*(-0.36) + X_{i2}*(-0.12) + X_{i3}*0.18,\ 1.37^2 + 0.77^2)$$