Log data analysis Assignment 1

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Task 3

Our first task is to generate a multivariate model and find the most parsimonious mean structure for it. Given that the data set is unbalanced we will use the `gee` and `geepack` libraries which allow us to conduct Generalized Estimating Equations. We will conduct these under the strict assumptions of Normality, however we will analyze the effects which different within subject covariate structures both with the help of Quasi-Information Criterium and the RMSE of the fitted Residuals. Holding the assumtion of Normality for the GEE models leads to functionally the same model as the Multivariate model described in the lecture. In this first step we will conduct some model searching in order to select the most parsimonious mean structure. We will start with a complete model as well as available interaction terms and slowly reduce it. We will compare all models against each other with the help of the `QICu` statistic (lower is better), the significance of the parameters as well as an `ANOVA\MANOVA` comparison. After we find the appropriate mean structure we will take care of selecting the appropriate covariance structure. The models run below are run under the assumption of independence between observations of the same individual.

```
mf <- formula(y ~ age+TIME+side+age:TIME+age:side+TIME:side)
gee1 <- geeglm(mf, data=df, id=id, corstr="independence")
QIC(gee1)[2]
```

```
##      QICu
## 336295.1
```

```
mean(sqrt(resid(gee1)^2))
```

```
## [1] 6.540803
```

```
coef(summary(gee1))
```

```
##                   Estimate      Std.err        Wald      Pr(>|W|)
## (Intercept)   -4.735246112 0.923489548  26.2918499 2.935247e-07
## age            0.237289867 0.020042856 140.1648660 0.000000e+00
## TIME          -0.047977954 0.139186881   0.1188193 7.303186e-01
## sideright      0.258743907 0.630430628   0.1684479 6.814949e-01
## age:TIME       0.004965421 0.003154596   2.4775627 1.154811e-01
## age:sideright -0.005008229 0.012959024   0.1493564 6.991512e-01
## TIME:sideright 0.011966651 0.034989705   0.1169674 7.323472e-01
```

```
#mf2 <- formula(y ~ age+TIME+age:TIME+age:side+TIME:side)
#gee2 <- geeglm(mf2, data=df, id=id, corstr="independence")
#QIC(gee2)[2]
#mean(sqrt(resid(gee2)^2))
#coef(summary(gee2))
#mf3 <- formula(y ~ age+TIME+age:side+TIME:side)
#gee3 <- geeglm(mf3, data=df, id=id, corstr="independence")
#QIC(gee3)[2]
#mean(sqrt(resid(gee3)^2))
#coef(summary(gee3))
mf4 <- formula(y ~ age+TIME)
gee4 <- geeglm(mf4, data=df, id=id, corstr="independence")
QIC(gee4)[2]
```

```
##    QICu
## 337008
```

```
mean(sqrt(resid(gee4)^2))
```

```
## [1] 6.556228
```

```
coef(summary(gee4))
```

```
##               Estimate    Std.err      Wald      Pr(>|W|)
## (Intercept) -5.7536304 0.88071498  42.67889 6.450451e-11
## age          0.2577779 0.01857869 192.51343 0.000000e+00
## TIME         0.1985119 0.04500454  19.45630 1.029275e-05
```

```
mf5 <- formula(y ~ age)
gee5 <- geeglm(mf5, data=df, id=id, corstr="independence")
QIC(gee5)[2]
```

```
##      QICu
## 341929.3
```

```
mean(sqrt(resid(gee5)^2))
```

```
## [1] 6.594221
```

```
coef(summary(gee5))
```

```
##               Estimate    Std.err      Wald      Pr(>|W|)
## (Intercept) -4.2317764 0.85696267  24.38494 7.888314e-07
## age          0.2506885 0.01840205 185.58224 0.000000e+00
```

```
#mf6 <- formula(y ~ TIME)
#gee6 <- geeglm(mf6, data=df, id=id, corstr="independence")
#QIC(gee6)[2]
```

```
#mean(sqrt(resid(gee6)^2))
#coef(summary(gee6))

#anova(gee1,gee2)
#anova(gee1,gee3)
anova(gee1,gee4)
```

```
## Analysis of 'Wald statistic' Table
##
## Model 1 y ~ age + TIME + side + age:TIME + age:side + TIME:side
## Model 2 y ~ age + TIME
##   Df      X2 P(>|Chi|)
## 1   4 3.0084    0.5564
```

```
anova(gee1,gee5)
```

```
## Analysis of 'Wald statistic' Table
##
## Model 1 y ~ age + TIME + side + age:TIME + age:side + TIME:side
## Model 2 y ~ age
##   Df      X2 P(>|Chi|)
## 1   5 20.349  0.001074 **
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
#anova(gee1,gee6)

#anova(gee2,gee3)
#anova(gee2,gee4)
#anova(gee2,gee5)
#anova(gee2,gee6)

#anova(gee3,gee4)
#anova(gee3,gee5)
#anova(gee3,gee6)

anova(gee4,gee5)
```

```
## Analysis of 'Wald statistic' Table
##
## Model 1 y ~ age + TIME
## Model 2 y ~ age
##   Df      X2 P(>|Chi|)
## 1   1 19.456 1.029e-05 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
#anova(gee4,gee6)

#anova(gee5,gee6)
```

We find that the the model `y~ age+ TIME` that is we use only the age at the start of the survey as well as the elapsed time since the survey began is the most parsimonious model. In essence the actual participant age is what is most important. We further find that the effect of the `side` variable, nor does any of its interaction terms, does not play a large role in predicting hearing loss. This is something we would intuitively expect, people are not prone on average to loosing hearing in one ear compared to the other. These conclusions hold for a much wider selection of models (we present here only sample of what we tested) or even when we filter the data under different conditions (Removing subjects with less than $n = \{2, 4, 5, 6\}$ observations,looking at only the right/left ear data base,treating each ear-subject pair as single subject, balancing the data, grouping the subjects in cohorts of $\{1, 5, 10, 15, 20\}$ years an creating dummy variables for them).

Now we will take a look at the covariance structure of the model. Certain structure are naturally excluded due to the nature of our data e.g. `AR(n)` or `Toeplitz` are not really meaningful when the time series points are not equally spaced. We will compare the same model mean structure i.e. `y~ age+ TIME` under different covariance structures and see which one produces the smallest Quasi Information Criterion (`QIC`) value.`[Comment: the code for unstructured covariance will not run bellow as it takes some computing time and may be annoying on weaker machines]`

```
mf <- formula(y ~ age+TIME)
gee_opt1 <- geeglm(mf, data=df, id=id, corstr="independence")
QIC(gee_opt1)
```

```
##          QIC          QICu     Quasi Lik          CIC        params          QICC
##   337035.2382   337007.9592  -168500.9796      16.6395        3.0000   337035.2825
```

```
mean(sqrt(resid(gee_opt1)^2))
```

```
## [1] 6.556228
```

```
gee_opt2 <- geeglm(mf, data=df, id=id, corstr="exchangeable")
QIC(gee_opt2)
```

```
##            QIC            QICu      Quasi Lik            CIC          params
##   339239.30297   339221.28567  -169607.64284       12.00865         3.00000
##           QICC
##   339239.37691
```

```
mean(sqrt(resid(gee_opt2)^2))
```

```
## [1] 6.636954
```

```
#gee_opt3 <- geeglm(mf, data=df, id=id, corstr="unstructured")
#QIC(gee_opt3)
```

It appears that an independent covariance structure produces the lowest `QIC` value, nevertheless is behooves us to take a closer look at these two models. First lets consider the model with an exchangeable covariance structure.

```
mf <- formula(y ~ age+TIME)
gee_opt2_new<-gee(mf, data=df, id=id,family = gaussian, corstr = "exchangeable")
```

```
## Beginning Cgee S-function, @(#) geeformula.q 4.13 98/01/27


## running glm to get initial regression estimate


## (Intercept)         age        TIME
##  -5.7536304   0.2577779   0.1985119
```

```
summary(gee_opt2_new)$coefficients
```

```
##               Estimate Naive S.E.    Naive z Robust S.E.   Robust z
## (Intercept) -5.3392967 0.93172783 -5.730533  0.80414355 -6.639731
## age          0.2496282 0.01682033 14.840865  0.01687625 14.791689
## TIME         0.2851447 0.01897425 15.027977  0.02851307 10.000489
```

```
gee_opt2_new
```

```
##
##  GEE:  GENERALIZED LINEAR MODELS FOR DEPENDENT DATA
##  gee S-function, version 4.13 modified 98/01/27 (1998)
##
## Model:
##  Link:                      Identity
##  Variance to Mean Relation: Gaussian
##  Correlation Structure:     Exchangeable
##
## Call:
## gee(formula = mf, id = id, data = df, family = gaussian, corstr = "exchangeable")
##
## Number of observations :  4419
##
## Maximum cluster size    :  29
##
##
## Coefficients:
## (Intercept)         age        TIME
##  -5.3392967   0.2496282   0.2851447
##
## Estimated Scale Parameter:  76.81489
## Number of Iterations:  3
##
## Working Correlation[1:4,1:4]
##          [,1]      [,2]      [,3]      [,4]
## [1,] 1.0000000 0.6140421 0.6140421 0.6140421
## [2,] 0.6140421 1.0000000 0.6140421 0.6140421
## [3,] 0.6140421 0.6140421 1.0000000 0.6140421
## [4,] 0.6140421 0.6140421 0.6140421 1.0000000
##
##
## Returned Error Value:
## [1] 0
```

In the above output we notice that we get two standart errors: Naive and Robust. Normally we would want to use the Robust estimates because the variances of coefficient estimates tend to be too small when

responses within subjects are correlated (Bilder and Loughin, 2015), however in this case there is little difference between the Naive and Robust estimates. This further suggest that the independence assumption of the correlation structure seems realistic (Hothorn and Everitt, 2014). In the bottom we see a `Working correlation` output which shows an the upper 4×4 of the Variance-Covariance matrix used for this model (the size depends on the number of observations per individual with the largest beeing 29×29). Below we will report the best model we could find under the conditions of this task. It has the same parameter estimates as a least squares model with the same mean structure specification, however the robust errors in this model are more accurate, as some of the consitions of the least squares model are not fulfilled (e.g. Normaly distributed residuals)

```
mf <- formula(y ~ age+TIME)
gee_opt1_new<-gee(mf, data=df, id=id,family = gaussian, corstr = "independence")
```

```
## Beginning Cgee S-function, @(#) geeformula.q 4.13 98/01/27
```

```
## running glm to get initial regression estimate
```

```
## (Intercept)          age          TIME
## -5.7536304    0.2577779    0.1985119
```

```
summary(gee_opt1_new)$coefficients
```

```
##                 Estimate  Naive S.E.      Naive z  Robust S.E.   Robust z
## (Intercept) -5.7536304 0.458852942 -12.539160   0.88071498 -6.532909
## age          0.2577779 0.007787969  33.099505   0.01857869 13.874921
## TIME         0.1985119 0.024714929   8.032064   0.04500454  4.410930
```

```
gee_opt1_new
```

```
##
##  GEE:  GENERALIZED LINEAR MODELS FOR DEPENDENT DATA
##  gee S-function, version 4.13 modified 98/01/27 (1998)
##
## Model:
##  Link:                     Identity
##  Variance to Mean Relation: Gaussian
##  Correlation Structure:     Independent
##
## Call:
## gee(formula = mf, id = id, data = df, family = gaussian, corstr = "independence")
##
## Number of observations :   4419
##
## Maximum cluster size    :   29
##
##
## Coefficients:
## (Intercept)          age          TIME
##  -5.7536304    0.2577779    0.1985119
##
## Estimated Scale Parameter:  76.31385
```

```
## Number of Iterations:  1
##
## Working Correlation[1:4,1:4]
##      [,1] [,2] [,3] [,4]
## [1,]    1    0    0    0
## [2,]    0    1    0    0
## [3,]    0    0    1    0
## [4,]    0    0    0    1
##
##
## Returned Error Value:
## [1] 0
```

Task 4

In this task we will conduct an explicit two stage analysis of the data first computing the intecepts and then computing the slopes of the model. First let us take a look at the per subject/side intercept.

```
db_fixed = lme(y ~ 1,random=~1|id/age/side, data = df)
```
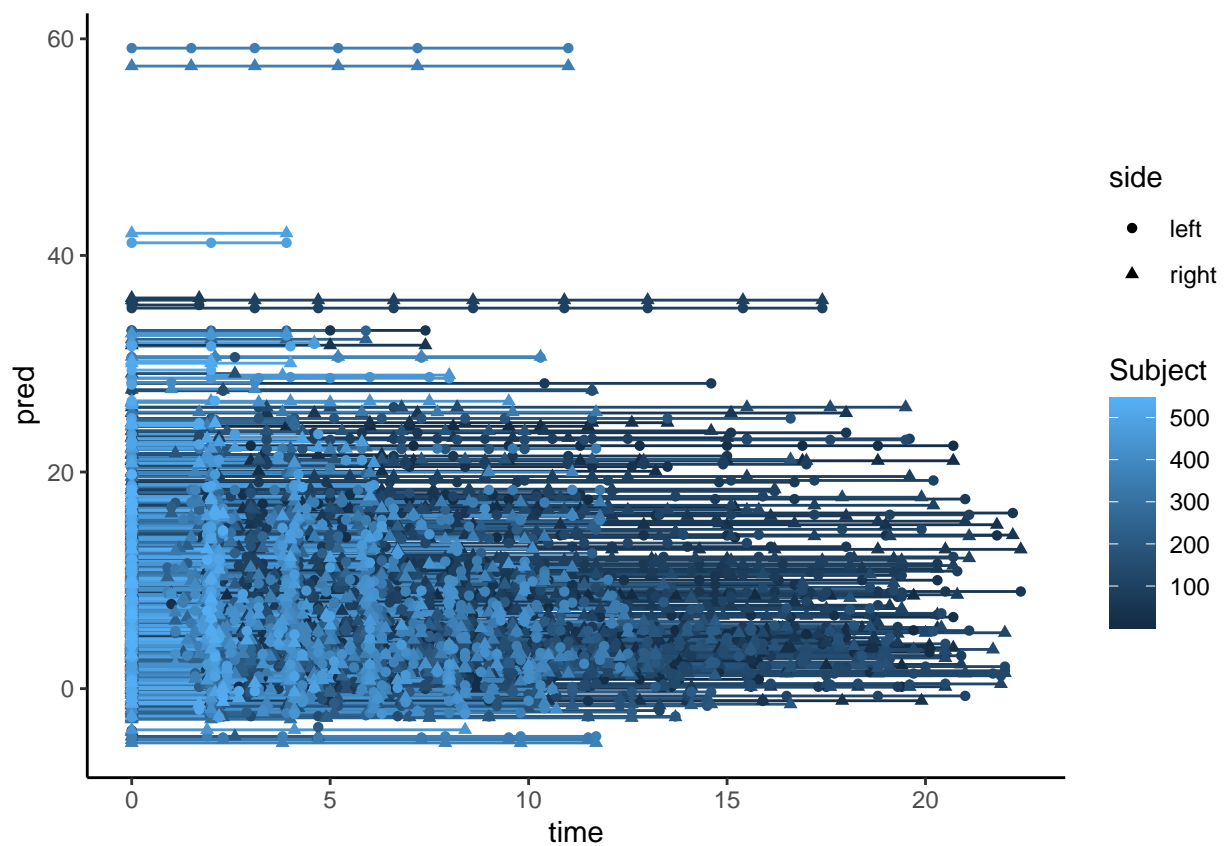
Distribution of all intercepts
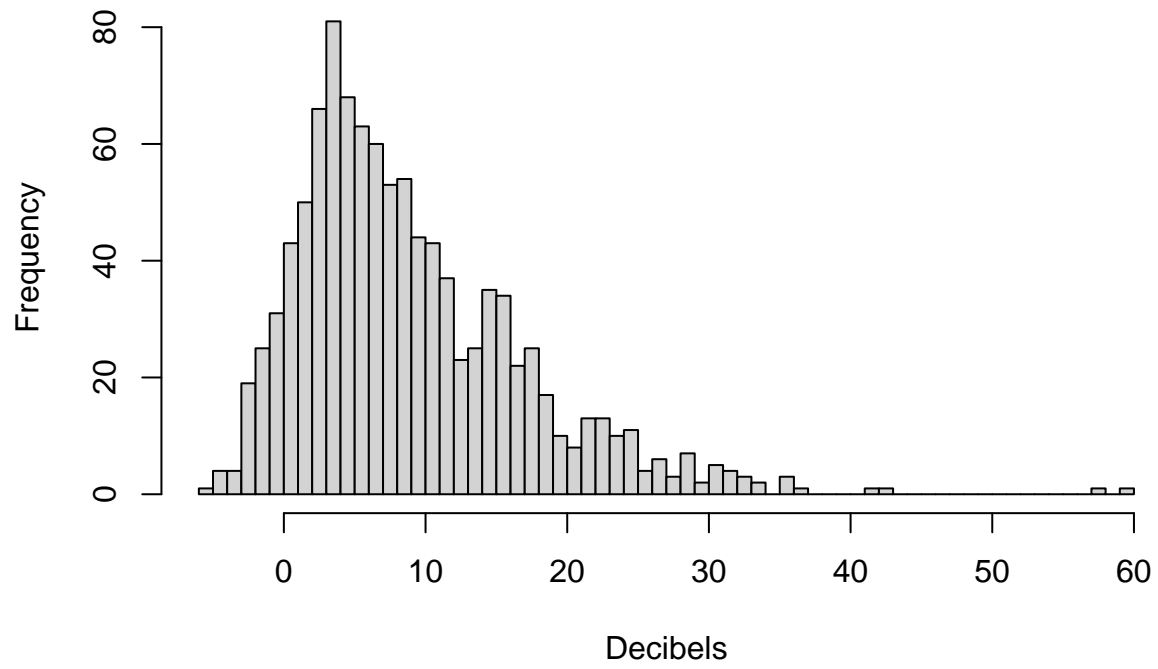
Distribution of left eat intercepts   **Distribution of right ear intercept**
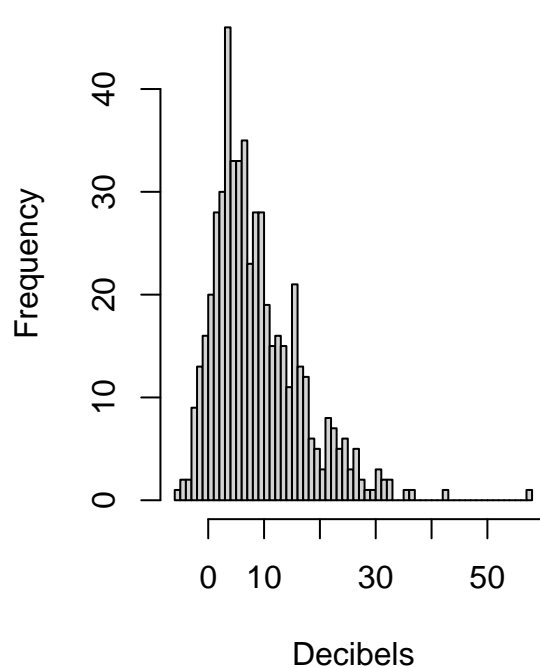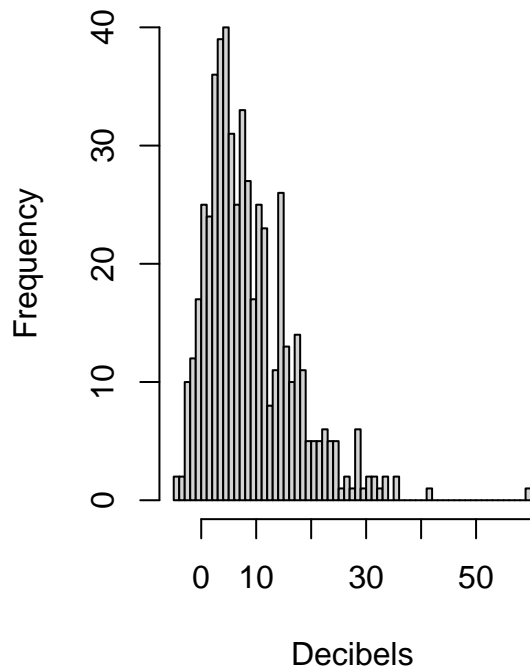
Further we can run a Komogorov-Smirnov test to see if the distribution of the left and right ear intercepts come from the same distribution

```
ks.test(left_intercepts,right_intercepts)
```

```
## Warning in ks.test(left_intercepts, right_intercepts): p-value will be
## approximate in the presence of ties
```

```
##
##  Two-sample Kolmogorov-Smirnov test
##
## data:  left_intercepts and right_intercepts
## D = 0.022838, p-value = 0.9991
## alternative hypothesis: two-sided
```

Next we will run a series of linear models for each model, as we will see

```
df1<-cbind(df,fitted(db_fixed))
colnames(df1)[8]<-"fitted_val"
```

```
res.list1 <- lmList(I(y-fitted_val) ~0+age+ TIME|id/age/side, data=df1)
```

```
## Warning in Ops.factor(id, age): '/' not meaningful for factors
```

```
## Warning in Ops.factor(id/age, side): '/' not meaningful for factors
```

```
b <- lapply(res.list1, coef)
b <- as.data.frame(do.call(rbind,b))
intercept<-rep(0,nrow(b))
ID<-str_split_fixed(row.names(b), "/", 3)
b<-cbind(ID,intercept,b)
colnames(b)[1]<-"ID"
colnames(b)[2]<-"age_true"
colnames(b)[3]<-"side"
b$ID<-as.numeric(b$ID)

#for some reason it wont knit with these 3 graphs :( something is bugging it

#ggplot(b)  + geom_abline(aes(intercept = intercept, slope = TIME, color=ID)) +
  #xlim(0.5, 10) +
  #ylim(-1, 1)


#plot(b$age_true,b$age,main = "Intercepts of age against age",xlab = "age",ylab = "slope of age for ind
#plot(b$age_true,b$TIME,main = "Intercepts of TIME against age",xlab = "age",ylab = "slope of TIME for
```

notes on how slopes are more disperesed at lower ages, how age effects when taken out of the entire datase (age is fixed for an id), still need to plot correlation between slopes and intercepts

Task 5

```
db_mixed = lmer(y ~ age+TIME+ (1 | id), data = df)
summary(db_mixed)
```

```
## Linear mixed model fit by REML ['lmerMod']
## Formula: y ~ age + TIME + (1 | id)
##    Data: df
##
## REML criterion at convergence: 28674.7
##
## Scaled residuals:
##     Min      1Q  Median      3Q     Max
## -4.1008 -0.5748 -0.0442  0.5048  6.6171
##
## Random effects:
##  Groups   Name        Variance Std.Dev.
##  id       (Intercept) 48.60    6.971
##  Residual             28.23    5.313
## Number of obs: 4419, groups:  id, 546
##
## Fixed effects:
##              Estimate Std. Error t value
## (Intercept) -5.32864    0.94126  -5.661
## age          0.24942    0.01700  14.675
```

```
## TIME            0.28581     0.01854  15.416
##
## Correlation of Fixed Effects:
##      (Intr) age
## age  -0.939
## TIME -0.111  0.033
```

```
plot(db_mixed)
```
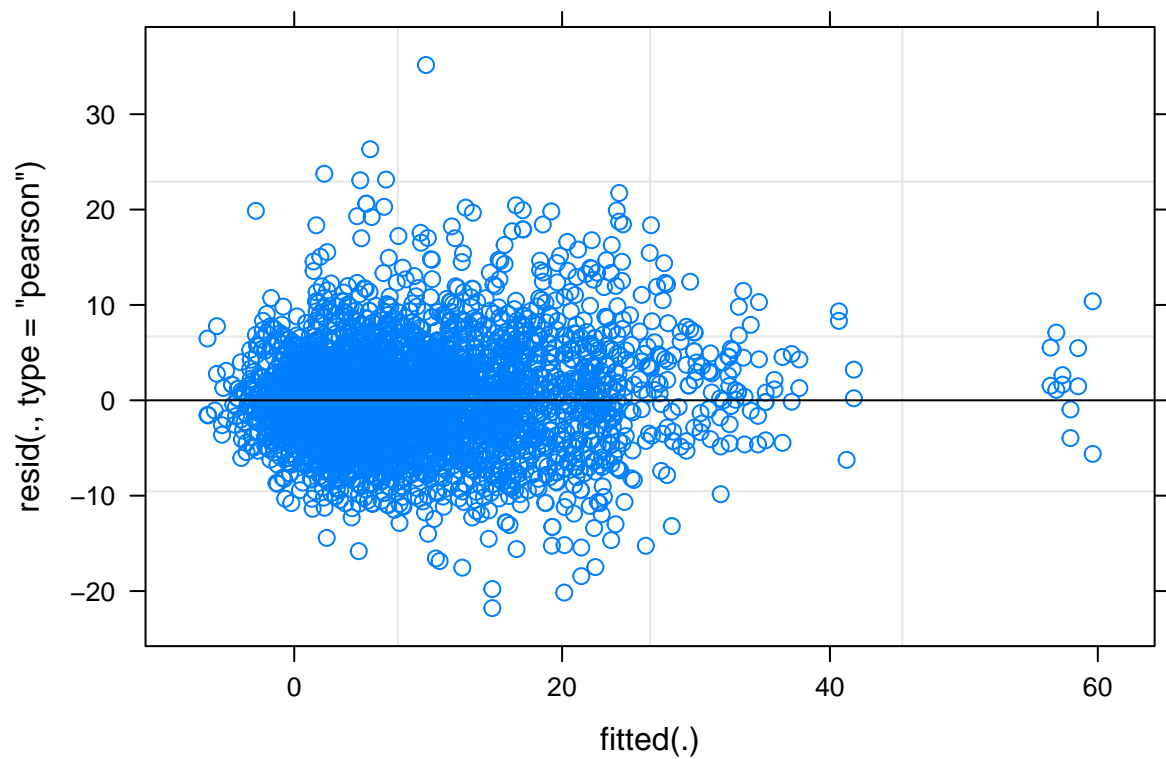


```
hist(residuals(db_mixed), breaks = 50)
```

Histogram of residuals(db_mixed)
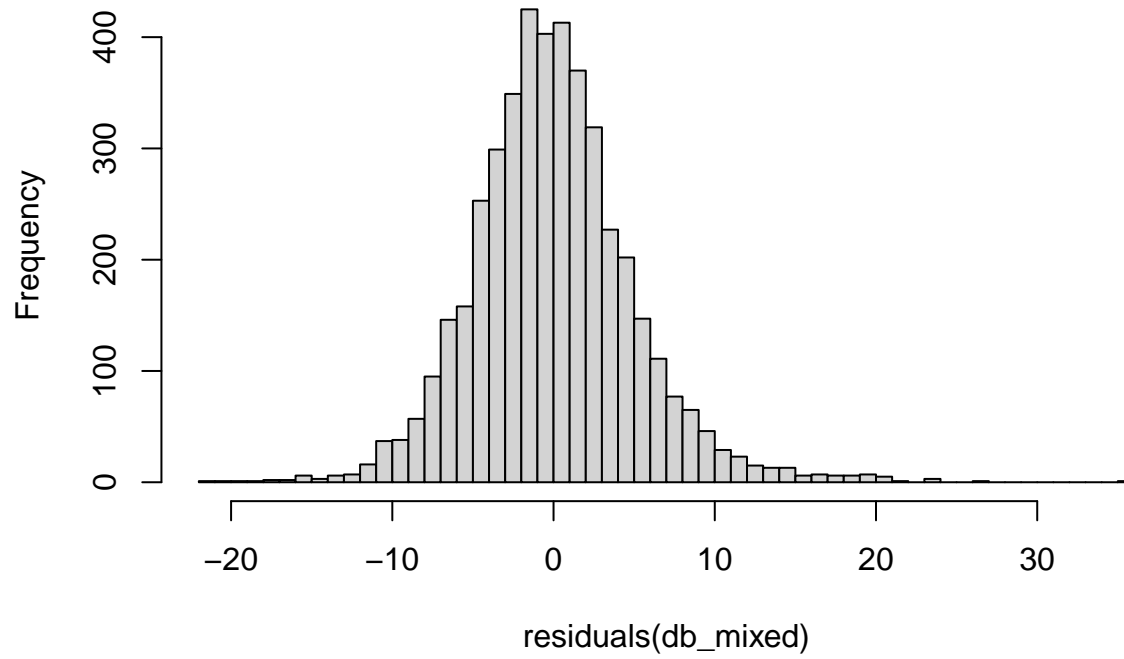

```
plot(residuals(db_mixed), type = "l")
```
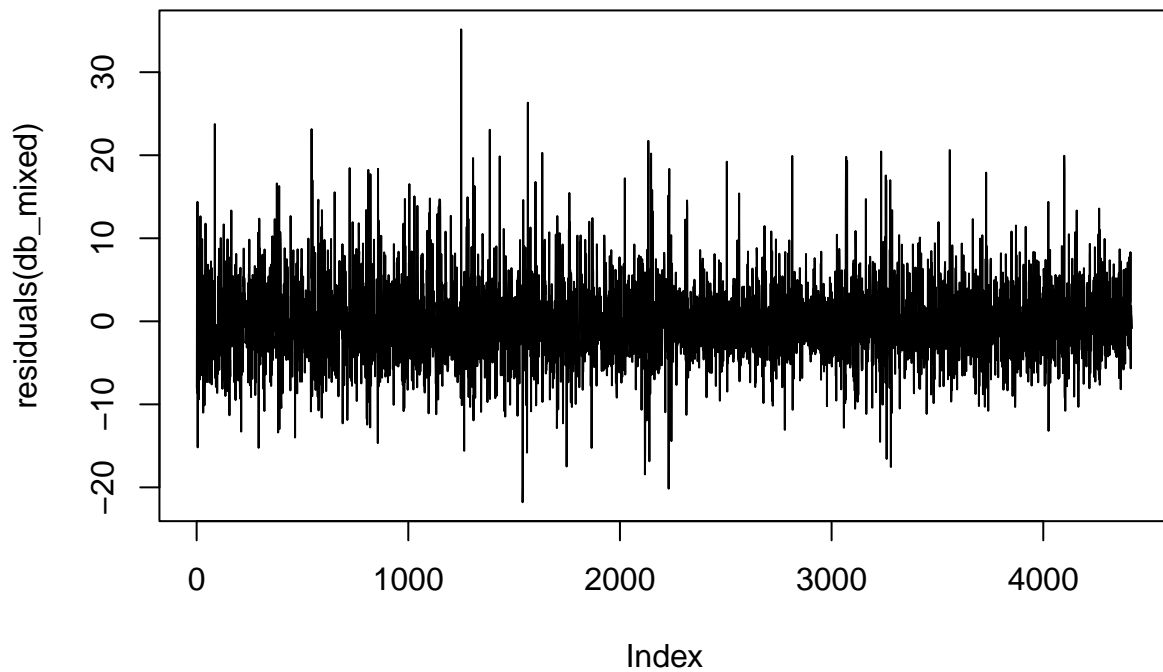
```
shapiro.test(residuals(db_mixed))
```

```
##
##  Shapiro-Wilk normality test
##
## data:  residuals(db_mixed)
## W = 0.97432, p-value < 2.2e-16
```

```
acf(residuals(db_mixed))
```

Series residuals(db_mixed)
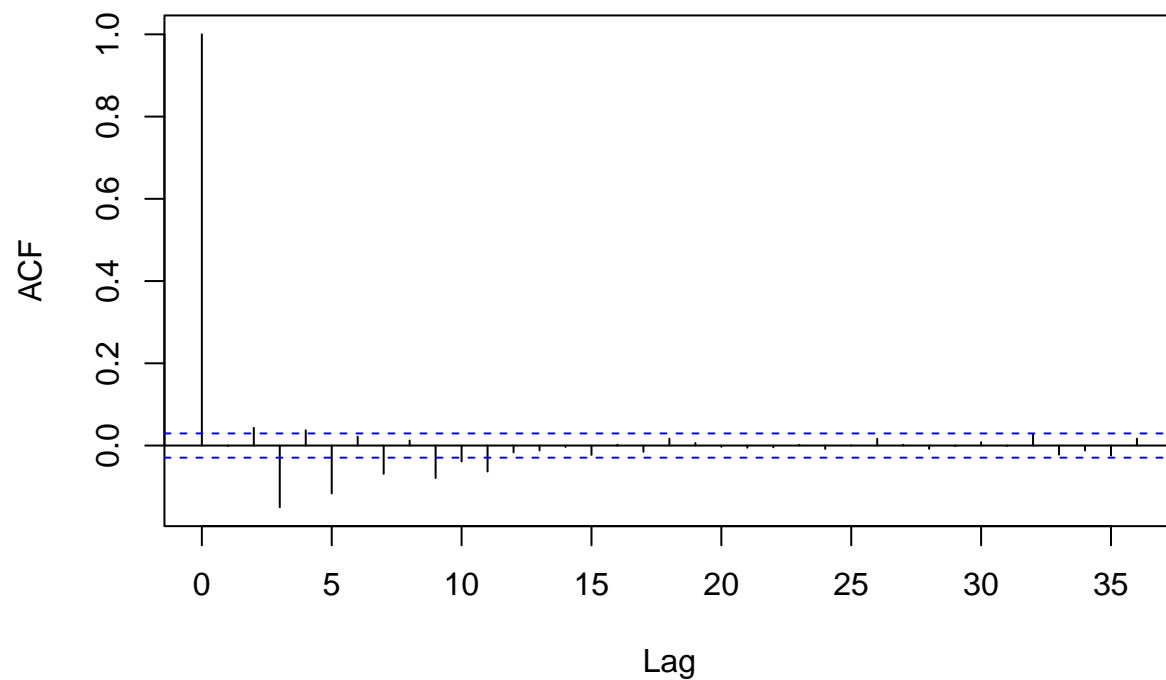

```
confint(db_mixed)
```

```
## Computing profile confidence intervals ...
```

```
##                    2.5 %      97.5 %
## .sig01        6.5201576   7.4364912
## .sigma        5.1967604   5.4332566
## (Intercept)  -7.1728196  -3.4834673
## age           0.2161043   0.2827228
## TIME          0.2494176   0.3221347
```

```
ranef(db_mixed)$id %>% head(5)
```

```
##   (Intercept)
## 1    6.014858
## 2   -4.935227
## 3   -7.522855
## 4   -6.913778
## 5   -2.064345
```

```
coef(db_mixed)$id %>% head(5)
```

```
##   (Intercept)       age       TIME
```

```
## 1    0.6862164 0.2494233 0.2858142
## 2  -10.2638683 0.2494233 0.2858142
## 3  -12.8514967 0.2494233 0.2858142
## 4  -12.2424199 0.2494233 0.2858142
## 5   -7.3929867 0.2494233 0.2858142
```

```
REsim(db_mixed)
```

```
##     groupFctr groupID        term         mean       median       sd
## 1          id       1 (Intercept)   5.921031836   5.860712755 1.366516
## 2          id       2 (Intercept)  -4.996040683  -5.008911261 1.171684
## 3          id       3 (Intercept)  -7.886633460  -8.107774999 3.470295
## 4          id       4 (Intercept)  -6.951297557  -6.990019795 1.258812
## 5          id       5 (Intercept)  -2.330901047  -2.519356490 3.328282
## 6          id       6 (Intercept)  -7.669912809  -7.674402670 1.270620
## 7          id       7 (Intercept) -12.568907244 -12.597502079 1.138802
## 8          id       8 (Intercept)  -7.988868957  -7.986361721 1.337046
## 9          id       9 (Intercept)  -5.962095737  -5.862016672 2.433585
## 10         id      10 (Intercept) -10.194796774 -10.185347007 1.318213
## 11         id      11 (Intercept)  -8.076079789  -8.095644518 1.326833
## 12         id      12 (Intercept)   1.130938492   1.145627117 1.295131
## 13         id      13 (Intercept) -13.869218793 -13.920167181 2.250389
## 14         id      14 (Intercept)  -2.270955241  -2.365255062 1.376815
## 15         id      15 (Intercept)   9.998212350  10.032754051 1.202521
## 16         id      16 (Intercept)  -8.077019399  -8.056256011 1.393285
## 17         id      17 (Intercept)  -0.426320949  -0.251604272 3.433333
## 18         id      18 (Intercept)   7.060957873   7.049878069 1.973036
## 19         id      19 (Intercept)  -5.311856133  -5.316481348 1.260965
## 20         id      20 (Intercept)  -7.295888801  -7.322648399 1.144286
## 21         id      21 (Intercept)   7.654549763   7.714388080 1.741456
## 22         id      22 (Intercept)  -5.693999242  -5.633268348 1.217312
## 23         id      23 (Intercept)  -4.363659179  -4.413557929 1.224792
## 24         id      24 (Intercept)   0.179264919   0.158678902 2.085292
## 25         id      25 (Intercept)  -2.543036133  -2.875650215 3.533785
## 26         id      26 (Intercept)   1.272896422   1.247734077 1.583939
## 27         id      27 (Intercept)  -4.078896500  -4.239929885 2.777520
## 28         id      28 (Intercept)  -4.754164793  -4.883406100 1.395076
## 29         id      29 (Intercept)   8.201360378   8.218657627 1.459052
## 30         id      30 (Intercept)  -9.688396042  -9.652876500 1.647238
## 31         id      31 (Intercept)  -4.016531384  -3.914637372 1.995465
## 32         id      32 (Intercept)  -1.950965563  -2.042390213 1.902374
## 33         id      33 (Intercept)   4.749398396   4.780090243 1.185741
## 34         id      34 (Intercept)   3.911287553   3.962017533 1.946775
## 35         id      35 (Intercept)  -6.960832533  -6.965553464 1.600071
## 36         id      36 (Intercept)  -2.794882470  -2.972946048 1.725899
## 37         id      37 (Intercept)  -4.930895899  -4.888972199 1.057460
## 38         id      38 (Intercept) -13.853906032 -13.859064182 1.481822
## 39         id      39 (Intercept)  -3.100395813  -3.113127587 2.178512
## 40         id      40 (Intercept)   2.292037026   2.443413414 2.597456
## 41         id      41 (Intercept)   0.587407715   0.626166655 1.606103
## 42         id      42 (Intercept)  -5.677681187  -5.721519768 2.012779
## 43         id      43 (Intercept)  -0.888290029  -0.926354957 1.665136
## 44         id      44 (Intercept)   0.766801784   0.776980063 2.109923
## 45         id      45 (Intercept)   2.262405261   2.280819734 1.661077
```

```
## 46         id      46 (Intercept)   2.749059836   2.749485870 1.579428
## 47         id      47 (Intercept)  -1.092701973  -1.120363282 1.933561
## 48         id      48 (Intercept)   6.841771968   6.861385704 1.496735
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## 304       id       304 (Intercept)   1.811170485    1.954764196 2.562033
## 305       id       305 (Intercept)  -1.956796923  -2.010787903 3.576973
## 306       id       306 (Intercept)   0.995917223    1.146514755 3.207361
## 307       id       307 (Intercept)   1.973797360    2.244203326 3.634613
## 308       id       308 (Intercept)  -7.343074726  -7.383346184 2.628399
## 309       id       309 (Intercept)  -8.595679513  -8.383271221 2.653688
## 310       id       310 (Intercept)   0.119943284    0.393788691 3.446296
## 311       id       311 (Intercept)   2.418900793    2.408676716 2.484545
## 312       id       312 (Intercept)  -6.246154084  -6.206615778 2.554055
## 313       id       313 (Intercept)  -5.149378512  -5.103972475 3.315093
## 314       id       314 (Intercept)   0.739070458    0.678872775 3.302741
## 315       id       315 (Intercept)   5.790605215    5.729639060 3.484616
```

```
## 316          id        316 (Intercept)    -2.995889879    -2.908162283 2.589871
## 317          id        317 (Intercept)    -0.557241154    -0.619749430 4.125632
## 318          id        318 (Intercept)    -3.190825996    -3.032827429 3.498845
## 319          id        319 (Intercept)    -0.722810866    -0.541725408 3.506915
## 320          id        320 (Intercept)    -3.039614857    -2.867385754 3.239049
## 321          id        321 (Intercept)    -2.690601611    -2.761717430 3.082598
## 322          id        322 (Intercept)    -3.863428126    -3.962799855 3.235428
## 323          id        323 (Intercept)    -4.920560567    -4.812819966 3.568233
## 324          id        324 (Intercept)    -1.417827491    -1.588278851 3.224253
## 325          id        325 (Intercept)     1.535880221     1.155458241 3.321452
## 326          id        326 (Intercept)     3.062381510     2.868675640 3.378459
## 327          id        327 (Intercept)    10.228298738    10.151198311 4.125985
## 328          id        328 (Intercept)    -6.494061814    -6.446671097 1.422737
## 329          id        329 (Intercept)     5.782223535     5.888211498 2.329028
## 330          id        330 (Intercept)    -0.497774026    -0.509489760 1.721687
## 331          id        331 (Intercept)    -0.032821795    -0.003061864 1.549049
## 332          id        332 (Intercept)     2.776292226     2.813859377 1.456510
## 333          id        333 (Intercept)    -7.014300980    -6.944468531 1.526289
## 334          id        334 (Intercept)    -6.332718612    -6.331757513 1.278348
## 335          id        335 (Intercept)    15.099001627    15.164977886 1.311287
## 336          id        336 (Intercept)    -3.578733096    -3.446951383 1.487259
## 337          id        337 (Intercept)     5.090616557     5.111436093 1.734198
## 338          id        338 (Intercept)     0.934478567     0.921932990 1.599235
## 339          id        339 (Intercept)    -1.648971980    -1.643613448 1.611325
## 340          id        340 (Intercept)    -1.577624510    -1.568560033 1.694669
## 341          id        341 (Intercept)    -2.911629151    -2.875359744 1.339588
## 342          id        342 (Intercept)    -6.954144068    -6.952923857 1.549288
## 343          id        343 (Intercept)     9.710410349     9.762210056 2.570546
## 344          id        344 (Intercept)    -3.119178483    -3.088843962 1.749813
## 345          id        345 (Intercept)     6.837184062     7.015493595 1.981563
## 346          id        346 (Intercept)    12.318873608    11.973036882 3.560810
## 347          id        347 (Intercept)     2.260622227     2.111892745 1.524786
## 348          id        348 (Intercept)     4.714550527     4.630694779 1.649793
## 349          id        349 (Intercept)     2.606080789     2.704891749 1.676976
## 350          id        350 (Intercept)    -2.860339884    -3.009276471 1.569356
## 351          id        351 (Intercept)    -1.107749101    -1.221814156 1.595974
## 352          id        352 (Intercept)     1.106831824     1.212607243 1.485242
## 353          id        353 (Intercept)    11.176609244    11.094248299 2.543607
## 354          id        354 (Intercept)    -0.672448734    -0.844703698 2.174168
## 355          id        355 (Intercept)    -5.627440211    -5.598219047 1.197477
## 356          id        356 (Intercept)    45.307049076    45.413000672 1.540233
## 357          id        357 (Intercept)    -6.105674153    -6.086539754 1.545959
## 358          id        358 (Intercept)    -2.841140495    -2.708296084 1.580716
## 359          id        359 (Intercept)    -8.488832390    -8.506016482 1.826027
## 360          id        360 (Intercept)    -0.056480899    -0.182465061 1.539838
## 361          id        361 (Intercept)    -5.654243230    -5.635862346 1.672917
## 362          id        362 (Intercept)     5.087953788     5.023936019 1.919214
## 363          id        363 (Intercept)    -6.151588626    -6.163050810 1.631438
## 364          id        364 (Intercept)    -9.126965241    -9.005822326 1.527900
## 365          id        365 (Intercept)    -5.849331352    -5.877521296 1.754755
## 366          id        366 (Intercept)    -4.102112018    -4.246502688 2.557918
## 367          id        367 (Intercept)    -0.471995796    -0.183662477 2.377620
## 368          id        368 (Intercept)     0.403452213     0.508108202 2.697750
## 369          id        369 (Intercept)    -0.990163166    -0.993324159 1.568624
```

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## 370      id     370 (Intercept)  -7.016407538   -7.058835717 1.946734
## 371      id     371 (Intercept)  -0.892922787   -0.855489421 1.329870
## 372      id     372 (Intercept)  -3.480106011   -3.485531779 2.003000
## 373      id     373 (Intercept)   3.144735077    3.045559698 2.921839
## 374      id     374 (Intercept)  -1.943090314   -1.963870753 1.975883
## 375      id     375 (Intercept)  -1.050806289   -1.234390622 2.309245
## 376      id     376 (Intercept)   0.280051421    0.205916878 2.005725
## 377      id     377 (Intercept)  -2.230430067   -2.323591396 1.546199
## 378      id     378 (Intercept)  -2.508138051   -2.481221659 1.448761
## 379      id     379 (Intercept)  -4.776839108   -4.698228345 1.462869
## 380      id     380 (Intercept)   8.138001336    8.200007663 1.618597
## 381      id     381 (Intercept)  21.075127332   21.065397197 1.655112
## 382      id     382 (Intercept)  -7.550584827   -7.440855406 1.916600
## 383      id     383 (Intercept)   2.811717059    2.818162212 2.263628
## 384      id     384 (Intercept)   0.426774389    0.455147839 1.688846
## 385      id     385 (Intercept)   0.571244800    0.541896880 1.626421
## 386      id     386 (Intercept)   2.864263707    2.905993744 1.472158
## 387      id     387 (Intercept)  -1.336334632   -1.193666566 1.628185
## 388      id     388 (Intercept)  -9.729245642   -9.754863199 1.767052
## 389      id     389 (Intercept)  -1.683758572   -1.797610569 1.985818
## 390      id     390 (Intercept)   5.022193991    5.198161054 2.975796
## 391      id     391 (Intercept)   5.009807284    4.943778334 1.964004
## 392      id     392 (Intercept)  -4.306803109   -4.339959533 3.293164
## 393      id     393 (Intercept)  -3.100031210   -3.108609752 2.118481
## 394      id     394 (Intercept)  -5.030443461   -5.113289967 1.989008
## 395      id     395 (Intercept)  -7.403923085   -7.336644672 1.518501
## 396      id     396 (Intercept)  -3.189689565   -3.280339450 3.378936
## 397      id     397 (Intercept)   5.520076976    5.447047894 1.960789
## 398      id     398 (Intercept)  -1.302137231   -1.547319639 3.058091
## 399      id     399 (Intercept)  14.550587664   14.584122251 2.252413
## 400      id     400 (Intercept)  -4.289477109   -4.530748685 4.252075
## 401      id     401 (Intercept)  -3.500494547   -3.621771262 1.818128
## 402      id     402 (Intercept)  -9.546318794   -9.425677573 1.679342
## 403      id     403 (Intercept)  -0.451771587   -0.458726901 2.130805
## 404      id     404 (Intercept)  -5.154278746   -5.199928099 1.829566
## 405      id     405 (Intercept)   3.261783457    3.214425346 1.504564
## 406      id     406 (Intercept)   0.712725434    0.838502625 3.449825
## 407      id     407 (Intercept)  -3.163796082   -3.222908212 2.462828
## 408      id     408 (Intercept)   4.018183719    4.218425746 2.031804
## 409      id     409 (Intercept)  -5.282521575   -5.253522012 1.654725
## 410      id     410 (Intercept)   2.455237650    2.493388781 2.039782
## 411      id     411 (Intercept)  -0.283885560   -0.151730892 1.623475
## 412      id     412 (Intercept)  -9.174859420   -9.235011799 2.244387
## 413      id     413 (Intercept)   1.208542478    1.153415739 1.763206
## 414      id     414 (Intercept)   6.060071520    6.109400153 1.717911
## 415      id     415 (Intercept)  -5.865668718   -5.929848956 1.801520
## 416      id     416 (Intercept)   3.327800106    3.213726195 2.152868
## 417      id     417 (Intercept)   5.744472583    5.677732192 1.649669
## 418      id     418 (Intercept) -10.232386159  -10.267892679 1.607549
## 419      id     419 (Intercept)  16.436759335   16.244564775 2.060931
## 420      id     420 (Intercept)  -2.460400042   -2.493110408 1.622590
## 421      id     421 (Intercept)   0.005057436   -0.101600366 1.993608
## 422      id     422 (Intercept)  -0.358459569   -0.469065899 2.029103
## 423      id     423 (Intercept)  -1.755325314   -1.861417283 1.653017
```

```
## 424       id      424 (Intercept)  -6.475915873   -6.332140894 1.918599
## 425       id      425 (Intercept)  -4.163474025   -4.168676339 2.538336
## 426       id      426 (Intercept)   0.140615011    0.169447103 1.567757
## 427       id      427 (Intercept)  -9.319504145   -9.385383462 1.458863
## 428       id      428 (Intercept)  -6.487325057   -6.359822266 2.397389
## 429       id      429 (Intercept)  -5.165254481   -5.156201942 1.710129
## 430       id      430 (Intercept)   1.139702230    1.120063693 1.531350
## 431       id      431 (Intercept)  -0.820331994   -0.963467000 2.238967
## 432       id      432 (Intercept)  -5.639885508   -5.681393206 2.018920
## 433       id      433 (Intercept)  -5.514490559   -5.661165692 2.696039
## 434       id      434 (Intercept)   1.818559094    1.893566465 2.182422
## 435       id      435 (Intercept)   2.848935944    2.710949497 3.592699
## 436       id      436 (Intercept)   0.157344825    0.347648055 2.140574
## 437       id      437 (Intercept)   6.136992099    6.163925884 2.162904
## 438       id      438 (Intercept) -10.944524918  -11.029297895 1.881426
## 439       id      439 (Intercept)  11.480766607   11.712891959 1.600097
## 440       id      440 (Intercept)  -0.082624948   -0.025752040 1.598309
## 441       id      441 (Intercept)  17.877719316   17.905224732 2.060020
## 442       id      442 (Intercept)  -1.207129953   -1.024414423 1.791605
## 443       id      443 (Intercept)  -9.248602077   -9.399185003 1.952915
## 444       id      444 (Intercept)   5.479911152    5.565605790 2.031576
## 445       id      445 (Intercept)   6.960201884    7.033108887 1.742904
## 446       id      446 (Intercept)  -6.131457787   -6.021269235 3.304092
## 447       id      447 (Intercept)   5.070468954    5.156946274 3.027578
## 448       id      448 (Intercept)  -4.616908243   -4.576496484 2.610992
## 449       id      449 (Intercept)  14.359921050   14.413741629 2.156788
## 450       id      450 (Intercept)  -0.409120687   -0.463372764 2.332007
## 451       id      451 (Intercept)   8.237484059    8.119849597 2.267675
## 452       id      452 (Intercept)  -4.917205263   -4.916742016 1.888782
## 453       id      453 (Intercept)  -3.795523890   -3.841647183 3.135939
## 454       id      454 (Intercept)   2.627689494    2.619085402 1.882503
## 455       id      455 (Intercept)  -0.636514859   -0.740497761 2.142843
## 456       id      456 (Intercept)  -2.735542137   -2.633992145 1.569668
## 457       id      457 (Intercept)  -2.139868895   -2.162262485 1.886013
## 458       id      458 (Intercept)  11.969253922   12.036783039 2.020671
## 459       id      459 (Intercept)  -6.645754747   -6.784900512 2.103799
## 460       id      460 (Intercept)   4.823433354    4.692089553 2.536349
## 461       id      461 (Intercept)   8.348073957    8.322816517 2.272086
## 462       id      462 (Intercept)  -6.765196109   -6.884750152 1.813700
## 463       id      463 (Intercept)  -2.731730272   -2.948104333 2.238380
## 464       id      464 (Intercept)  -3.934556322   -4.023946910 3.120912
## 465       id      465 (Intercept)   4.938816211    4.721037552 2.094303
## 466       id      466 (Intercept)   7.022360609    6.911272933 1.914526
## 467       id      467 (Intercept)  16.679597396   16.566672462 2.415353
## 468       id      468 (Intercept)   5.417415276    5.344303372 1.833601
## 469       id      469 (Intercept)   3.137400430    2.893376646 2.044754
## 470       id      470 (Intercept)   0.226328445    0.478098662 2.202820
## 471       id      471 (Intercept)   8.462904225    8.670754162 2.302394
## 472       id      472 (Intercept)   8.606178439    8.652075494 2.280788
## 473       id      473 (Intercept)  -2.155178680   -2.185932696 1.904913
## 474       id      474 (Intercept)  -4.008987375   -3.990452957 2.434584
## 475       id      475 (Intercept)   0.065792758    0.247729844 2.211369
## 476       id      476 (Intercept)   7.759080980    7.714285264 2.294318
## 477       id      477 (Intercept)   1.139401880    1.086382963 2.434162
```

```
## 478          id     478 (Intercept)    1.452080910     1.250748647 2.137062
## 479          id     479 (Intercept)   -3.772815811    -4.172108086 2.583343
## 480          id     480 (Intercept)   -3.459462711    -3.475919208 2.400876
## 481          id     481 (Intercept)    4.986420509     5.144164773 2.562584
## 482          id     482 (Intercept)   -0.395105323    -0.436373414 2.468992
## 483          id     483 (Intercept)    1.319323099     1.609158244 2.506618
## 484          id     484 (Intercept)   25.446369688    25.587512665 2.459626
## 485          id     485 (Intercept)   -1.611721671    -1.867470833 2.814399
## 486          id     486 (Intercept)    4.461515823     4.255010517 2.627411
## 487          id     487 (Intercept)   -1.965974629    -2.015832161 3.162190
## 488          id     488 (Intercept)   -5.954243490    -6.004860874 1.993310
## 489          id     489 (Intercept)    4.376638527     4.266727085 3.290472
## 490          id     490 (Intercept)   13.028356146    12.965220730 3.164312
## 491          id     491 (Intercept)    1.452335473     1.149352025 2.599997
## 492          id     492 (Intercept)    3.123041106     3.278121325 2.500049
## 493          id     493 (Intercept)   -3.970954388    -3.901938066 2.211268
## 494          id     494 (Intercept)   -1.855383810    -1.710532111 3.479248
## 495          id     495 (Intercept)   12.025125631    11.944749314 3.410659
## 496          id     496 (Intercept)    6.684623354     6.852344948 2.043928
## 497          id     497 (Intercept)   -0.708873540    -0.679331275 2.002812
## 498          id     498 (Intercept)   -0.292641619    -0.320281656 2.271521
## 499          id     499 (Intercept)   19.547328830    19.402794978 2.082965
## 500          id     500 (Intercept)   -5.002555488    -4.791454240 3.598830
## 501          id     501 (Intercept)    7.949652614     7.805875296 2.731124
## 502          id     502 (Intercept)    1.874799091     2.059299487 2.495346
## 503          id     503 (Intercept)    1.490717357     1.385291164 2.516980
## 504          id     504 (Intercept)    9.031477865     8.862595700 2.627156
## 505          id     505 (Intercept)    6.121010689     6.088495914 3.356826
## 506          id     506 (Intercept)   -4.582174084    -4.407574888 3.307578
## 507          id     507 (Intercept)   -3.349854762    -3.381673138 2.516752
## 508          id     508 (Intercept)    4.467357614     4.217376386 2.640596
## 509          id     509 (Intercept)   -3.781535378    -3.823974980 2.704097
## 510          id     510 (Intercept)   -0.418350048    -0.652503109 3.630838
## 511          id     511 (Intercept)   -3.802193392    -3.780365709 2.714479
## 512          id     512 (Intercept)    1.858189088     1.851266974 2.490426
## 513          id     513 (Intercept)   -2.913182616    -2.674358084 3.393477
## 514          id     514 (Intercept)   -4.854170477    -5.098310857 4.345181
## 515          id     515 (Intercept)   11.148982633    11.174940668 2.739590
## 516          id     516 (Intercept)   -3.753906684    -3.761900898 2.465926
## 517          id     517 (Intercept)   -3.464404421    -3.375644369 3.022528
## 518          id     518 (Intercept)   -2.072279253    -2.013256494 2.731650
## 519          id     519 (Intercept)   16.604555920    16.579913269 2.502551
## 520          id     520 (Intercept)   -5.823509763    -5.919401793 2.559061
## 521          id     521 (Intercept)   -8.622978012    -8.676670994 2.386457
## 522          id     522 (Intercept)   14.267293977    13.900069568 3.205363
## 523          id     523 (Intercept)    1.759266400     1.915204055 2.564081
## 524          id     524 (Intercept)   12.329081483    12.442466084 2.666153
## 525          id     525 (Intercept)    2.762399996     2.671572525 2.415492
## 526          id     526 (Intercept)   -4.149271068    -3.957113858 3.295550
## 527          id     527 (Intercept)    0.034407550     0.084545335 2.586000
## 528          id     528 (Intercept)    0.726375535     0.865232824 3.468683
## 529          id     529 (Intercept)    0.026507715     0.002559188 3.421044
## 530          id     530 (Intercept)   -0.083006647     0.062516868 3.397505
## 531          id     531 (Intercept)   -2.350444492    -2.398505792 3.399576
```

```
## 532        id       532 (Intercept)      5.591358638    5.601235157 2.519449
## 533        id       533 (Intercept)      9.657712831    9.623509299 2.400088
## 534        id       534 (Intercept)      4.948004425    4.845465156 2.957720
## 535        id       535 (Intercept)      1.455846199    1.936014971 4.388271
## 536        id       536 (Intercept)      7.086432486    7.248683331 3.235759
## 537        id       537 (Intercept)      3.188657709    3.291926343 3.377051
## 538        id       538 (Intercept)      1.906564365    1.792347648 3.529973
## 539        id       539 (Intercept)      0.196363718    0.148483599 4.337234
## 540        id       540 (Intercept)      7.680163425    7.524495177 3.433858
## 541        id       541 (Intercept)      1.497987786    1.506065110 3.532236
## 542        id       542 (Intercept)      7.967057943    7.991350980 3.184824
## 543        id       543 (Intercept)      4.628916540    4.924983853 3.726835
## 544        id       544 (Intercept)      6.495834839    6.319969910 3.567145
## 545        id       545 (Intercept)      2.437755793    2.777320396 3.206454
## 546        id       546 (Intercept)     -1.311584553   -1.679073074 3.539229
```

```
plotREsim(REsim(db_mixed))
```


Effect Ranges
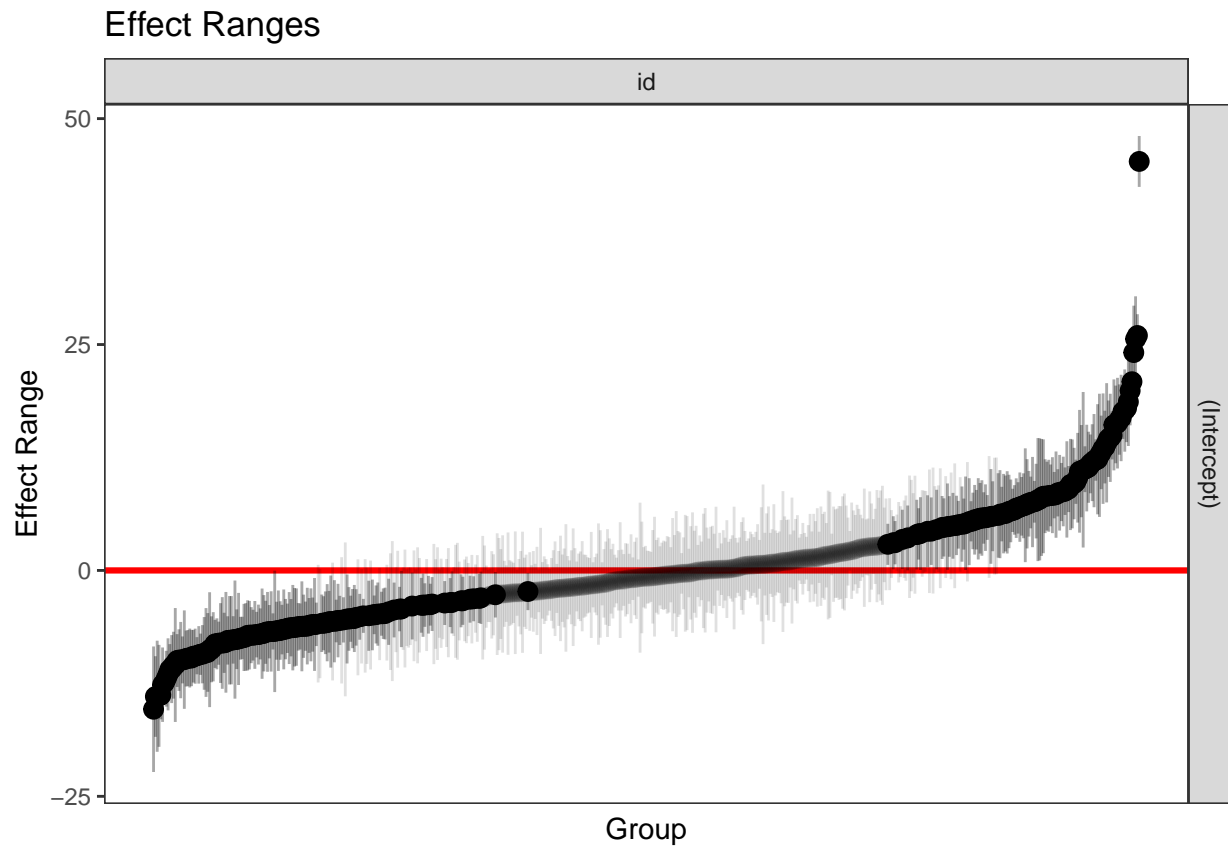
```
dat_mixed<-data.frame(time=df$TIME,pred=fitted(db_mixed),Subject=df$id)
dat_mixed$Subject<-as.numeric(dat_mixed$Subject)
ggplot(data=dat_mixed,aes(x=time,y=pred,group=Subject,color=Subject))+theme_classic()+geom_line()
```
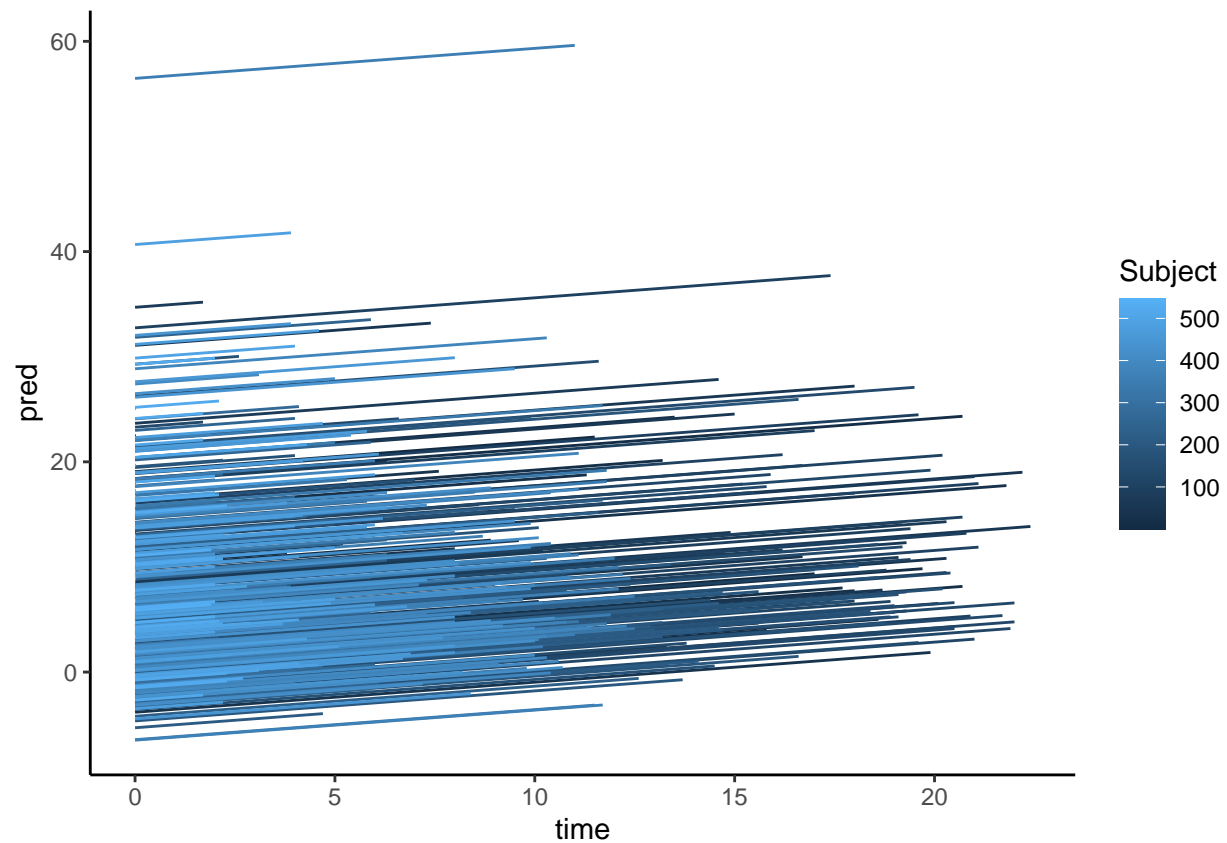
```
mean(sqrt(resid(db_mixed)^2))
```

```
## [1] 3.747102
```

```
#assumptions check
#1. Error terms follow a Normal Distribution
#2. Beta for subject i follows a Normal Distribution
qint<-ranef(db_mixed)$id[["(Intercept)"]]
qres<-residuals(db_mixed)
qqnorm(qint,ylab = "Estimated Random Intecepts",main = "Random Intecepts")
qqline(qint)
```

Random Intecepts
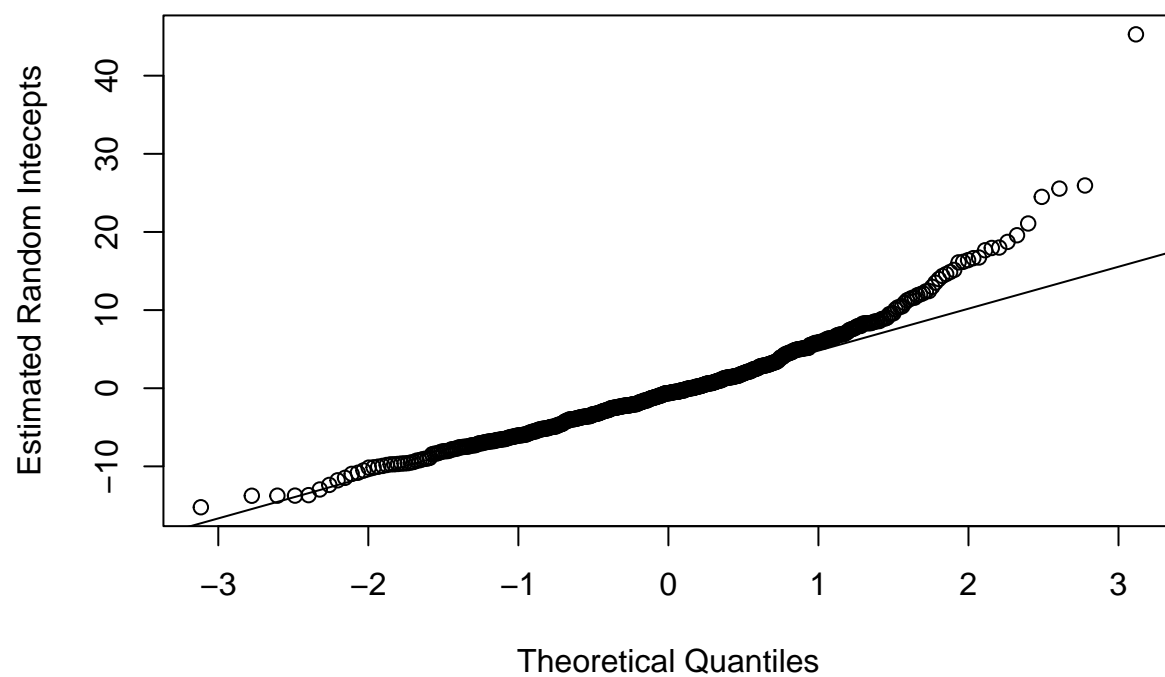

```
qqnorm(qres,ylab = "Estimated Residuals",main = "Residuals")
qqline(qres)
```

Residuals
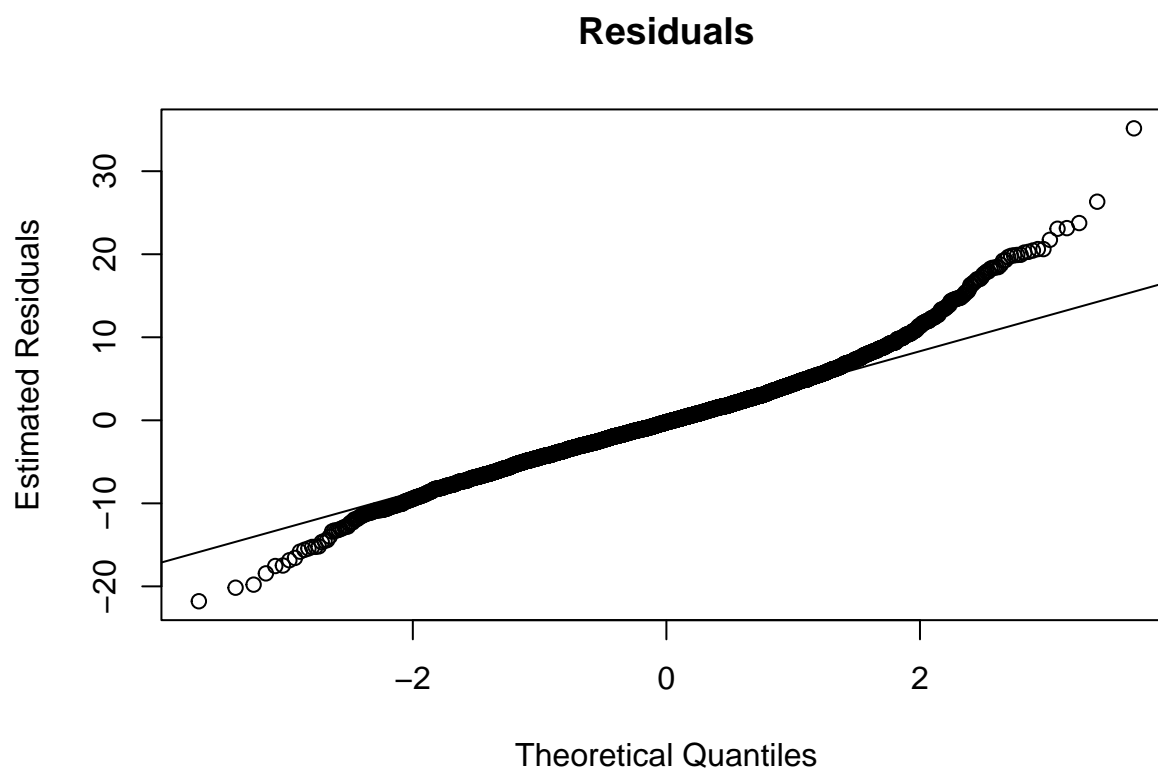

```
db_mixed2 = lmer(y ~ age+TIME + (TIME | id), data = df,na.action = na.omit)
```

```
## Warning in checkConv(attr(opt, "derivs"), opt$par, ctrl = control$checkConv, :
## Model failed to converge with max|grad| = 0.0329069 (tol = 0.002, component 1)
```

```
summary(db_mixed2)
```

```
## Linear mixed model fit by REML ['lmerMod']
## Formula: y ~ age + TIME + (TIME | id)
##    Data: df
##
## REML criterion at convergence: 28548
##
## Scaled residuals:
##     Min      1Q  Median      3Q     Max
## -4.2434 -0.5595 -0.0475  0.5043  6.9585
##
## Random effects:
##  Groups   Name        Variance Std.Dev. Corr
##  id       (Intercept) 49.3871  7.0276
##           TIME         0.1547  0.3933   -0.17
##  Residual             25.6657  5.0661
## Number of obs: 4419, groups:  id, 546
##
```

```
## Fixed effects:
##             Estimate Std. Error t value
## (Intercept) -5.03542    0.93729  -5.372
## age          0.24377    0.01690  14.428
## TIME         0.28296    0.03091   9.153
##
## Correlation of Fixed Effects:
##      (Intr) age
## age  -0.938
## TIME -0.118  0.025
## optimizer (nloptwrap) convergence code: 0 (OK)
## Model failed to converge with max|grad| = 0.0329069 (tol = 0.002, component 1)
```

```
plot(db_mixed2)
```
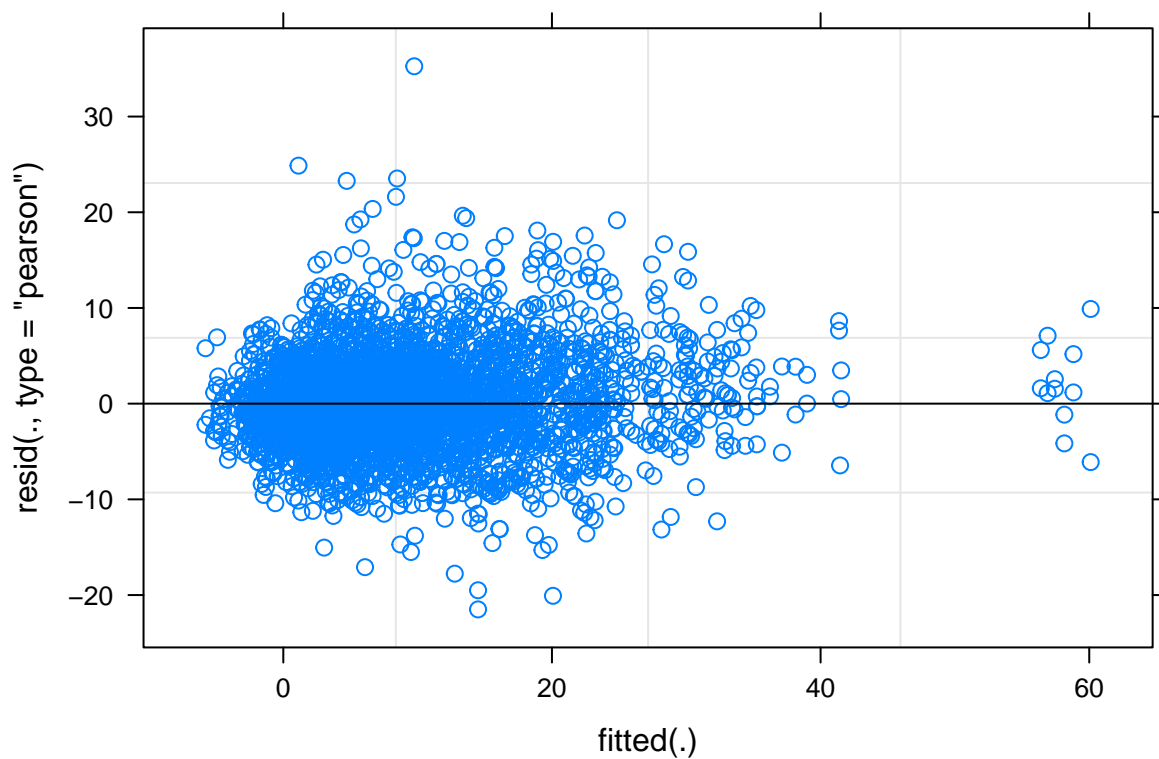


```
hist(residuals(db_mixed2), breaks = 50)
```

Histogram of residuals(db_mixed2)
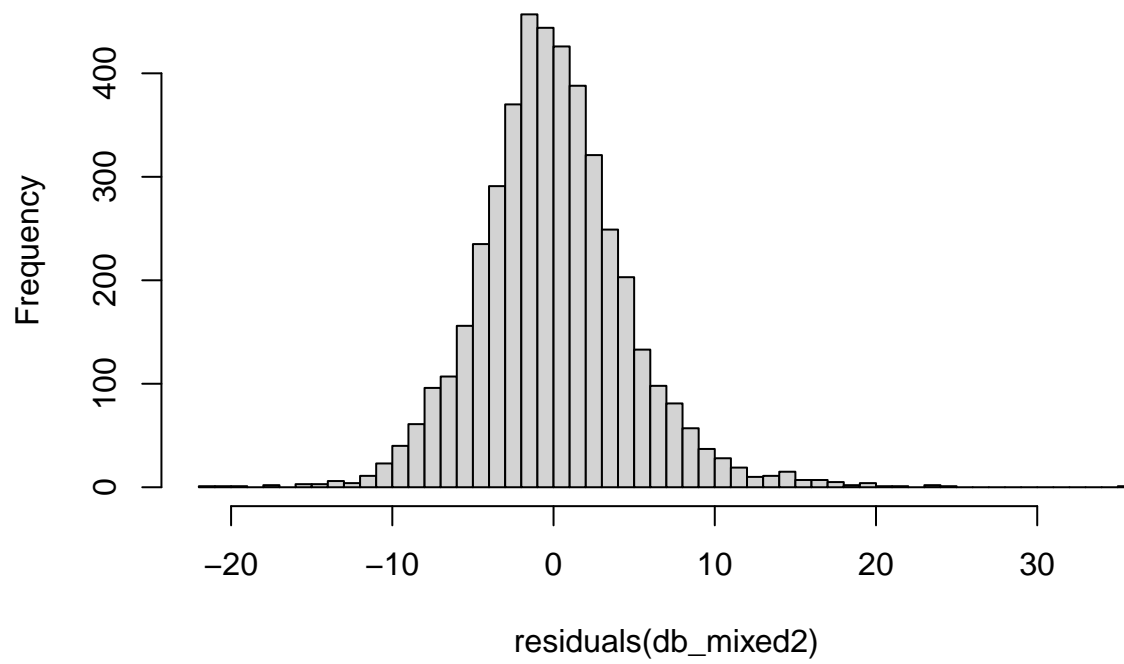

```
plot(residuals(db_mixed2), type = "l")
```
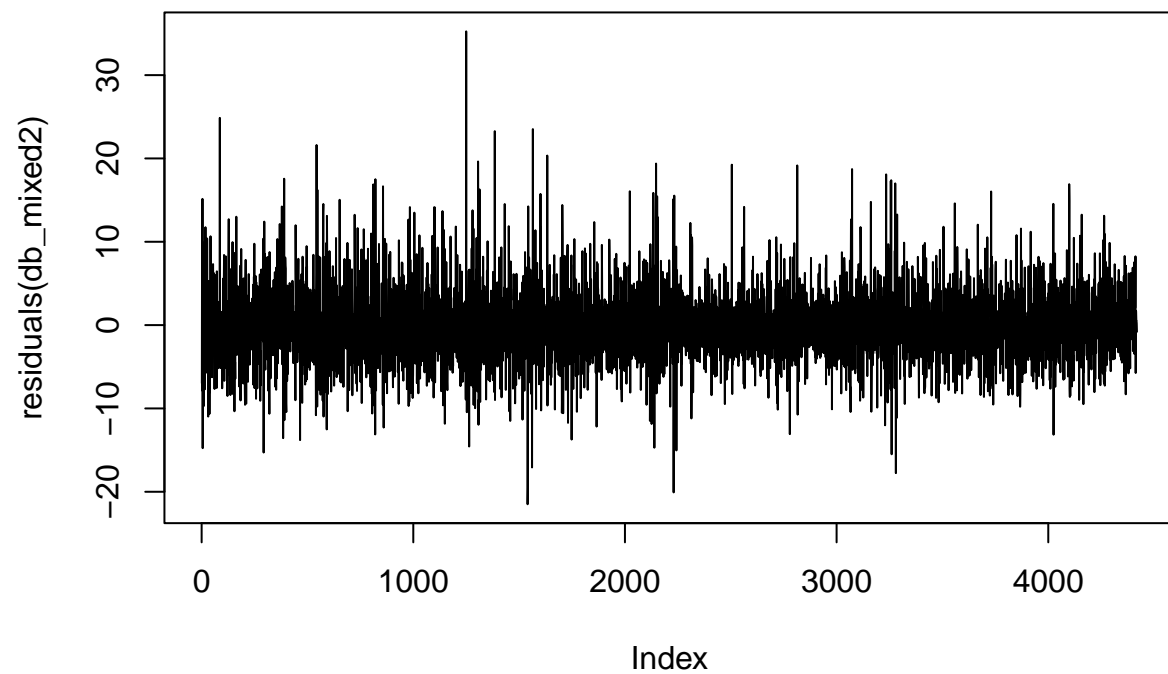
```
shapiro.test(residuals(db_mixed2))
```

```
## 
##  Shapiro-Wilk normality test
## 
## data:  residuals(db_mixed2)
## W = 0.97582, p-value < 2.2e-16
```

```
acf(residuals(db_mixed2))
```

Series residuals(db_mixed2)
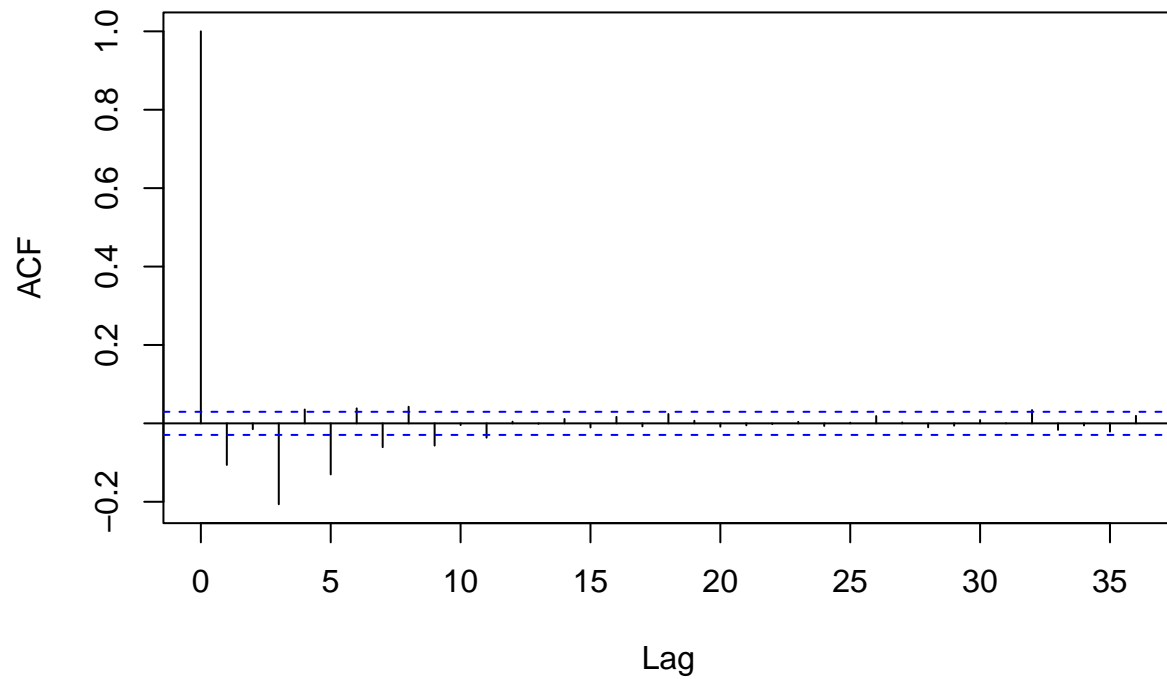

```r
confint(db_mixed2)
```

```
## Computing profile confidence intervals ...
```

```
##                     2.5 %       97.5 %
## .sig01         6.5406650   7.51789452
## .sig02        -0.3295534   0.00138868
## .sig03         0.3272181   0.46162676
## .sigma         4.9505555   5.18761884
## (Intercept)  -6.9147704  -3.15765854
## age            0.2097636   0.27775884
## TIME           0.2216831   0.34385036
```

```r
ranef(db_mixed2)$id %>% head(5)
```

```
##   (Intercept)        TIME
## 1    5.048471 0.17564946
## 2   -6.345893 0.14793964
## 3   -7.641045 0.07447785
## 4   -8.438962 0.19058724
## 5   -2.095547 0.02042546
```

```
coef(db_mixed2)$id %>% head(5)
```

```
##   (Intercept)        age       TIME
## 1    0.01305382 0.2437696 0.4586055
## 2  -11.38130988 0.2437696 0.4308957
## 3  -12.67646234 0.2437696 0.3574339
## 4  -13.47437975 0.2437696 0.4735433
## 5   -7.13096470 0.2437696 0.3033815
```

```
REsim(db_mixed2)
```

```
##      groupFctr groupID        term          mean        median        sd
## 1           id       1 (Intercept)  5.129393e+00   4.984581716 1.7719671
## 2           id       2 (Intercept) -6.510582e+00  -6.358139216 1.8228594
## 3           id       3 (Intercept) -7.085457e+00  -6.963498593 3.2284619
## 4           id       4 (Intercept) -8.477490e+00  -8.676919454 1.9333767
## 5           id       5 (Intercept) -2.273333e+00  -2.081406270 3.3318973
## 6           id       6 (Intercept) -4.600285e+00  -4.827531140 1.9818907
## 7           id       7 (Intercept) -1.391598e+01 -13.763626756 2.0796228
## 8           id       8 (Intercept) -5.742533e+00  -5.733606398 2.0958659
## 9           id       9 (Intercept) -5.219719e+00  -5.062586557 2.7185151
## 10          id      10 (Intercept) -9.746885e+00  -9.738282578 2.2541011
## 11          id      11 (Intercept) -8.897611e+00  -8.971608445 1.9426766
## 12          id      12 (Intercept)  2.043877e+00   2.024037757 1.8386760
## 13          id      13 (Intercept) -1.400353e+01 -14.004635421 2.5081510
## 14          id      14 (Intercept) -2.390923e+00  -2.343290003 1.9956054
## 15          id      15 (Intercept)  4.854849e+00   4.790225590 2.0489877
## 16          id      16 (Intercept) -7.362139e+00  -7.609782406 2.2229032
## 17          id      17 (Intercept) -3.462323e-01  -0.338585480 3.7642725
## 18          id      18 (Intercept)  7.018701e+00   6.650317282 2.2607156
## 19          id      19 (Intercept) -6.989203e+00  -6.922124530 2.0629165
## 20          id      20 (Intercept) -5.569820e+00  -5.409234706 1.9801069
## 21          id      21 (Intercept)  8.171315e+00   8.005693284 2.4313003
## 22          id      22 (Intercept) -5.466328e+00  -5.485697178 2.1429288
## 23          id      23 (Intercept) -4.575705e+00  -4.477073756 2.0745182
## 24          id      24 (Intercept)  5.262021e-01   0.672516938 2.0579281
## 25          id      25 (Intercept) -2.442134e+00  -2.066273616 3.0441617
## 26          id      26 (Intercept)  2.026864e+00   2.033113916 2.1437800
## 27          id      27 (Intercept) -4.032962e+00  -3.995868390 2.3092195
## 28          id      28 (Intercept) -2.301495e+00  -2.412011131 2.1352995
## 29          id      29 (Intercept)  1.056871e+01  10.622034954 2.1555395
## 30          id      30 (Intercept) -6.948872e+00  -6.812224745 2.1108423
## 31          id      31 (Intercept) -5.143198e+00  -5.513725588 2.4949251
## 32          id      32 (Intercept)  2.015647e+00   2.010141906 2.6579615
## 33          id      33 (Intercept)  8.327758e+00   8.319932257 2.1514407
## 34          id      34 (Intercept)  4.734131e+00   4.702944968 2.2618164
## 35          id      35 (Intercept) -9.007675e+00  -9.186577500 2.6206658
## 36          id      36 (Intercept) -2.565289e+00  -2.671441607 2.1768813
## 37          id      37 (Intercept) -3.958647e+00  -3.855794263 1.8514329
## 38          id      38 (Intercept) -1.190745e+01 -11.751757981 2.2919513
## 39          id      39 (Intercept) -3.099380e+00  -3.059422310 2.0575468
## 40          id      40 (Intercept)  2.376128e+00   2.156167429 2.5092280
## 41          id      41 (Intercept)  2.708617e+00   2.958817051 2.3829806
```

```
## 42        id      42 (Intercept) -6.964233e+00  -7.184385139 2.4904035
## 43        id      43 (Intercept)  1.890379e+00   1.945736091 2.3464377
## 44        id      44 (Intercept)  1.372869e+00   1.387323967 3.1231099
## 45        id      45 (Intercept)  2.331306e+00   2.455376823 2.2786622
## 46        id      46 (Intercept)  2.523544e+00   2.528859470 2.0414921
## 47        id      47 (Intercept)  4.252689e-02   0.098697589 2.2073587
## 48        id      48 (Intercept)  8.307464e+00   8.452520041 2.3244051
## 49        id      49 (Intercept)  1.721145e+01  17.383120935 2.4968637
## 50        id      50 (Intercept) -1.356669e+01 -13.695193129 3.1284525
## 51        id      51 (Intercept) -7.943283e+00  -7.863386415 2.4210651
## 52        id      52 (Intercept)  5.227435e+00   5.293139492 2.2800326
## 53        id      53 (Intercept)  3.837893e+00   3.882137031 2.0610317
## 54        id      54 (Intercept) -8.126798e+00  -8.129332348 2.4155229
## 55        id      55 (Intercept) -4.847428e+00  -4.894803114 2.4131227
## 56        id      56 (Intercept) -2.822562e+00  -2.846880800 2.0428101
## 57        id      57 (Intercept)  1.463417e+01  14.443976841 2.0941983
## 58        id      58 (Intercept)  3.382214e+00   3.557781132 2.4476293
## 59        id      59 (Intercept) -6.943279e-01  -0.689958659 2.1605988
## 60        id      60 (Intercept)  2.821091e+00   2.804258718 2.2201679
## 61        id      61 (Intercept)  4.710959e-01   0.615989795 2.1635018
## 62        id      62 (Intercept)  1.053685e+01  10.658247020 3.0699713
## 63        id      63 (Intercept) -1.824091e+00  -1.844556499 1.8939952
## 64        id      64 (Intercept) -5.002151e+00  -5.045804064 2.0451882
## 65        id      65 (Intercept)  2.685920e+00   2.619415286 2.6441931
## 66        id      66 (Intercept) -6.976823e+00  -7.061215041 2.0016599
## 67        id      67 (Intercept)  6.455580e+00   6.398812280 1.9508297
## 68        id      68 (Intercept) -4.150574e-01  -0.326442914 2.0273613
## 69        id      69 (Intercept) -1.015154e+01 -10.257815086 2.2045692
## 70        id      70 (Intercept)  6.698311e+00   6.749448685 2.6386642
## 71        id      71 (Intercept) -8.716392e+00  -9.026444398 2.2839796
## 72        id      72 (Intercept)  2.522313e+01  25.136169407 2.5580790
## 73        id      73 (Intercept) -8.536176e-04  -0.164792640 1.9195087
## 74        id      74 (Intercept) -8.464392e-01  -0.856383719 2.0842768
## 75        id      75 (Intercept) -6.336599e+00  -6.263099413 2.0959661
## 76        id      76 (Intercept)  4.653542e+00   4.769219786 2.2715283
## 77        id      77 (Intercept) -2.681902e+00  -2.637329422 2.3104587
## 78        id      78 (Intercept) -8.409104e+00  -8.388765529 2.2822241
## 79        id      79 (Intercept) -8.781994e+00  -8.960569861 2.0052072
## 80        id      80 (Intercept)  2.295053e+00   2.343907419 2.1414000
## 81        id      81 (Intercept) -5.980224e+00  -6.164695161 1.9001608
## 82        id      82 (Intercept) -7.247804e+00  -7.101101534 3.3626891
## 83        id      83 (Intercept)  5.195955e+00   5.025163976 3.4494889
## 84        id      84 (Intercept) -7.110176e+00  -7.201431970 2.4591767
## 85        id      85 (Intercept) -3.808757e+00  -3.828963842 1.7777097
## 86        id      86 (Intercept) -6.183143e-02  -0.029698071 2.4136968
## 87        id      87 (Intercept)  4.093774e+00   3.934358348 2.2535515
## 88        id      88 (Intercept) -2.219530e+00  -2.115637319 1.9888860
## 89        id      89 (Intercept) -6.648895e-01  -0.343984791 3.1856786
## 90        id      90 (Intercept) -5.570020e+00  -5.555750612 2.1118149
## 91        id      91 (Intercept) -3.953559e+00  -4.023224682 1.8503845
## 92        id      92 (Intercept)  1.100307e+01  10.894684246 2.2547167
## 93        id      93 (Intercept) -6.293616e+00  -6.388708508 2.2994559
## 94        id      94 (Intercept) -4.587346e-01  -0.470242693 1.9156027
## 95        id      95 (Intercept) -1.625640e-01  -0.050857611 2.1654334
```

```
## 96       id       96 (Intercept) -3.707594e+00  -3.709619683 2.2608769
## 97       id       97 (Intercept) -1.605400e+00  -1.616951541 2.1094815
## 98       id       98 (Intercept) -3.748851e+00  -3.730754645 2.5093394
## 99       id       99 (Intercept)  2.440908e+01  24.436007942 2.0781897
## 100      id      100 (Intercept)  3.798783e+00   3.954612713 2.1993088
## 101      id      101 (Intercept) -3.905308e+00  -4.054669861 3.0387302
## 102      id      102 (Intercept)  3.790855e-01   0.274193762 1.9991434
## 103      id      103 (Intercept)  6.084438e+00   6.073719692 2.4679545
## 104      id      104 (Intercept)  1.902995e+00   1.636117796 2.0763398
## 105      id      105 (Intercept)  5.482652e+00   5.282069949 1.7836942
## 106      id      106 (Intercept) -5.177115e+00  -5.055050429 2.1100290
## 107      id      107 (Intercept)  5.466927e+00   5.373370708 1.9158854
## 108      id      108 (Intercept) -1.046719e+01 -10.616361760 2.3650275
## 109      id      109 (Intercept) -2.857497e+00  -2.890981150 2.6384006
## 110      id      110 (Intercept) -6.659804e+00  -6.692611083 2.4533223
## 111      id      111 (Intercept)  2.968890e+00   2.974600982 2.4467947
## 112      id      112 (Intercept) -1.135134e+01 -11.590525482 2.5705663
## 113      id      113 (Intercept) -1.878532e+00  -1.766394569 2.6723218
## 114      id      114 (Intercept) -1.558349e+01 -15.670230207 3.4680169
## 115      id      115 (Intercept) -1.068420e+00  -1.381465650 2.1861965
## 116      id      116 (Intercept) -1.171431e-01  -0.271317450 2.5590938
## 117      id      117 (Intercept)  1.210740e+00   1.119621360 2.3107145
## 118      id      118 (Intercept) -2.967443e+00  -3.031908809 2.4036480
## 119      id      119 (Intercept) -7.303399e+00  -7.181128659 2.5056616
## 120      id      120 (Intercept) -5.073479e+00  -4.927079709 2.1787502
## 121      id      121 (Intercept) -8.545166e+00  -8.694389041 2.0209935
## 122      id      122 (Intercept) -3.571034e+00  -3.526505804 1.8758381
## 123      id      123 (Intercept) -2.380425e+00  -2.685529046 2.0497730
## 124      id      124 (Intercept) -1.161015e+01 -11.910615534 2.3775623
## 125      id      125 (Intercept) -3.133420e+00  -2.972408016 2.0635161
## 126      id      126 (Intercept)  7.098281e+00   7.248328990 2.1032329
## 127      id      127 (Intercept)  1.531968e+01  15.260416585 2.2519335
## 128      id      128 (Intercept)  5.833228e+00   5.634507712 3.2906028
## 129      id      129 (Intercept) -8.209392e+00  -8.297438126 2.3483375
## 130      id      130 (Intercept)  5.979603e+00   6.155688838 2.4949080
## 131      id      131 (Intercept) -6.749465e+00  -6.512074611 2.5498267
## 132      id      132 (Intercept)  8.732883e+00   8.840785736 2.2815715
## 133      id      133 (Intercept) -1.080121e-01  -0.146114489 3.0445188
## 134      id      134 (Intercept)  2.772518e+00   2.828297041 2.9505217
## 135      id      135 (Intercept) -1.242467e+00  -1.038366124 2.0951063
## 136      id      136 (Intercept) -1.303461e+00  -1.291058720 2.2964259
## 137      id      137 (Intercept) -1.431412e+00  -1.358251780 2.0175461
## 138      id      138 (Intercept)  2.856289e+00   2.811629491 2.1582018
## 139      id      139 (Intercept) -5.672909e+00  -5.783347504 2.2015634
## 140      id      140 (Intercept)  2.462593e+00   2.652042485 2.3106320
## 141      id      141 (Intercept)  6.590544e+00   6.728789967 1.9533578
## 142      id      142 (Intercept)  4.663122e-01   0.634121491 2.6668803
## 143      id      143 (Intercept) -7.631783e+00  -7.698681776 2.2832133
## 144      id      144 (Intercept)  8.238334e+00   8.227340736 3.6761054
## 145      id      145 (Intercept) -4.867896e+00  -4.914034723 2.2972858
## 146      id      146 (Intercept) -6.017120e+00  -6.011119986 2.0637634
## 147      id      147 (Intercept) -4.526451e+00  -4.567958584 2.2804027
## 148      id      148 (Intercept) -7.754925e+00  -7.908195896 2.2080874
## 149      id      149 (Intercept)  1.965689e+00   1.985754558 2.5730458
```

```
## 150        id        150 (Intercept) -7.216666e+00   -7.096180236 1.8402303
## 151        id        151 (Intercept)  9.767740e+00    9.891012219 2.4627000
## 152        id        152 (Intercept) -4.677071e+00   -4.884149235 2.2812876
## 153        id        153 (Intercept)  1.958440e+00    2.166983247 3.3530157
## 154        id        154 (Intercept) -3.644506e+00   -3.547139471 2.0968177
## 155        id        155 (Intercept) -2.816513e-01   -0.207913185 2.1946052
## 156        id        156 (Intercept) -8.602226e+00   -8.437211654 3.0465320
## 157        id        157 (Intercept)  5.038564e+00    5.125129893 2.0524259
## 158        id        158 (Intercept) -1.712130e+00   -2.013396937 2.4314326
## 159        id        159 (Intercept)  3.187176e+00    3.295380511 3.0733521
## 160        id        160 (Intercept) -4.760918e+00   -5.012510983 2.6481352
## 161        id        161 (Intercept)  1.766812e+00    1.684580850 2.3525752
## 162        id        162 (Intercept)  4.257892e+00    4.336332116 2.1441364
## 163        id        163 (Intercept) -1.180646e+00   -1.081326198 2.5234371
## 164        id        164 (Intercept) -1.034357e+01  -10.463131407 2.0568146
## 165        id        165 (Intercept) -1.834501e+00   -1.693358417 2.6936060
## 166        id        166 (Intercept)  1.667702e+01   16.795088095 2.5254655
## 167        id        167 (Intercept)  1.431219e+00    1.385838989 2.6849592
## 168        id        168 (Intercept) -1.799516e+00   -1.981701299 2.2658932
## 169        id        169 (Intercept)  1.448051e-01    0.090532010 2.3782261
## 170        id        170 (Intercept)  1.927460e+01   19.140991398 2.3152374
## 171        id        171 (Intercept) -5.639411e+00   -5.565023568 2.0508947
## 172        id        172 (Intercept) -3.498744e-01   -0.313466140 2.1674275
## 173        id        173 (Intercept)  9.490385e-01    0.900352497 2.4318194
## 174        id        174 (Intercept) -7.417711e+00   -7.261539614 2.3700177
## 175        id        175 (Intercept) -2.522916e+00   -2.550314711 2.4684235
## 176        id        176 (Intercept)  2.129272e+00    2.224540577 2.1004347
## 177        id        177 (Intercept)  6.850801e-01    0.628357198 2.2620949
## 178        id        178 (Intercept)  2.282897e+00    2.182026742 1.9722267
## 179        id        179 (Intercept) -4.680716e+00   -4.587323283 3.2174162
## 180        id        180 (Intercept) -3.454305e+00   -3.501353193 2.0237238
## 181        id        181 (Intercept)  7.784176e+00    7.751562540 1.7627547
## 182        id        182 (Intercept) -5.195028e+00   -5.112294945 3.2568688
## 183        id        183 (Intercept) -1.334825e-01   -0.267389256 2.1419704
## 184        id        184 (Intercept)  1.296189e+00    1.407410687 2.7467838
## 185        id        185 (Intercept) -4.362163e-02   -0.015524925 2.0549768
## 186        id        186 (Intercept)  2.241353e+00    2.239205606 2.2995361
## 187        id        187 (Intercept)  8.648268e-01    1.006439537 2.1379079
## 188        id        188 (Intercept)  3.560547e+00    3.743239131 1.8686314
## 189        id        189 (Intercept)  3.193542e+00    2.905482411 2.1013918
## 190        id        190 (Intercept)  1.527111e+00    1.590198933 2.1987347
## 191        id        191 (Intercept) -5.342540e+00   -5.187048115 2.1317503
## 192        id        192 (Intercept) -7.828762e-01   -0.741487198 2.2424289
## 193        id        193 (Intercept) -5.587187e+00   -5.819155539 2.1497721
## 194        id        194 (Intercept) -3.542692e+00   -3.382354047 2.2097898
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## 233        id      233 (Intercept) -7.114260e+00  -7.254455560 1.9446217
## 234        id      234 (Intercept)  4.578287e+00   4.600541436 2.2805581
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## 268        id     268 (Intercept)  1.128318e+00   1.197947765 2.5156053
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## 272        id     272 (Intercept) -1.888690e+00  -1.795564303 2.2927852
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## 274        id     274 (Intercept)  7.953995e-03   0.083117092 2.1486136
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## 450       id       450 (Intercept) -9.321349e-02  -0.030407651 2.4432371
## 451       id       451 (Intercept)  8.420286e+00   8.561153925 2.2277404
## 452       id       452 (Intercept) -4.683899e+00  -4.698779055 2.0346196
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## 454       id       454 (Intercept)  2.628411e+00   2.607528167 1.8313691
## 455       id       455 (Intercept) -2.804760e-01  -0.463378560 2.2993625
## 456       id       456 (Intercept) -2.067532e+00  -2.092981365 1.9382757
## 457       id       457 (Intercept) -2.562312e+00  -2.567299067 1.9014301
## 458       id       458 (Intercept)  1.203907e+01  11.757382023 2.1134532
## 459       id       459 (Intercept) -6.445255e+00  -6.509336132 2.4271867
## 460       id       460 (Intercept)  4.438010e+00   4.519955270 2.5693456
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## 465       id       465 (Intercept)  5.164735e+00   5.160824315 2.3221797
## 466       id       466 (Intercept)  6.717379e+00   6.345128508 2.5115546
## 467       id       467 (Intercept)  1.703728e+01  17.285577273 2.3099747
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## 470       id       470 (Intercept)  5.206860e-01   0.553738219 2.0493585
## 471       id       471 (Intercept)  8.667034e+00   8.507815061 2.2474085
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## 473       id       473 (Intercept) -2.425928e+00  -2.714704370 2.2783292
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## 478       id     478 (Intercept)  1.232555e+00   1.169440155 2.3246560
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## 549      id       3       TIME   1.073605e-01   0.087072283 0.3684069
## 550      id       4       TIME   1.925210e-01   0.211537165 0.1635428
## 551      id       5       TIME   3.320844e-02   0.048703735 0.3745900
## 552      id       6       TIME  -3.009414e-01  -0.291583373 0.1520137
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## 554      id       8       TIME  -1.988835e-01  -0.191990214 0.1486379
## 555      id       9       TIME  -2.303563e-01  -0.207043156 0.3852745
## 556      id      10       TIME  -5.833141e-02  -0.055058424 0.2501446
## 557      id      11       TIME   1.619563e-01   0.144440329 0.2491580
## 558      id      12       TIME  -1.028254e-01  -0.104439966 0.2028159
## 559      id      13       TIME  -7.334773e-03  -0.020641534 0.3707057
## 560      id      14       TIME   6.825802e-02   0.048259207 0.2892728
## 561      id      15       TIME   4.849955e-01   0.483569199 0.1464267
## 562      id      16       TIME  -1.090298e-01  -0.081605787 0.2394111
## 563      id      17       TIME   3.841262e-02   0.025530347 0.4120076
## 564      id      18       TIME   5.725274e-02   0.073745013 0.2664606
## 565      id      19       TIME   1.555099e-01   0.146359252 0.1642928
## 566      id      20       TIME  -1.820041e-01  -0.189375160 0.1676772
## 567      id      21       TIME  -4.716737e-02  -0.033036710 0.3503073
## 568      id      22       TIME  -1.023687e-02   0.002907119 0.1583251
## 569      id      23       TIME   2.308119e-02   0.028040121 0.1550981
## 570      id      24       TIME   4.671977e-02   0.022097987 0.3906786
## 571      id      25       TIME   1.064988e-02   0.017400321 0.3775908
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## 573      id      27       TIME  -3.000712e-03  -0.009343562 0.3799785
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## 576      id      30       TIME  -6.442061e-01  -0.665809528 0.3021078
## 577      id      31       TIME   1.427842e-01   0.145216804 0.2906533
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## 593       id       47        TIME -2.244772e-01  -0.215231778 0.2645187
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## 611       id       65        TIME  2.981594e-01   0.302843186 0.1591360
## 612       id       66        TIME  6.883348e-01   0.697046902 0.2723001
## 613       id       67        TIME -6.446002e-02  -0.075349079 0.1740263
## 614       id       68        TIME -1.370994e-01  -0.123840010 0.2876179
## 615       id       69        TIME  7.851051e-02   0.066936015 0.2894206
## 616       id       70        TIME  6.277381e-01   0.628621796 0.2379495
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## 630       id       84        TIME -5.331576e-02  -0.058850468 0.2954757
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## 632       id       86        TIME -5.269645e-01  -0.519616877 0.2140667
## 633       id       87        TIME -4.770183e-01  -0.458529494 0.1554208
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## 666      id     120      TIME -1.623629e-01  -0.163390159 0.2600018
## 667      id     121      TIME -4.625511e-02  -0.041978549 0.1409025
## 668      id     122      TIME  1.046457e-01   0.100454735 0.1334526
## 669      id     123      TIME  3.057718e-01   0.295660262 0.1923812
## 670      id     124      TIME  5.371753e-01   0.560458178 0.2627245
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## 691        id      145        TIME  4.198851e-01   0.461774567 0.2829751
## 692        id      146        TIME  3.799450e-01   0.377516844 0.1690103
## 693        id      147        TIME -1.841845e-01  -0.203908437 0.3704451
## 694        id      148        TIME  1.108561e-01   0.121826195 0.3249982
## 695        id      149        TIME  4.856090e-02   0.059756279 0.3371764
## 696        id      150        TIME -2.620314e-01  -0.261912398 0.1465324
## 697        id      151        TIME  7.010215e-01   0.713251732 0.2835787
## 698        id      152        TIME -1.673667e-01  -0.174896692 0.1754345
## 699        id      153        TIME -3.216668e-02  -0.043980972 0.3781744
## 700        id      154        TIME  2.479018e-01   0.223094192 0.2630575
## 701        id      155        TIME -2.326374e-01  -0.237627614 0.1804952
## 702        id      156        TIME  3.387219e-02   0.062368274 0.3772699
## 703        id      157        TIME -1.150245e-02  -0.040837555 0.3141106
## 704        id      158        TIME -2.923652e-01  -0.275057023 0.3927044
## 705        id      159        TIME  1.969676e-02   0.019197499 0.3683700
## 706        id      160        TIME  1.032227e-01   0.131195150 0.3850990
## 707        id      161        TIME -7.761302e-02  -0.043558899 0.2322437
## 708        id      162        TIME -5.916960e-02  -0.050684411 0.3299211
## 709        id      163        TIME  1.333907e-01   0.136271068 0.1796629
## 710        id      164        TIME -9.933737e-02  -0.087787586 0.2836215
## 711        id      165        TIME -1.764105e-01  -0.154943848 0.3329953
## 712        id      166        TIME -8.327573e-02  -0.095628918 0.3821977
## 713        id      167        TIME -3.707700e-01  -0.350506214 0.1827182
## 714        id      168        TIME  2.362689e-01   0.234391733 0.1716610
## 715        id      169        TIME  1.104236e-01   0.102727030 0.1747153
## 716        id      170        TIME -1.868003e-01  -0.178406716 0.3707656
## 717        id      171        TIME  6.218694e-02   0.054533467 0.1580001
## 718        id      172        TIME -6.431550e-02  -0.052835133 0.1841591
## 719        id      173        TIME -6.711268e-02  -0.061086060 0.3322655
## 720        id      174        TIME  4.899520e-02   0.046167974 0.2195591
## 721        id      175        TIME -1.757780e-02  -0.006624241 0.2718599
## 722        id      176        TIME  3.807318e-01   0.346811450 0.3762033
## 723        id      177        TIME -2.340702e-01  -0.233824273 0.2069120
## 724        id      178        TIME  1.268188e+00   1.262215034 0.2746740
## 725        id      179        TIME  3.610852e-02   0.028936400 0.3725128
## 726        id      180        TIME  4.392884e-01   0.432869088 0.2717177
## 727        id      181        TIME -1.894209e-02  -0.035176659 0.1770428
## 728        id      182        TIME  1.076948e-01   0.111247361 0.3949012
## 729        id      183        TIME  1.012496e-02   0.017218229 0.1661485
## 730        id      184        TIME  1.444844e-01   0.131520014 0.2609720
## 731        id      185        TIME  1.872522e-01   0.200323689 0.2963918
## 732        id      186        TIME -2.012257e-01  -0.202104916 0.2044341
## 733        id      187        TIME -1.622859e-01  -0.152830583 0.2929416
## 734        id      188        TIME -9.110001e-02  -0.097256544 0.3324646
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## 736        id      190        TIME -1.213695e-01  -0.107355516 0.2113003
## 737        id      191        TIME -1.687775e-01  -0.155543362 0.1962634
## 738        id      192        TIME -1.354175e-01  -0.126645405 0.3807291
## 739        id      193        TIME -1.241792e-01  -0.128456167 0.2272997
## 740        id      194        TIME  2.163199e-02   0.053617731 0.3488880
## 741        id      195        TIME -1.046754e-01  -0.059548393 0.4031057
## 742        id      196        TIME -1.253592e-02  -0.010453219 0.2621032
## 743        id      197        TIME -2.854424e-01  -0.286012166 0.3730497
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## 750      id     204      TIME  3.685728e-01   0.359263308 0.2161054
## 751      id     205      TIME -2.003140e-01  -0.212443769 0.2535519
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## 753      id     207      TIME  3.906125e-02   0.030821603 0.2491256
## 754      id     208      TIME  1.505774e-01   0.144370282 0.2210211
## 755      id     209      TIME -8.162018e-02  -0.055781928 0.3890193
## 756      id     210      TIME  1.246255e-01   0.134504276 0.2345240
## 757      id     211      TIME -7.675811e-02  -0.073464085 0.3496763
## 758      id     212      TIME -9.944038e-02  -0.111766985 0.2022917
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## 761      id     215      TIME -9.325337e-02  -0.106650194 0.3473694
## 762      id     216      TIME  7.666135e-02   0.093572826 0.3991909
## 763      id     217      TIME -6.748115e-02  -0.075501392 0.4121594
## 764      id     218      TIME -6.493669e-02  -0.064153432 0.2198989
## 765      id     219      TIME  1.248862e-01   0.139545257 0.2299774
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## 769      id     223      TIME  6.493428e-03   0.033269707 0.2297504
## 770      id     224      TIME  1.362404e-02   0.023377453 0.3854360
## 771      id     225      TIME  4.979676e-02   0.035362666 0.3889798
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## 773      id     227      TIME -1.089938e-01  -0.102297880 0.2691707
## 774      id     228      TIME -4.073692e-01  -0.424188857 0.2771777
## 775      id     229      TIME -4.289558e-03  -0.044858156 0.4023036
## 776      id     230      TIME -2.981412e-02  -0.042435856 0.3905129
## 777      id     231      TIME  2.118021e-02   0.023762631 0.4037978
## 778      id     232      TIME  3.261334e-02   0.039596575 0.2835251
## 779      id     233      TIME  1.191904e-01   0.118084842 0.3299674
## 780      id     234      TIME -1.249986e-01  -0.131745133 0.3678319
## 781      id     235      TIME -5.059295e-02  -0.042158321 0.3770203
## 782      id     236      TIME  1.574286e-02   0.019215508 0.3045143
## 783      id     237      TIME  1.574232e-01   0.163311703 0.2673809
## 784      id     238      TIME -2.650603e-02  -0.024793903 0.3258464
## 785      id     239      TIME  6.317073e-01   0.625790417 0.3265257
## 786      id     240      TIME -1.506788e-01  -0.111320907 0.3244562
## 787      id     241      TIME  1.225266e-01   0.110123471 0.3224070
## 788      id     242      TIME -4.715426e-03  -0.025175983 0.3531719
## 789      id     243      TIME  2.014351e-01   0.210033030 0.2915865
## 790      id     244      TIME  8.973708e-02   0.101852534 0.3650178
## 791      id     245      TIME  4.121674e-01   0.429008453 0.3606298
## 792      id     246      TIME  8.648044e-02   0.093915214 0.3237756
## 793      id     247      TIME -2.109746e-01  -0.182271394 0.3486204
## 794      id     248      TIME -9.463562e-02  -0.056598627 0.4122176
## 795      id     249      TIME -2.742486e-02  -0.023716572 0.3481982
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## 802        id    256        TIME  5.948340e-02   0.052709313 0.3940109
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## 819        id    273        TIME -2.411787e-02  -0.049558417 0.3709331
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## 823        id    277        TIME -1.975107e-01  -0.237007965 0.3892378
## 824        id    278        TIME -5.315131e-02  -0.010359874 0.3790401
## 825        id    279        TIME  4.582050e-02   0.038166121 0.3787721
## 826        id    280        TIME  1.020745e-02   0.025728229 0.3706035
## 827        id    281        TIME -1.589290e-02   0.001676233 0.3749486
## 828        id    282        TIME -5.044365e-02  -0.074204383 0.3488273
## 829        id    283        TIME -3.911201e-02  -0.005945653 0.3637856
## 830        id    284        TIME  4.659394e-02   0.050338990 0.3720948
## 831        id    285        TIME -1.442116e-01  -0.122676016 0.3667401
## 832        id    286        TIME  4.606253e-02   0.036931110 0.3788198
## 833        id    287        TIME  2.124237e-03   0.021532918 0.3704622
## 834        id    288        TIME  1.064831e-01   0.131998549 0.3783688
## 835        id    289        TIME  7.559704e-04   0.010042499 0.3484937
## 836        id    290        TIME  7.925103e-02   0.111494169 0.3680958
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## 840        id    294        TIME -1.231395e-02  -0.055183626 0.4116432
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## 849        id    303        TIME  2.545768e-02   0.053359564 0.4184087
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## 879      id    333      TIME -2.497205e-01  -0.253675093 0.3020435
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## 881      id    335      TIME -1.983241e-01  -0.191493283 0.2541917
## 882      id    336      TIME  2.664111e-01   0.259776988 0.2579025
## 883      id    337      TIME  3.698692e-01   0.356880210 0.3024678
## 884      id    338      TIME -3.581195e-01  -0.338639777 0.2479498
## 885      id    339      TIME -4.266385e-02  -0.048338492 0.2547355
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## 890      id    344      TIME  2.480487e-01   0.255603563 0.2575194
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## 894      id    348      TIME  7.091667e-01   0.701895979 0.2449736
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## 903      id    357      TIME  3.599211e-01   0.373809408 0.3247009
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## 933       id    387       TIME  1.733117e-02   0.021253164 0.2818677
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## 935       id    389       TIME -5.535671e-02  -0.044750137 0.3029831
## 936       id    390       TIME -1.506447e-01  -0.114627555 0.3873578
## 937       id    391       TIME -1.330229e-01  -0.141643404 0.2780476
## 938       id    392       TIME  6.869208e-02   0.049031564 0.3789952
## 939       id    393       TIME  1.406180e-01   0.159528486 0.3241098
## 940       id    394       TIME  2.020783e-01   0.186702002 0.3113050
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## 944       id    398       TIME  3.586991e-02   0.007361112 0.4264355
## 945       id    399       TIME -2.045722e-01  -0.244595518 0.3942998
## 946       id    400       TIME  4.972193e-02   0.071386617 0.4198394
## 947       id    401       TIME  1.306527e-01   0.100443484 0.3421204
## 948       id    402       TIME  7.085920e-02   0.086691432 0.2572453
## 949       id    403       TIME  2.788316e-01   0.307431291 0.3107334
## 950       id    404       TIME  3.985183e-01   0.404013471 0.2990970
## 951       id    405       TIME -1.853946e-01  -0.197774610 0.2677839
## 952       id    406       TIME -4.360649e-02  -0.055750653 0.3717928
## 953       id    407       TIME -4.081190e-02  -0.034983210 0.3956202
## 954       id    408       TIME  6.150055e-01   0.608425118 0.3583219
## 955       id    409       TIME -3.063663e-01  -0.310812558 0.2991017
## 956       id    410       TIME -1.474389e-01  -0.134468277 0.3435268
## 957       id    411       TIME  5.341861e-02   0.065637450 0.3055793
## 958       id    412       TIME -9.062318e-02  -0.083280174 0.3448545
## 959       id    413       TIME -1.480112e-01  -0.147295620 0.2927809
```

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```
## 960     id     414     TIME  2.880550e-02    0.035805075 0.2993067
## 961     id     415     TIME  1.123022e-02    0.027270805 0.3292829
## 962     id     416     TIME  5.744776e-02    0.032974865 0.3373111
## 963     id     417     TIME -1.404672e-01   -0.141141408 0.3016000
## 964     id     418     TIME -1.361647e-01   -0.108170530 0.2853449
## 965     id     419     TIME  1.501040e-01    0.132933753 0.3513712
## 966     id     420     TIME  2.261956e-02    0.001548755 0.3274315
## 967     id     421     TIME -1.719833e-01   -0.175736781 0.2946326
## 968     id     422     TIME  1.116847e-01    0.125497986 0.3045919
## 969     id     423     TIME -5.246142e-02   -0.057410514 0.2992477
## 970     id     424     TIME  4.334354e-02    0.032404170 0.3054738
## 971     id     425     TIME  1.741620e-02    0.037517800 0.4043640
## 972     id     426     TIME  1.018671e-01    0.090672152 0.2767314
## 973     id     427     TIME -2.143852e-01   -0.212097806 0.2640744
## 974     id     428     TIME -3.280662e-01   -0.319138095 0.3424908
## 975     id     429     TIME  6.846910e-02    0.077438282 0.3359147
## 976     id     430     TIME  8.055601e-02    0.047848637 0.3000777
## 977     id     431     TIME -8.862237e-02   -0.129780211 0.3972545
## 978     id     432     TIME  2.051971e-02    0.044577607 0.3292819
## 979     id     433     TIME  2.472842e-01    0.224918852 0.3834853
## 980     id     434     TIME -5.591535e-02   -0.056498452 0.3870398
## 981     id     435     TIME -3.432837e-02   -0.030290905 0.3931291
## 982     id     436     TIME -2.764810e-02   -0.042861101 0.3431263
## 983     id     437     TIME  3.544971e-02    0.044814775 0.3596628
## 984     id     438     TIME -6.167656e-02   -0.037425567 0.2883923
## 985     id     439     TIME -1.857020e-01   -0.186223270 0.3138722
## 986     id     440     TIME -9.914264e-02   -0.113562035 0.3064657
## 987     id     441     TIME -3.951473e-02   -0.046491000 0.3426530
## 988     id     442     TIME -2.413010e-02   -0.016181737 0.2991401
## 989     id     443     TIME  9.902802e-02    0.084439049 0.3500223
## 990     id     444     TIME -3.476761e-01   -0.322034981 0.3262697
## 991     id     445     TIME -3.337061e-02   -0.005834529 0.3558073
## 992     id     446     TIME  1.054502e-01    0.142204434 0.4084717
## 993     id     447     TIME -2.795624e-02   -0.030511317 0.3485940
## 994     id     448     TIME  1.527191e-01    0.132457295 0.4181556
## 995     id     449     TIME  1.011148e-01    0.111989832 0.3334991
## 996     id     450     TIME -7.074256e-02   -0.098141521 0.3515212
## 997     id     451     TIME  1.116960e-01    0.126525544 0.3797807
## 998     id     452     TIME -1.349129e-01   -0.165075270 0.3502835
## 999     id     453     TIME  5.424524e-02    0.038568083 0.4128987
## 1000    id     454     TIME  6.918681e-02    0.064769628 0.3602885
## 1001    id     455     TIME -2.473395e-02    0.004426510 0.3678367
## 1002    id     456     TIME -1.305316e-01   -0.149065586 0.3005146
## 1003    id     457     TIME  9.955161e-02    0.075339353 0.3465493
## 1004    id     458     TIME -2.166214e-02   -0.024567161 0.3831507
## 1005    id     459     TIME -8.348260e-03    0.012270736 0.3215399
## 1006    id     460     TIME  8.438717e-02    0.107924936 0.3705982
## 1007    id     461     TIME -8.934930e-01   -0.906269783 0.3090240
## 1008    id     462     TIME -1.533929e-01   -0.137107884 0.3268557
## 1009    id     463     TIME  2.130783e-01    0.227184461 0.3606830
## 1010    id     464     TIME  3.898344e-02    0.050272487 0.4147890
## 1011    id     465     TIME  8.760694e-02    0.092437210 0.3529243
## 1012    id     466     TIME  2.581729e-02    0.029005726 0.3633519
## 1013    id     467     TIME  2.640703e-02    0.013690355 0.3470615
```

```
## 1014      id      468        TIME -1.101534e-01  -0.106778770 0.3125395
## 1015      id      469        TIME -6.651511e-02  -0.075046671 0.3355487
## 1016      id      470        TIME  4.094282e-02   0.057740683 0.3871658
## 1017      id      471        TIME  2.605420e-02   0.048592065 0.3366802
## 1018      id      472        TIME  2.273336e-02   0.040456471 0.3569023
## 1019      id      473        TIME  2.212587e-01   0.207605351 0.3426200
## 1020      id      474        TIME -8.126217e-03  -0.028836819 0.4104744
## 1021      id      475        TIME -1.599241e-01  -0.163399837 0.3488397
## 1022      id      476        TIME -1.111750e-01  -0.120726768 0.3590172
## 1023      id      477        TIME  1.669593e-01   0.181162086 0.3730801
## 1024      id      478        TIME -1.209115e-01  -0.102686752 0.3783558
## 1025      id      479        TIME  2.037274e-03   0.020508824 0.3869742
## 1026      id      480        TIME  4.808232e-02   0.049775655 0.3915087
## 1027      id      481        TIME -1.950867e-02  -0.047215950 0.3619035
## 1028      id      482        TIME -6.762968e-02  -0.094161009 0.3673627
## 1029      id      483        TIME -7.796252e-02  -0.092445070 0.3697389
## 1030      id      484        TIME -2.456957e-01  -0.253548660 0.3290279
## 1031      id      485        TIME  4.089558e-02   0.033214008 0.3354497
## 1032      id      486        TIME  7.041984e-02   0.062189592 0.3400820
## 1033      id      487        TIME  4.941766e-02   0.050418880 0.4027078
## 1034      id      488        TIME -1.056911e-01  -0.112493915 0.3777612
## 1035      id      489        TIME -1.361317e-02  -0.018514869 0.3679237
## 1036      id      490        TIME -1.892793e-01  -0.192612159 0.4034936
## 1037      id      491        TIME  3.680902e-02   0.040931008 0.3579728
## 1038      id      492        TIME  8.642932e-02   0.117181442 0.4007389
## 1039      id      493        TIME -9.962787e-03  -0.003531574 0.3429573
## 1040      id      494        TIME  4.112236e-02   0.031919571 0.3878046
## 1041      id      495        TIME -7.851103e-02  -0.082948430 0.3740638
## 1042      id      496        TIME -1.853004e-01  -0.180251084 0.3715733
## 1043      id      497        TIME  1.014100e-01   0.102241360 0.3348402
## 1044      id      498        TIME -4.466566e-02  -0.056709870 0.3770367
## 1045      id      499        TIME -4.923667e-02  -0.089567612 0.3455550
## 1046      id      500        TIME  7.411754e-02   0.045020983 0.4019619
## 1047      id      501        TIME -2.032390e-02  -0.030356538 0.3934068
## 1048      id      502        TIME -1.068330e-01  -0.068498399 0.3766217
## 1049      id      503        TIME -9.240835e-02  -0.111651954 0.3850698
## 1050      id      504        TIME -7.016861e-02  -0.060074987 0.3964024
## 1051      id      505        TIME -1.176837e-01  -0.116464463 0.3941488
## 1052      id      506        TIME  2.515388e-02   0.031673646 0.4068559
## 1053      id      507        TIME -7.357451e-03  -0.031597454 0.3723941
## 1054      id      508        TIME  1.338942e-02  -0.017380361 0.3450472
## 1055      id      509        TIME  1.869163e-02   0.040180888 0.4084419
## 1056      id      510        TIME -1.432458e-02  -0.034816039 0.3879469
## 1057      id      511        TIME  8.260968e-02   0.082423195 0.3858343
## 1058      id      512        TIME -2.399661e-02  -0.049999842 0.3849621
## 1059      id      513        TIME  2.465157e-02   0.009458109 0.3989220
## 1060      id      514        TIME  7.054099e-02   0.058127624 0.3907927
## 1061      id      515        TIME -1.510547e-01  -0.149286881 0.3994882
## 1062      id      516        TIME  2.355450e-02   0.043008253 0.3576823
## 1063      id      517        TIME  2.708752e-03  -0.008042278 0.3775792
## 1064      id      518        TIME  2.179823e-02   0.033087154 0.3785875
## 1065      id      519        TIME -3.354337e-02  -0.077540585 0.3543976
## 1066      id      520        TIME  3.671696e-02   0.028680856 0.3800472
## 1067      id      521        TIME -1.494874e-02  -0.010246040 0.3655218
```

```
## 1068         id      522     TIME -1.231096e-01 -0.088174881 0.3863496
## 1069         id      523     TIME  4.689777e-02  0.059276839 0.3804436
## 1070         id      524     TIME  4.065965e-02  0.047050165 0.3727864
## 1071         id      525     TIME  5.862047e-02  0.054975172 0.3846853
## 1072         id      526     TIME  8.267914e-02  0.065307992 0.3736034
## 1073         id      527     TIME  3.880042e-02  0.024980948 0.3690206
## 1074         id      528     TIME  4.958031e-02  0.043423441 0.3968259
## 1075         id      529     TIME -1.972858e-02  0.018257768 0.3503873
## 1076         id      530     TIME  2.785005e-02  0.022686769 0.4084390
## 1077         id      531     TIME  3.072628e-02  0.048007055 0.3927544
## 1078         id      532     TIME  4.327602e-02  0.055701849 0.3510821
## 1079         id      533     TIME -9.891108e-03 -0.015034077 0.3778936
## 1080         id      534     TIME -3.178622e-02 -0.012002817 0.3761102
## 1081         id      535     TIME -1.927633e-02 -0.012663251 0.4220863
## 1082         id      536     TIME -1.474515e-01 -0.130918154 0.3786304
## 1083         id      537     TIME -7.982723e-02 -0.092582707 0.3835059
## 1084         id      538     TIME -4.189330e-02 -0.057215484 0.4087745
## 1085         id      539     TIME -5.020666e-02 -0.058207503 0.3687715
## 1086         id      540     TIME -1.064022e-01 -0.119409510 0.4196486
## 1087         id      541     TIME -6.996206e-03  0.007952643 0.3481657
## 1088         id      542     TIME -7.876182e-02 -0.107742718 0.3701339
## 1089         id      543     TIME -1.451324e-02 -0.020256894 0.3798277
## 1090         id      544     TIME -8.621476e-02 -0.074513786 0.3995097
## 1091         id      545     TIME  5.817947e-03  0.011274628 0.3849204
## 1092         id      546     TIME -9.440976e-03 -0.023052688 0.4065739
```

```
plotREsim(REsim(db_mixed2))
```

Effect Ranges
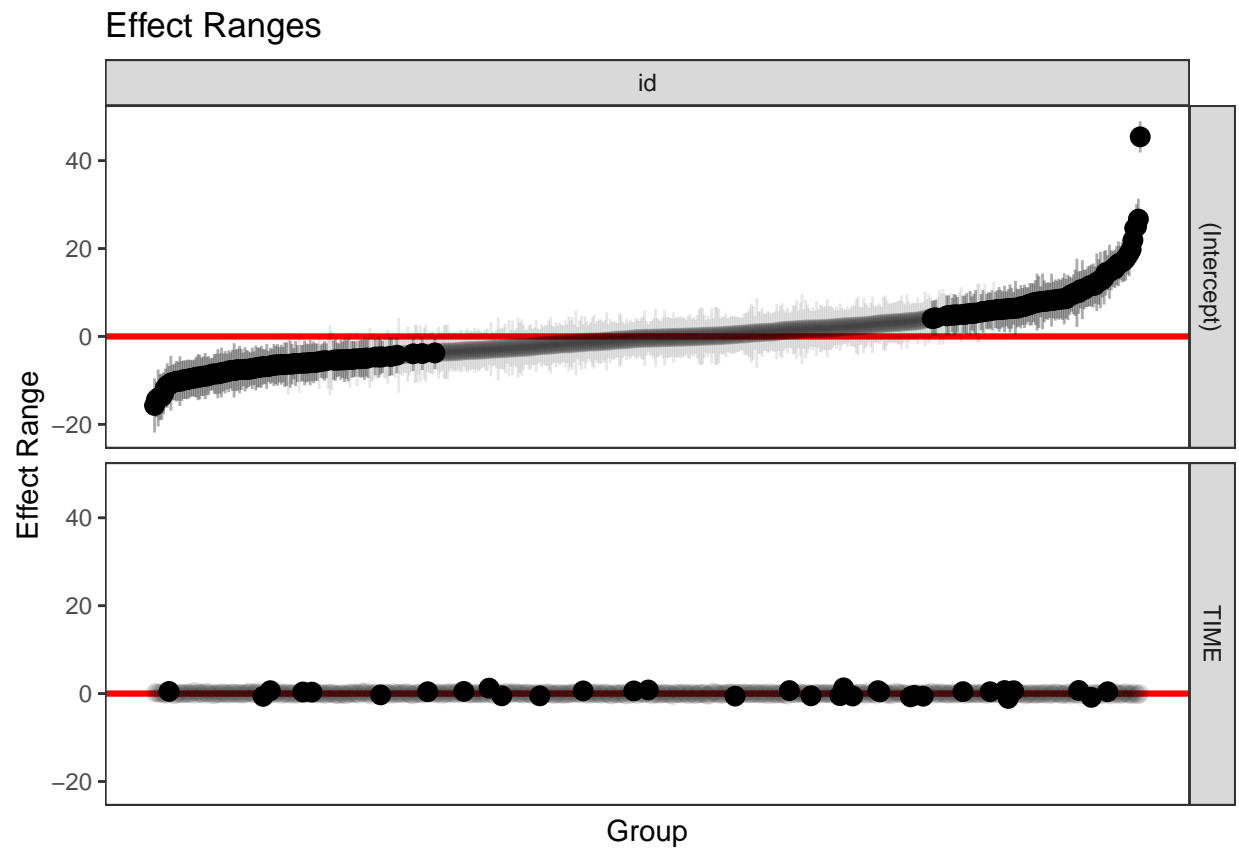

```
dat_mixed2<-data.frame(time=df$TIME,pred=fitted(db_mixed2),Subject=df$id)
dat_mixed2$Subject<-as.numeric(dat_mixed2$Subject)
ggplot(data=dat_mixed2,aes(x=time,y=pred,group=Subject,color=Subject))+theme_classic()+geom_line()
```
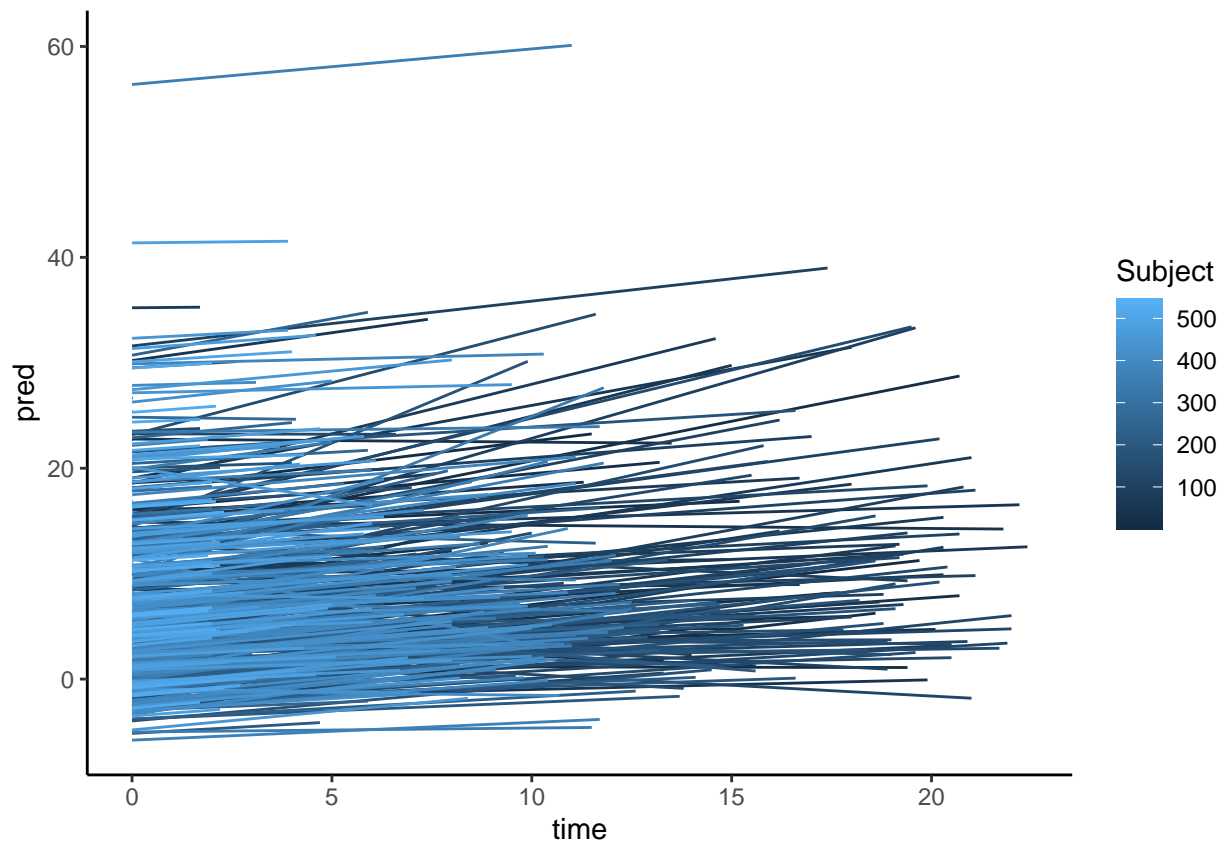
```
anova(db_mixed,db_mixed2)
```

```
## refitting model(s) with ML (instead of REML)
```

```
## Data: df
## Models:
## db_mixed: y ~ age + TIME + (1 | id)
## db_mixed2: y ~ age + TIME + (TIME | id)
##           npar   AIC   BIC logLik deviance  Chisq Df Pr(>Chisq)
## db_mixed     5 28672 28704 -14331    28662
## db_mixed2    7 28550 28595 -14268    28536 125.77  2  < 2.2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
db_mixed5 = lme(y ~ age+TIME ,random=~1|TIME/id, data = df,cor = corAR1())
summary(db_mixed5)
```

```
## Linear mixed-effects model fit by REML
##   Data: df
##        AIC       BIC    logLik
##   30128.64 30173.39 -15057.32
##
## Random effects:
##  Formula: ~1 | TIME
```

```
##         (Intercept)
## StdDev:    1.575724
##
##  Formula: ~1 | id %in% TIME
##         (Intercept) Residual
## StdDev:    7.324583 4.554834
##
## Correlation Structure: AR(1)
##  Formula: ~1 | TIME/id
##  Parameter estimate(s):
##         Phi
## -0.01533482
## Fixed effects:  y ~ age + TIME
##                 Value Std.Error   DF   t-value p-value
## (Intercept) -6.308886 0.7026172 2132 -8.979122       0
## age          0.259290 0.0101740 1988 25.485653       0
## TIME         0.239849 0.0443270 1988  5.410912       0
##  Correlation:
##      (Intr) age
## age  -0.800
## TIME -0.597  0.117
##
## Standardized Within-Group Residuals:
##         Min          Q1         Med          Q3         Max
## -3.35377025 -0.45714697 -0.04599545  0.41175736  4.41035010
##
## Number of Observations: 4419
## Number of Groups:
##         TIME id %in% TIME
##          297        2287
```
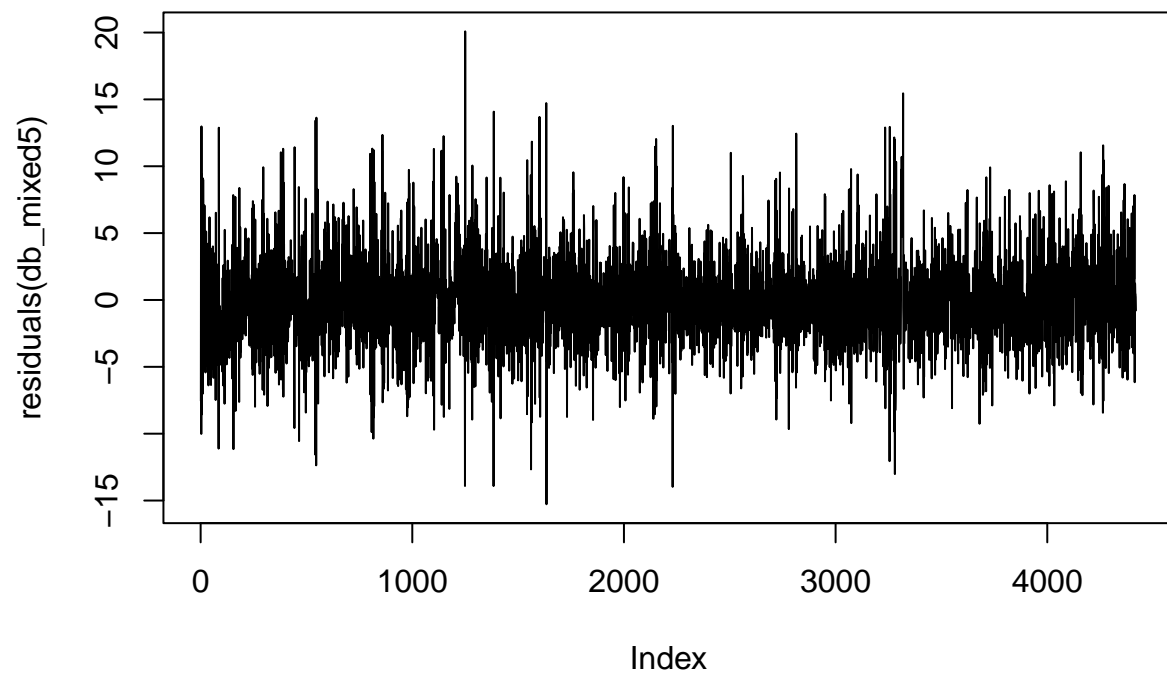
```
plot(db_mixed5)
```
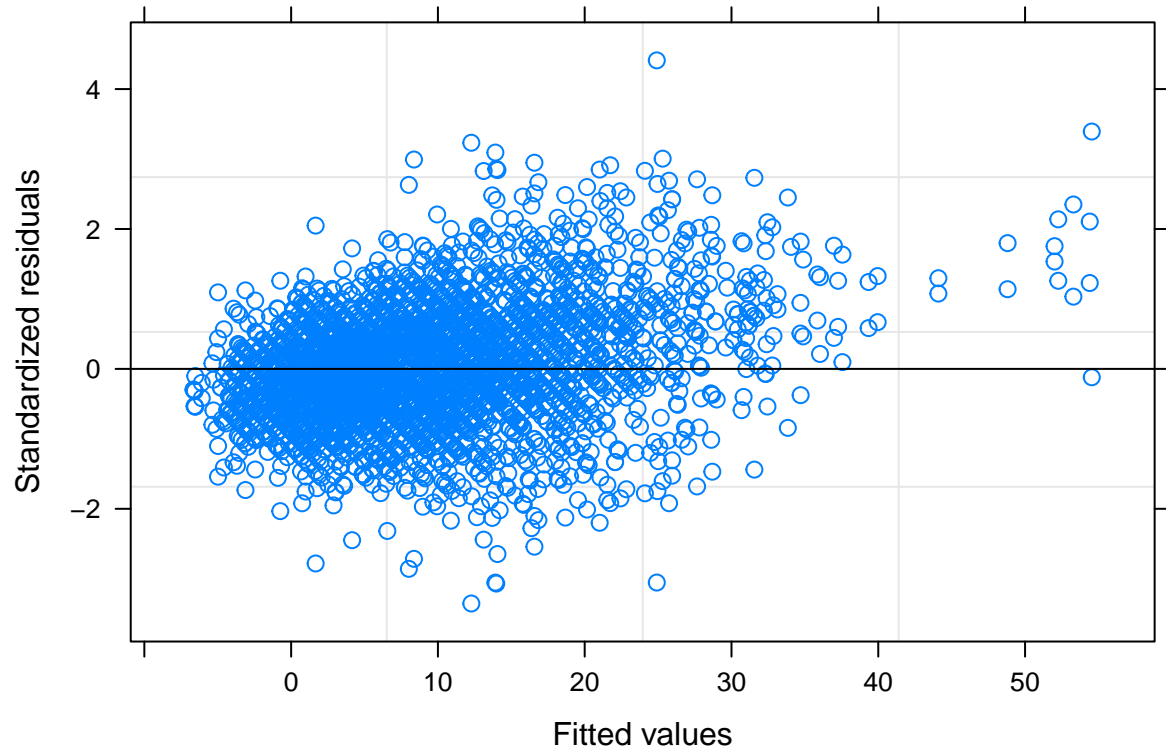
```
hist(residuals(db_mixed5), breaks = 50)
```

Histogram of residuals(db_mixed5)
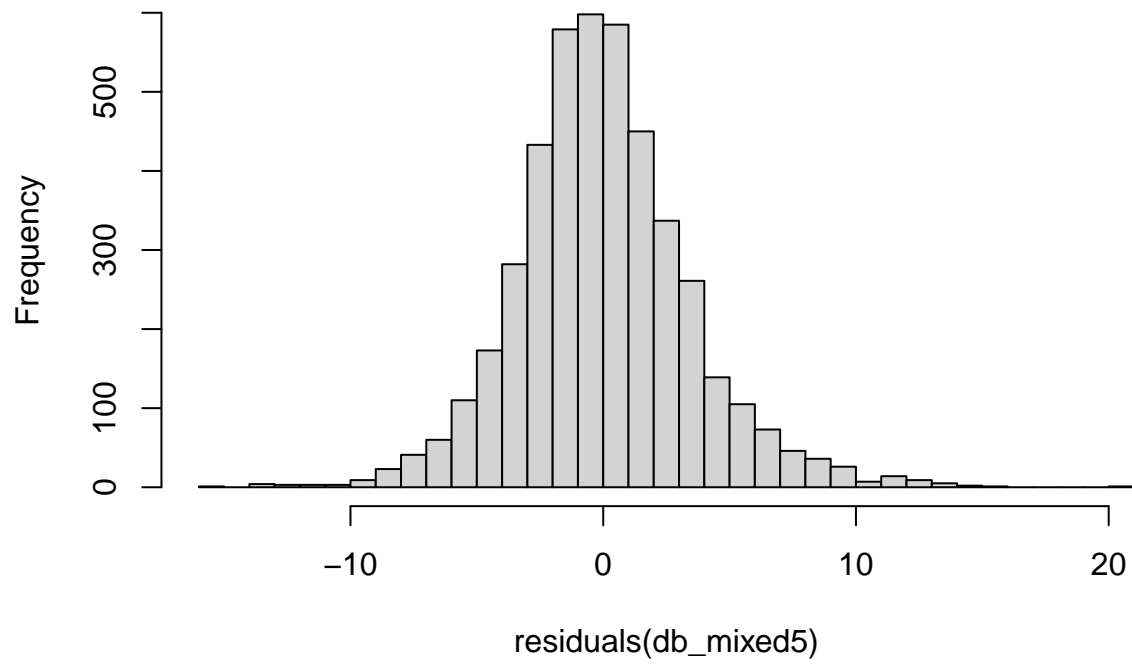

```
plot(residuals(db_mixed5), type = "l")
```
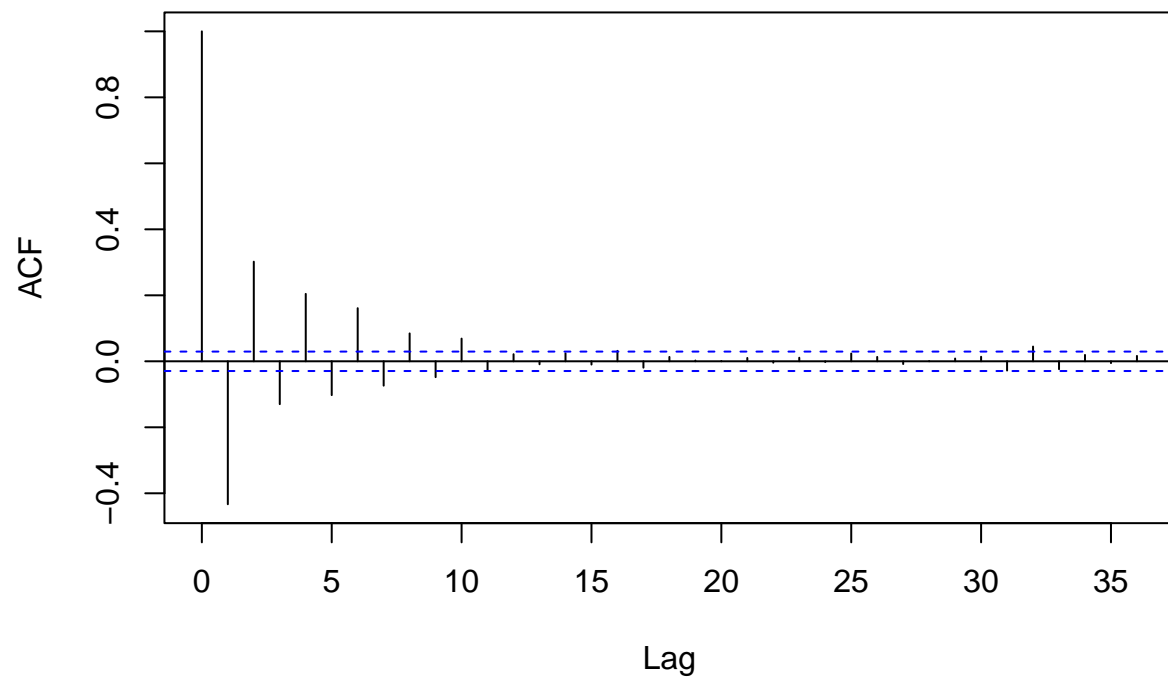
```
shapiro.test(residuals(db_mixed5))
```

```
##
##  Shapiro-Wilk normality test
##
## data:  residuals(db_mixed5)
## W = 0.98131, p-value < 2.2e-16
```

```
acf(residuals(db_mixed5))
```

Series residuals(db_mixed5)


```
dat_mixed5<-data.frame(time=df$TIME,pred=fitted(db_mixed5),Subject=df$id,side=df$side)
dat_mixed5$Subject<-as.numeric(dat_mixed5$Subject)
dat_mixed5<-dat_mixed5 %>% filter(side=="right")
ggplot(data=dat_mixed5,aes(x=time,y=pred,color=Subject,shape=side,group=interaction(Subject, side)))+the
  geom_line()+geom_point()
```
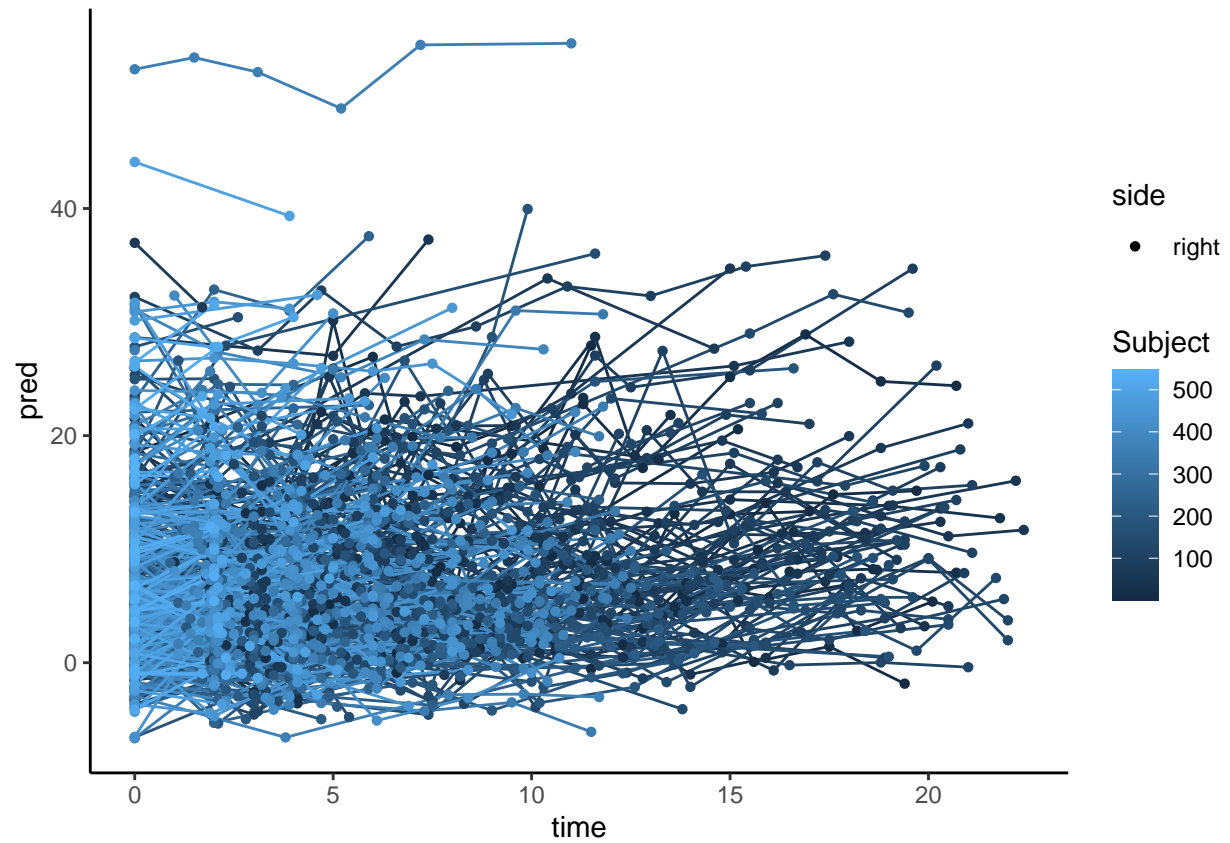
Bilder, C. and Loughin, T. (2015). Analysis of Categorical Data with R. CRC Press. Hothorn, T. and Everitt, B. (2014). A Handbook of Statistical Analyses using R. CRC Press, 3rd Edition.