Effect of auditory distraction on cognitive flexibility: Analysis for students

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Knitting this document will produce analysis that you should use for your written report. It includes some decisions that we have made and we would like you to write your report also making these decisions. You can augment the work here with additional analyses, but you should not substitute other analyses for the work done here.

Note that this analysis is provided without commentary.

```
## Observations: 216
## Variables: 16
## $ id          <dbl> 1, 1, 1, 2, 2, 2, 3, 3, 3, 4, 4, 4, 5, 5, 5, 6, 6,...
## $ cblind      <chr> "No", "No", "No", "No", "No", "No", "No", "No", "N...
## $ english     <dbl> 12, 12, 12, 7, 7, 7, 4, 4, 4, 5, 5, 5, 18, 18, 18,...
## $ vgames      <chr> "No", "No", "No", "No", "No", "No", "No", "No", "N...
## $ device      <chr> "iPhone / iPod", "iPhone / iPod", "iPhone / iPod",...
## $ headphones  <chr> "Over-ear headphones; noise cancelling", "Over-ear...
## $ alllevels   <chr> "Control (quiet);Song with lyrics (Shape of You by...
## $ distraction <chr> "control", "lyrics", "classical", "control", "clas...
## $ sleep       <dbl> 8, 8, 8, 8, 8, 8, 9, 9, 8, 7, 7, 7, 8, 8, 8, 7, 7,...
## $ start       <chr> "afternoon", "afternoon", "afternoon", "morning", ...
## $ offtime     <dbl> 47.379, 46.169, 44.765, 61.675, 64.676, 70.651, 75...
## $ ontime      <dbl> 50.003, 48.313, 45.911, 74.913, 64.676, 82.432, 82...
## $ runsoff     <dbl> 6, 5, 6, 5, 6, 6, 5, 5, 5, 5, 6, 5, 5, 5, 5, 5, 6,...
## $ runson      <dbl> 7, 5, 7, 5, 6, 7, 5, 5, 5, 5, 5, 6, 5, 5, 5, 5, 5,...
## $ diff        <dbl> 2.624, 2.144, 1.146, 13.238, 25.934, 11.781, 7.028...
## $ order       <dbl> 1, 2, 3, 1, 2, 3, 1, 2, 3, 1, 2, 3, 1, 2, 3, 1, 2,...
```

Start with model with just distraction

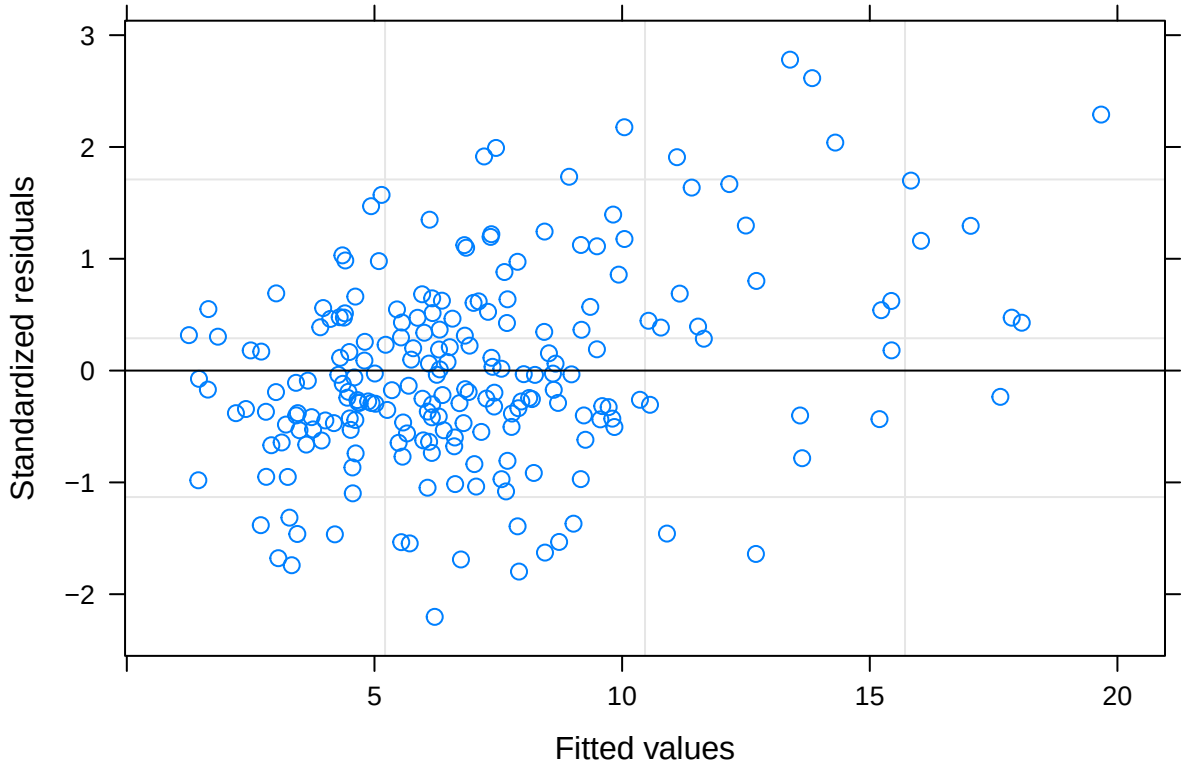
```
data %>% group_by(distraction) %>% summarize(means = mean(diff))
```

```
## # A tibble: 3 x 2
##   distraction means
##   <chr>       <dbl>
## 1 classical    6.41
## 2 control      8.21
## 3 lyrics       6.61
```

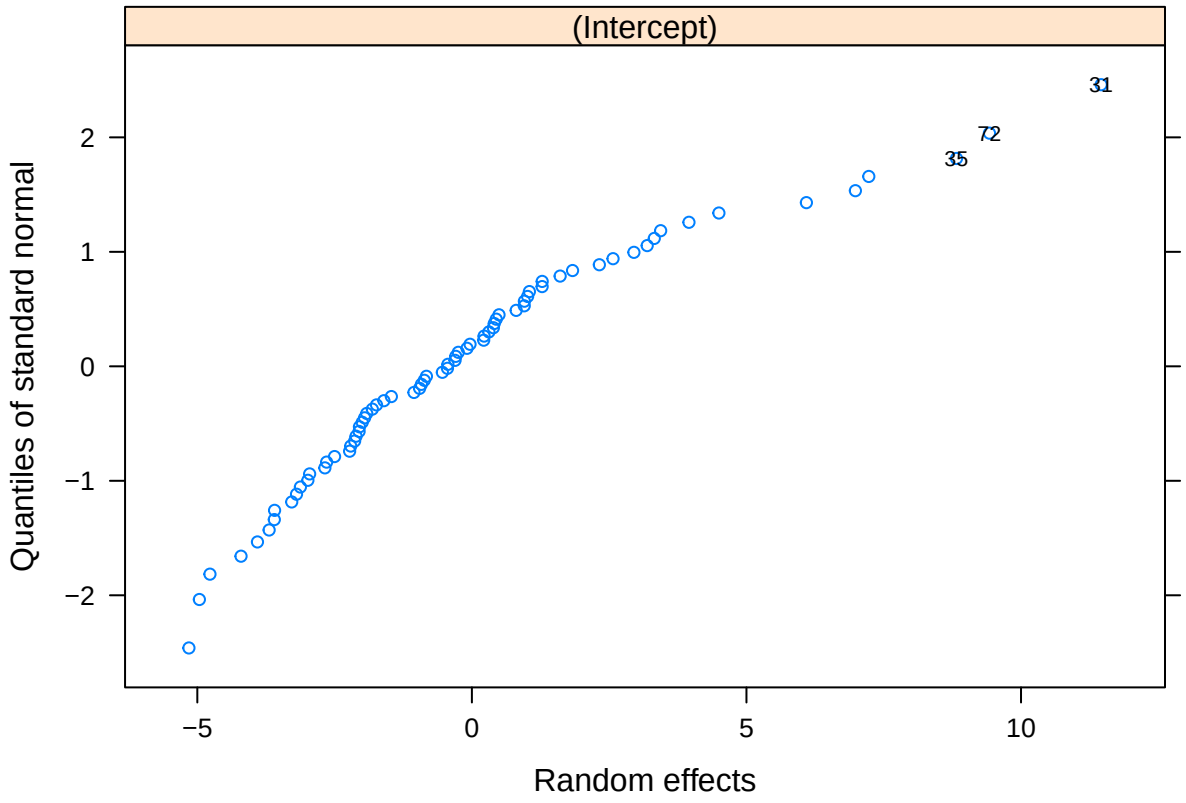
```
simple.model <- lme(diff ~ distraction, random=~1|id, method="REML", data=data)
anova(simple.model)
```

```
##             numDF denDF   F-value p-value
## (Intercept)     1   142 156.88699  <.0001
## distraction     2   142   3.46155  0.0341
```

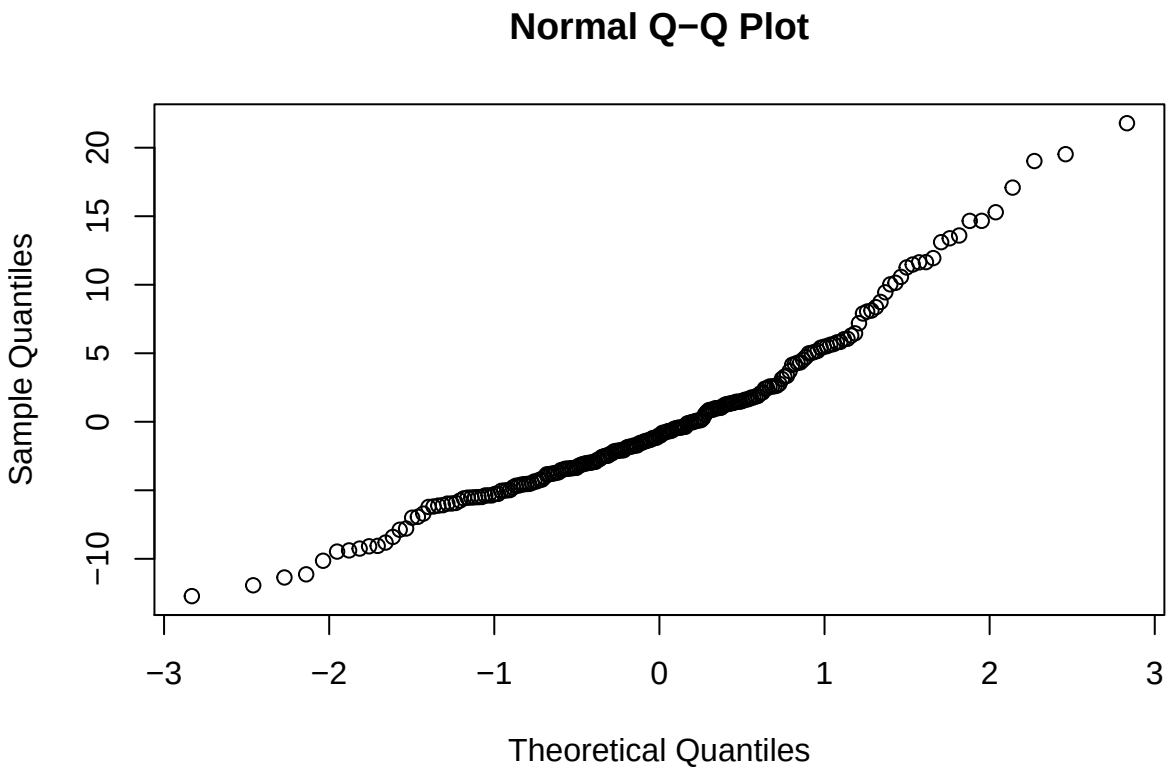
```
plot(simple.model)
```



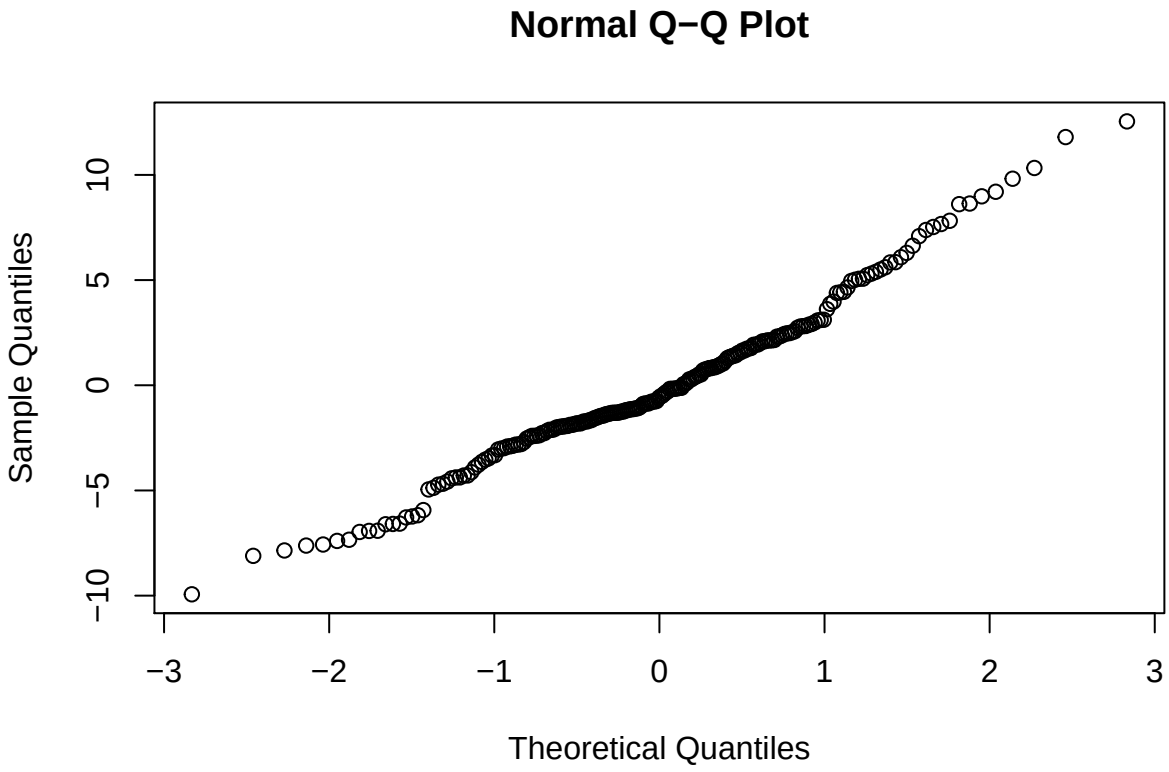

```
# qq plot of random effects
qqnorm(simple.model, ~ranef(.), id=0.05, cex=0.7)
```



```r
# marginal residuals
qqnorm(resid(simple.model, level=0))
```




```r
# conditional residuals
qqnorm(resid(simple.model,level=1))
```



Effect of order

```
data %>%
  group_by(order, distraction)%>%
  summarise(n=n())%>%
  spread(distraction, n) %>%
  kable()
```

order	classical	control	lyrics
1	6	56	10
2	28	7	37
3	38	9	25

```
data %>% group_by(order) %>% summarize(means = mean(diff))
```

```
## # A tibble: 3 x 2
##   order means
##   <dbl> <dbl>
## 1     1  8.42
## 2     2  6.64
## 3     3  6.16
```

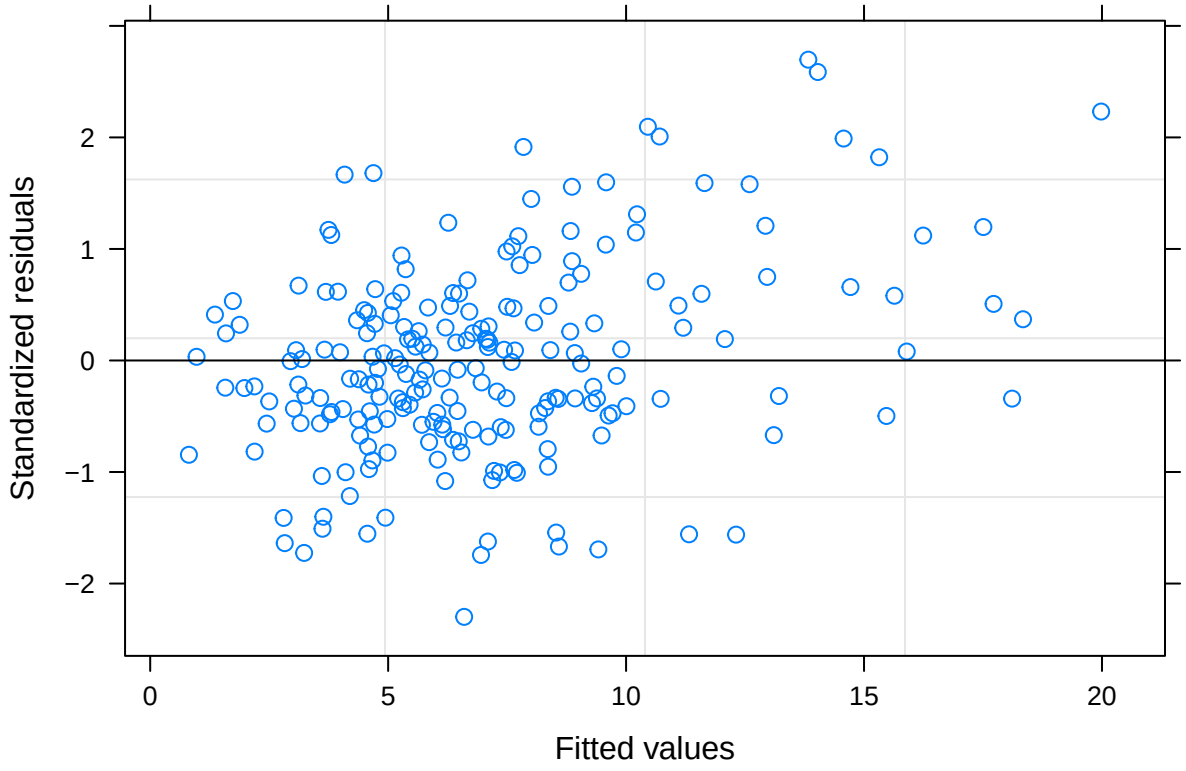
```
data %>% group_by(distraction, order) %>% summarize(means = mean(diff))
```

```
## # A tibble: 9 x 3
## # Groups:   distraction [3]
##   distraction order means
##   <chr>       <dbl> <dbl>
## 1 classical       1  8.74
## 2 classical       2  6.01
## 3 classical       3  6.33
## 4 control         1  8.70
## 5 control         2  6.67
## 6 control         3  6.40
## 7 lyrics          1  6.72
## 8 lyrics          2  7.11
## 9 lyrics          3  5.82
```

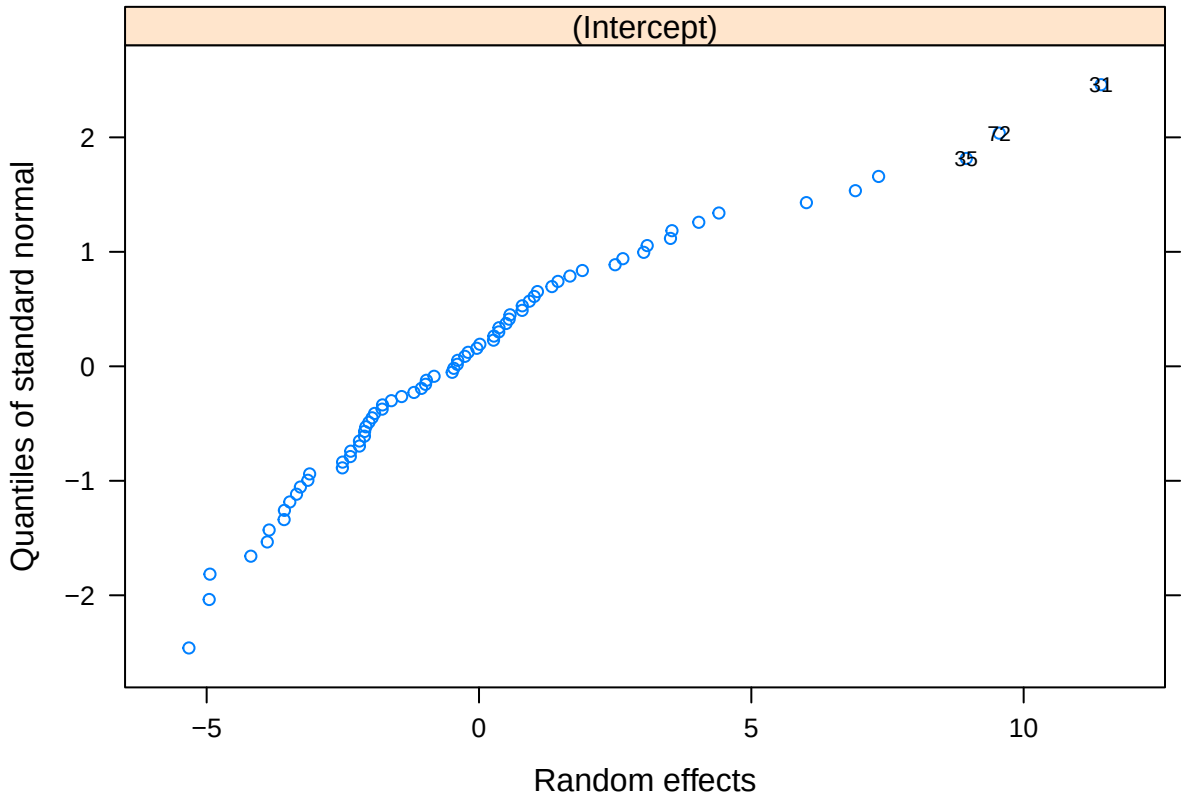
```
# model with order interaction
simple.model.plus.order <- lme(diff ~ distraction*order, random=~1|id, method="REML", data=data)
anova(simple.model.plus.order)
```

```
##                   numDF denDF   F-value p-value
## (Intercept)           1   139 155.35895  <.0001
## distraction           2   139   3.49626  0.0330
## order                 1   139   3.40265  0.0672
## distraction:order     2   139   0.16504  0.8480
```

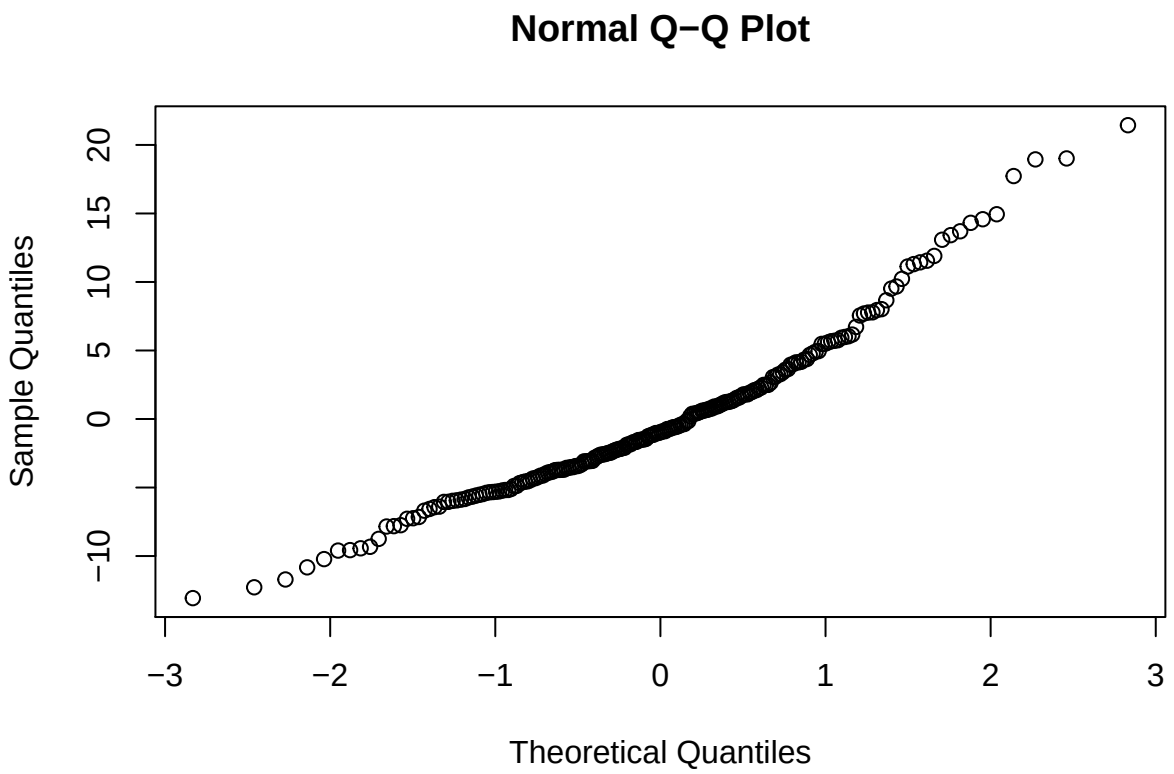
```
plot(simple.model.plus.order)
```



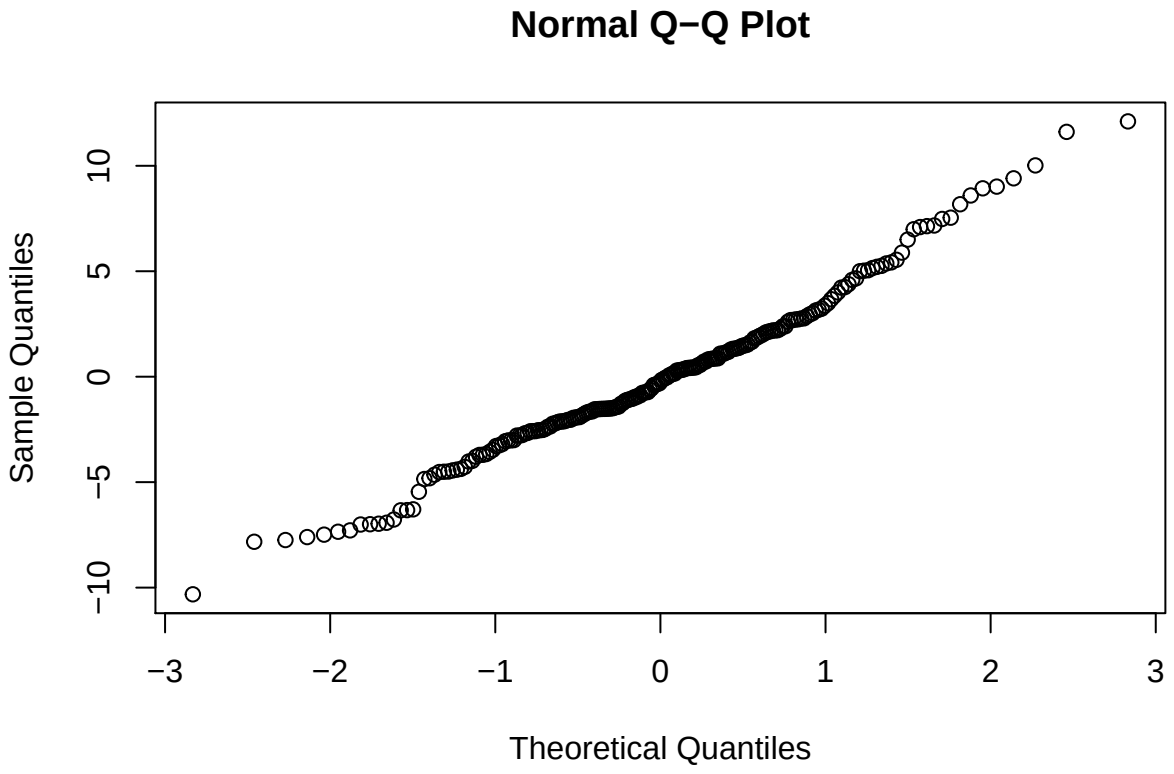

```
# random effects
qqnorm(simple.model.plus.order, ~ranef(.), id=0.05, cex=0.7)
```



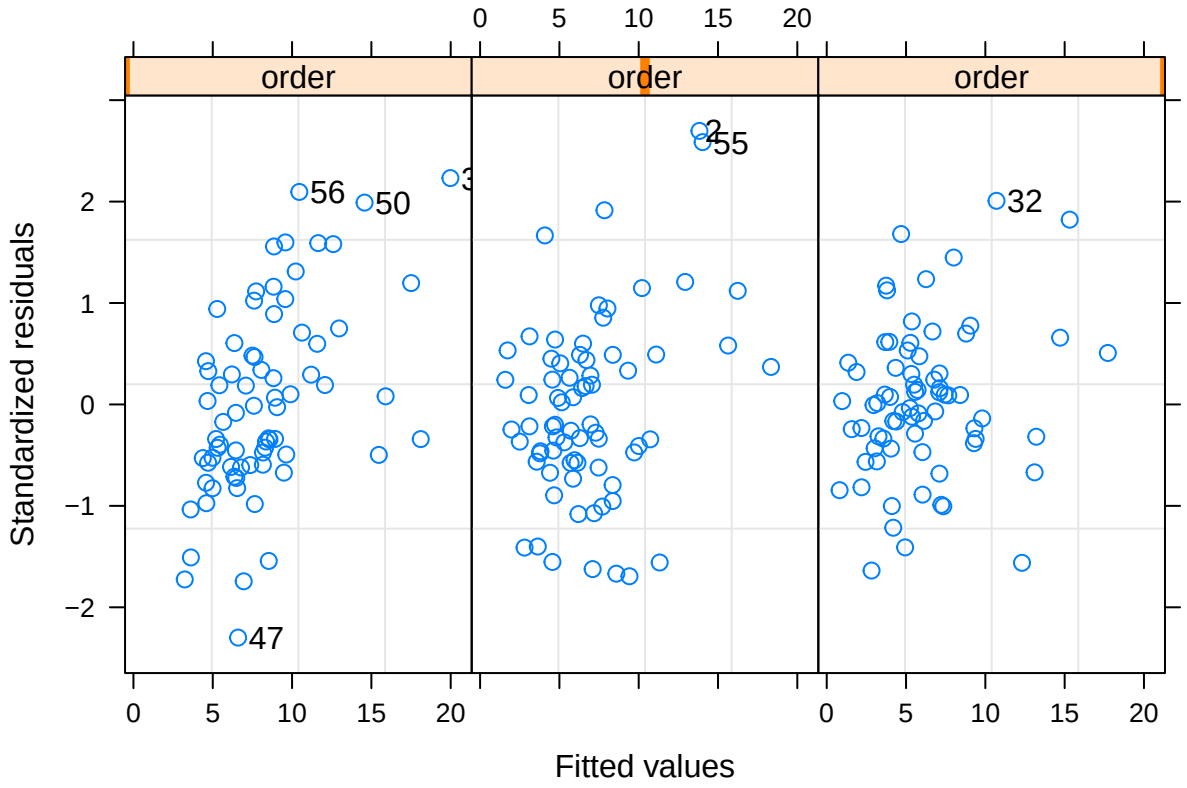
```r
# marginal residuals
qqnorm(resid(simple.model.plus.order, level=0))
```




```r
# conditional residuals
qqnorm(resid(simple.model.plus.order,level=1))
```



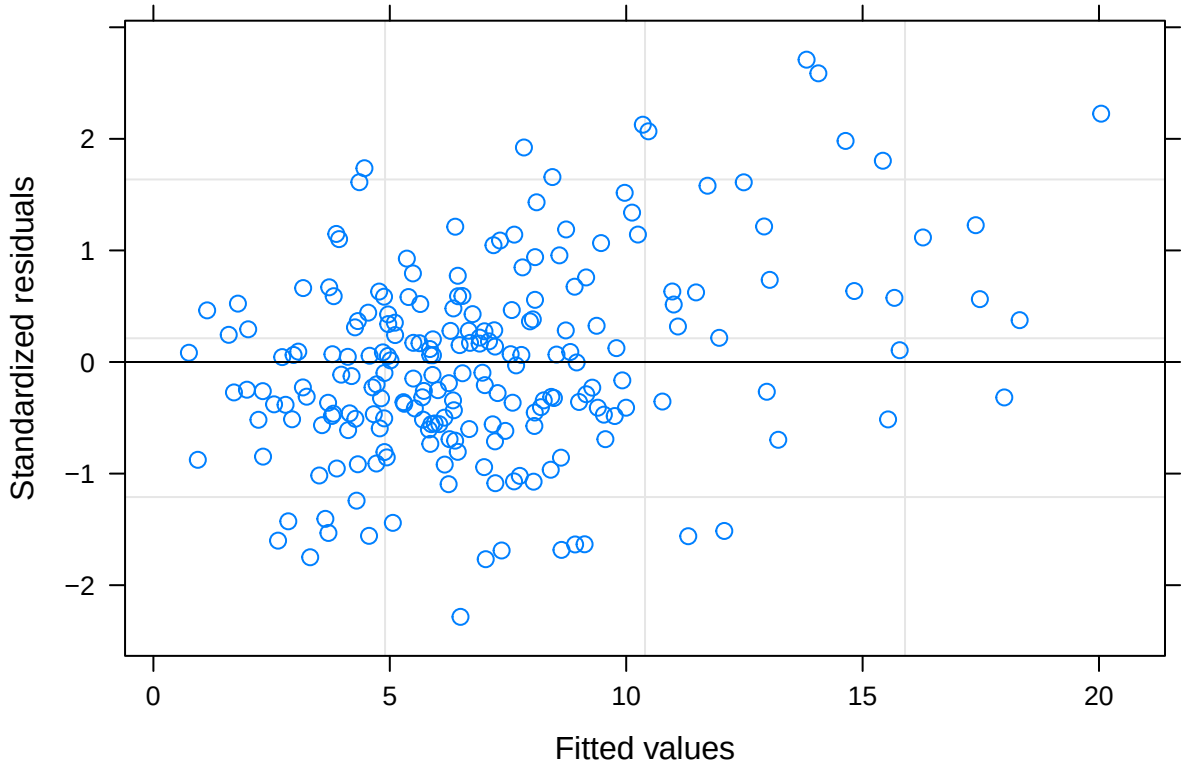
```
# by order
plot(simple.model.plus.order, resid(., type="p")~fitted(.)|order, id=0.05, adj=-.3)
```



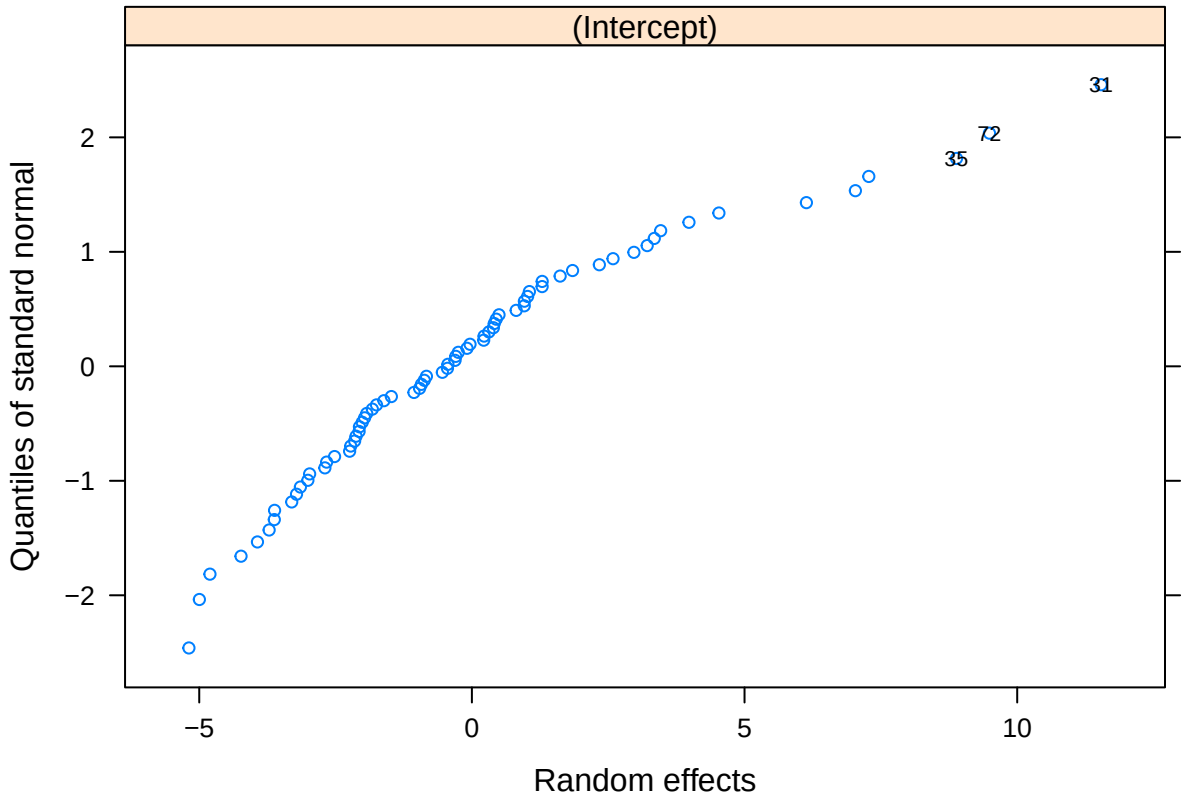

```
# remove interaction
simple.model.plus.order.no.ix <- lme(diff ~ distraction + order, random=~1|id, method="REML", data=data
anova(simple.model.plus.order.no.ix)
```

```
##             numDF denDF   F-value p-value
## (Intercept)     1   141 156.88699  <.0001
## distraction     2   141   3.52069  0.0322
## order           1   141   3.42643  0.0663
```

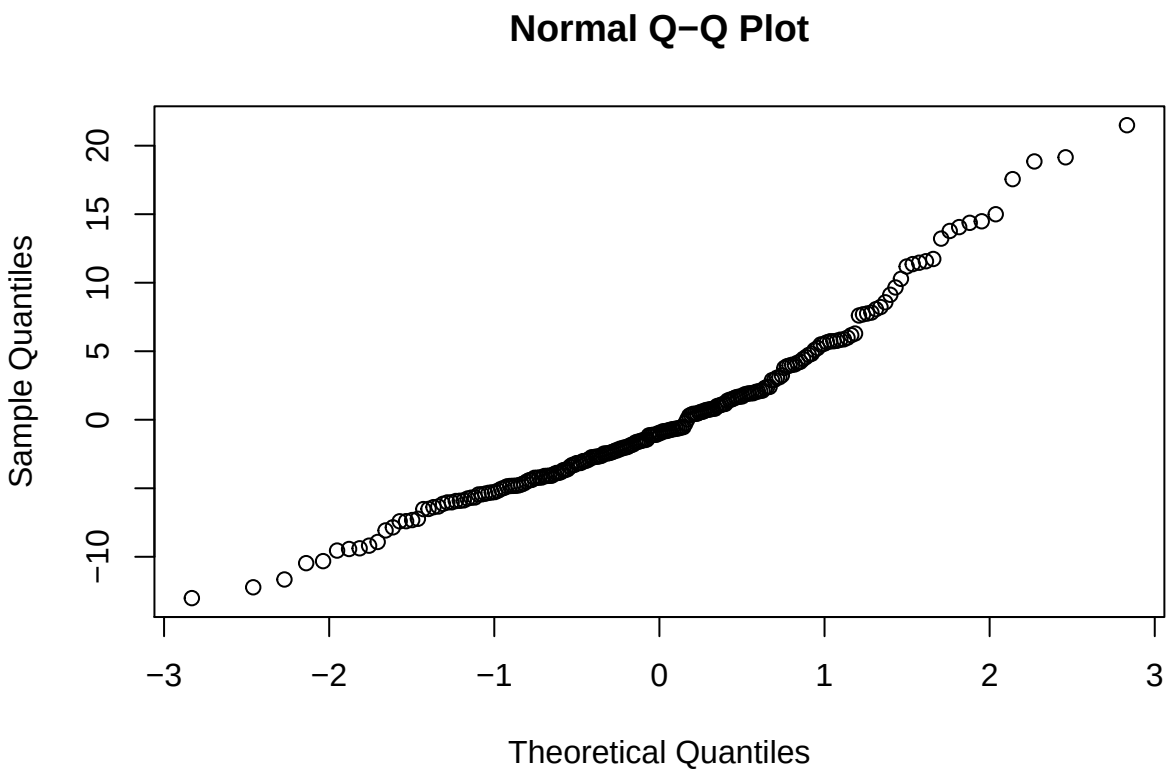
```
plot(simple.model.plus.order.no.ix)
```



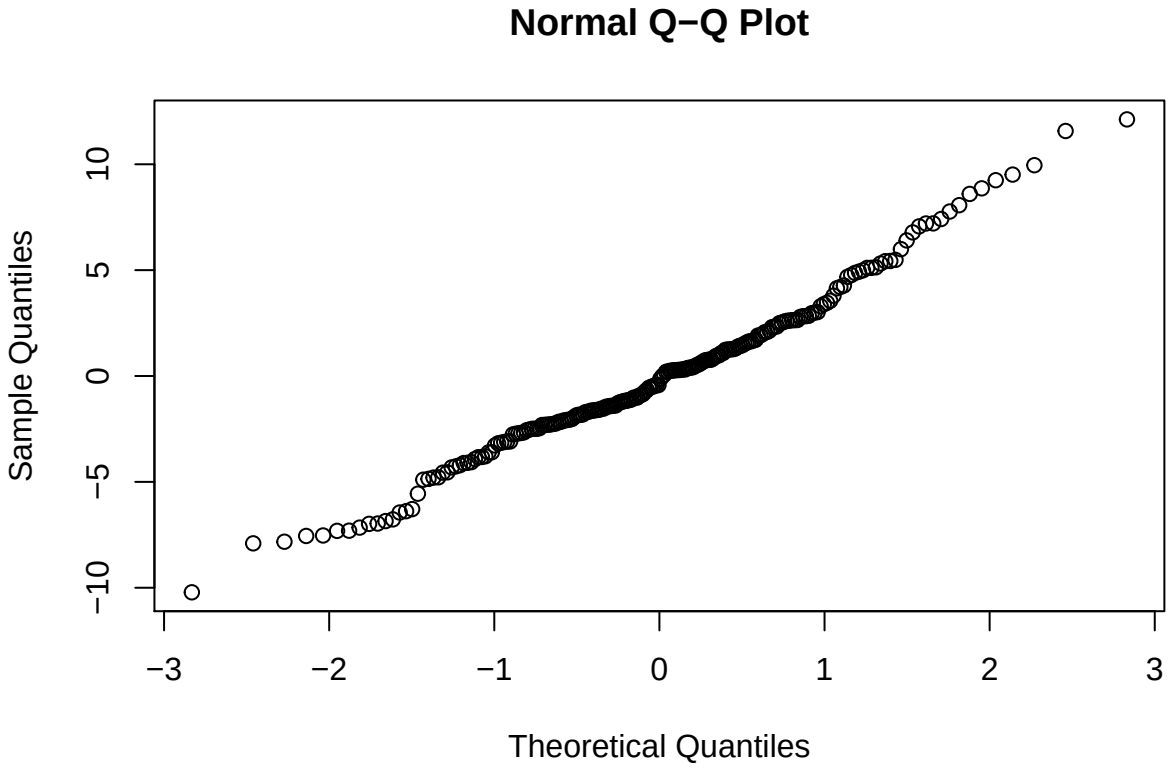

```
# random effects
qqnorm(simple.model.plus.order.no.ix, ~ranef(.), id=0.05, cex=0.7)
```



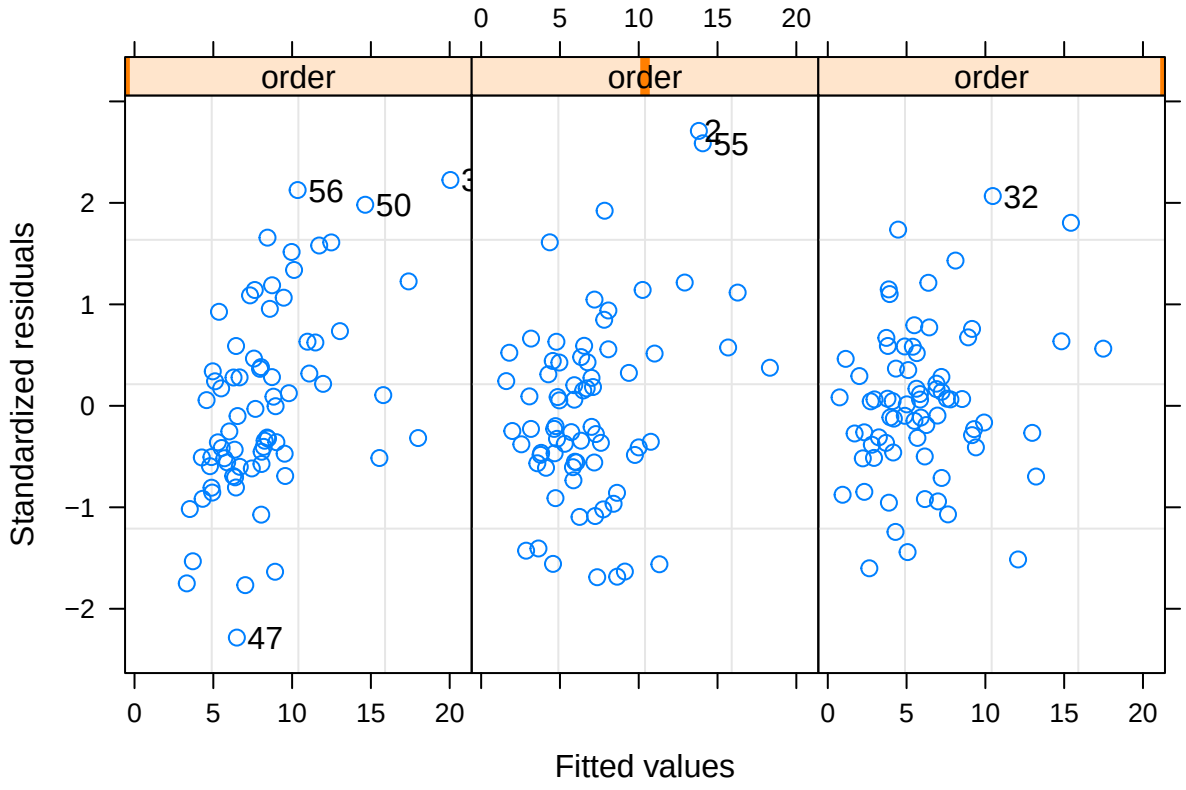
```r
# marginal residuals
qqnorm(resid(simple.model.plus.order.no.ix, level=0))
```




```r
# conditional residuals
qqnorm(resid(simple.model.plus.order.no.ix,level=1)) # same as from residuals command
```



```
# by order
plot(simple.model.plus.order.no.ix, resid(., type="p")~fitted(.)|order, id=0.05, adj=-.3)
```



Look at correlations between pairs of observations on same subject

```
print('Correlation and Variance-Covariance matrices by distraction')
```

```
## [1] "Correlation and Variance-Covariance matrices by distraction"
```

```
cor(cbind(data$diff[data$distraction=="control"],
data$diff[data$distraction=="lyrics"],
data$diff[data$distraction=="classical"]))
```

```
##           [,1]      [,2]      [,3]
## [1,] 1.0000000 0.4503484 0.4780272
## [2,] 0.4503484 1.0000000 0.4054406
## [3,] 0.4780272 0.4054406 1.0000000
```

```
var(cbind(data$diff[data$distraction=="control"],
data$diff[data$distraction=="lyrics"],
data$diff[data$distraction=="classical"]))
```

```
##          [,1]     [,2]     [,3]
## [1,] 43.94507 16.93844 18.34075
## [2,] 16.93844 32.19136 13.31393
## [3,] 18.34075 13.31393 33.49798
```

```
print('Correlation and Variance-Covariance matrices by order')
```

```
## [1] "Correlation and Variance-Covariance matrices by order"
```

```
cor(cbind(data$diff[data$order==1],
data$diff[data$order==2],
data$diff[data$order==3]))
```

```
##           [,1]      [,2]      [,3]
## [1,] 1.0000000 0.4372640 0.5343075
## [2,] 0.4372640 1.0000000 0.4012349
## [3,] 0.5343075 0.4012349 1.0000000
```

```
var(cbind(data$diff[data$order==1],
data$diff[data$order==2],
data$diff[data$order==3]))
```

```
##          [,1]     [,2]     [,3]
## [1,] 44.90689 17.77793 18.61137
## [2,] 17.77793 36.80966 12.65349
## [3,] 18.61137 12.65349 27.01851
```

Examine whether variance differing with distraction / order gives better fit

```
# check variance differing with distraction
model.Vdistraction <- lme(diff ~ distraction + order, random=~1|id, weights=varIdent(form=~1|distractio
anova(model.Vdistraction)
```

```
##             numDF denDF   F-value p-value
## (Intercept)     1   141 155.28726  <.0001
## distraction     2   141   3.16590  0.0452
## order           1   141   3.35619  0.0691
```

```
anova(simple.model.plus.order.no.ix, model.Vdistraction)
```

```
##                               Model df      AIC      BIC    logLik   Test
## simple.model.plus.order.no.ix     1  6 1354.019 1374.159 -671.0097
## model.Vdistraction                2  8 1356.645 1383.497 -670.3223 1 vs 2
##                                L.Ratio p-value
## simple.model.plus.order.no.ix
## model.Vdistraction            1.374784  0.5029
```

```
# check variance differing with order
model.Vorder <- lme(diff ~ distraction + order, random=~1|id, weights=varIdent(form=~1|order), method="
anova(model.Vorder)
```

```
##             numDF denDF   F-value p-value
## (Intercept)     1   141 153.85763  <.0001
## distraction     2   141   3.31881  0.0390
## order           1   141   3.70586  0.0562
```

```
anova(simple.model.plus.order.no.ix, model.Vorder)
```

```
##                               Model df      AIC      BIC    logLik   Test
## simple.model.plus.order.no.ix     1  6 1354.019 1374.159 -671.0097
## model.Vorder                      2  8 1353.037 1379.890 -668.5187 1 vs 2
##                                L.Ratio p-value
## simple.model.plus.order.no.ix
## model.Vorder                  4.981998  0.0828
```

```r
summary(emmeans(model.Vorder, ~distraction))
```

```
##  distraction emmean    SE df lower.CL upper.CL
##  classical     6.80 0.721 71     5.37     8.24
##  control       7.66 0.756 71     6.16     9.17
##  lyrics        6.81 0.711 71     5.40     8.23
##
## Degrees-of-freedom method: containment
## Confidence level used: 0.95
```

Can I get a better fit with UN covariance structure?

```r
# CS covariance structure, different variances with levels of order
simple.model.Vcs <- lme(diff ~ distraction + order, random=~1|id, weights=varIdent(form=~1|order), metho

# UN covariance structure,  different variances with levels of order
simple.model.Vun <- lme(diff ~ distraction + order, random=~1|id,weights=varIdent(form=~1|order), method

anova(simple.model.Vcs, simple.model.Vun)
```

```
##                  Model df      AIC      BIC    logLik   Test  L.Ratio
## simple.model.Vcs     1  8 1353.037 1379.89 -668.5187
## simple.model.Vun     2 11 1356.968 1393.89 -667.4840 1 vs 2 2.069411
##                  p-value
## simple.model.Vcs
## simple.model.Vun  0.5581
```

Role of other variables

colour blind

Only one colour blind student

english

```r
model_en <- lme(diff ~ distraction*english + order, random=~1|id, weights=varIdent(form=~1|order), metho
anova(model_en)
```

```
##                     numDF denDF   F-value p-value
## (Intercept)             1   139 152.59813  <.0001
## distraction             2   139   3.30645  0.0395
## english                 1    70   0.17771  0.6746
## order                   1   139   3.72694  0.0556
## distraction:english     2   139   0.43917  0.6455
```

video games

```r
model_vg <- lme(diff ~ distraction*vgames + order, random=~1|id, weights=varIdent(form=~1|order), method
anova(model_vg)
```

```
##                     numDF denDF   F-value p-value
## (Intercept)             1   139 151.67356  <.0001
## distraction             2   139   3.33792  0.0384
## vgames                  1    70   0.00204  0.9641
## order                   1   139   3.79939  0.0533
## distraction:vgames      2   139   0.71987  0.4886
```

```
model_vg <- lme(diff ~ distraction + order + vgames, random=~1|id, weights=varIdent(form=~1|order), meth
anova(model_vg)
```

```
##             numDF denDF   F-value p-value
## (Intercept)     1   141 151.74061  <.0001
## distraction     2   141   3.32353  0.0389
## order           1   141   3.70477  0.0563
## vgames          1    70   0.00101  0.9748
```

device

```
model_dv <- lme(diff ~ distraction*device + order, random=~1|id, weights=varIdent(form=~1|order), metho
anova(model_dv)
```

```
##                     numDF denDF   F-value p-value
## (Intercept)             1   137 164.94241  <.0001
## distraction             2   137   3.20329  0.0437
## device                  2    69   3.27748  0.0437
## order                   1   137   3.58502  0.0604
## distraction:device      4   137   1.26687  0.2861
```

```
model_dv <- lme(diff ~ distraction + order + device, random=~1|id, weights=varIdent(form=~1|order), meth
anova(model_dv)
```

```
##             numDF denDF   F-value p-value
## (Intercept)     1   141 163.15944  <.0001
## distraction     2   141   3.27555  0.0407
## order           1   141   3.67899  0.0571
## device          2    69   3.19301  0.0472
```

```
summary(emmeans(model_dv, ~device))
```

```
##  device        emmean    SE df lower.CL upper.CL
##  Android phone  10.10 1.312 71     7.49    12.72
##  iPad tablet     6.68 1.261 69     4.16     9.20
##  iPhone / iPod   6.44 0.668 69     5.10     7.77
##
## Results are averaged over the levels of: distraction
## Degrees-of-freedom method: containment
## Confidence level used: 0.95
```

headphones

```
model_hp <- lme(diff ~ distraction*headphones + order, random=~1|id, weights=varIdent(form=~1|order), m
anova(model_hp)
```

```
##                         numDF denDF   F-value p-value
```

```
## (Intercept)                1   135 164.28097  <.0001
## distraction                2   135   3.18130  0.0447
## headphones                 3    68   2.64161  0.0563
## order                      1   135   3.51878  0.0628
## distraction:headphones     6   135   0.14111  0.9905
```

```
model_hp <- lme(diff ~ distraction + headphones + order, random=~1|id, weights=varIdent(form=~1|order),
anova(model_hp)
```

```
##             numDF denDF   F-value p-value
## (Intercept)     1   141 164.63460  <.0001
## distraction     2   141   3.33005  0.0386
## headphones      3    68   2.64981  0.0557
## order           1   141   3.68295  0.0570
```

```
summary(emmeans(model_hp, ~headphones))
```

```
##  headphones                                  emmean    SE df lower.CL
##  In-ear headphones; noise cancelling           5.14 1.434 71     2.28
##  In-ear headphones; not noise cancelling       7.37 0.688 68     5.99
##  Over-ear headphones; noise cancelling         4.96 1.511 68     1.94
##  Over-ear headphones; not noise cancelling    10.06 1.511 68     7.05
##  upper.CL
##      8.00
##      8.74
##      7.98
##     13.08
##
## Results are averaged over the levels of: distraction
## Degrees-of-freedom method: containment
## Confidence level used: 0.95
```

hours of sleep

```
model_sl <- lme(diff ~ distraction*sleep + order, random=~1|id, weights=varIdent(form=~1|order), method=
anova(model_sl)
```

```
##                    numDF denDF   F-value p-value
## (Intercept)            1   138 152.43366  <.0001
## distraction            2   138   3.31306  0.0393
## sleep                  1   138   0.45623  0.5005
## order                  1   138   3.60707  0.0596
## distraction:sleep      2   138   0.20130  0.8179
```

```
model_sl <- lme(diff ~ distraction + sleep + order, random=~1|id, weights=varIdent(form=~1|order), metho
anova(model_sl)
```

```
##             numDF denDF   F-value p-value
## (Intercept)     1   140 152.89646  <.0001
## distraction     2   140   3.33285  0.0385
## sleep           1   140   0.45680  0.5002
## order           1   140   3.63378  0.0587
```

start time

```
model_start <- lme(diff ~ distraction*start + order, random=~1|id, weights=varIdent(form=~1|order), meth
anova(model_start)
```

```
##                   numDF denDF   F-value p-value
## (Intercept)           1   135 154.66433  <.0001
## distraction           2   135   3.32768  0.0388
## start                 2   135   1.78990  0.1709
## order                 1   135   4.13834  0.0439
## distraction:start     4   135   0.28682  0.8861
```

```
model_start <- lme(diff ~ distraction + start + order, random=~1|id, weights=varIdent(form=~1|order), m
anova(model_start)
```

```
##             numDF denDF   F-value p-value
## (Intercept)     1   139 155.70859  <.0001
## distraction     2   139   3.35875  0.0376
## start           2   139   1.77508  0.1733
## order           1   139   4.14916  0.0436
```

Check sensitivity of results to decisions made in data cleaning

Does one-person with colour-blind make a difference?

```
data %>% group_by(cblind) %>% summarize(mean = mean(diff))
```

```
## # A tibble: 2 x 2
##   cblind   mean
##   <chr>   <dbl>
## 1 No     7.18
## 2 Yes    0.0353
```

```
data_ncb <- data %>% filter(cblind=="No")
model.Vorder.ncb <- lme(diff ~ distraction + order, random=~1|id, weights=varIdent(form=~1|order), metho
anova(model.Vorder.ncb)
```

```
##             numDF denDF   F-value p-value
## (Intercept)     1   139 159.93377  <.0001
## distraction     2   139   3.32015   0.039
## order           1   139   3.59668   0.060
```

```
summary(emmeans(model.Vorder.ncb, ~distraction))
```

```
##  distraction emmean    SE df lower.CL upper.CL
##  classical     6.95 0.721 70     5.51     8.39
##  control       7.80 0.755 70     6.29     9.30
##  lyrics        6.85 0.712 70     5.43     8.27
##
## Degrees-of-freedom method: containment
## Confidence level used: 0.95
```

Examine effect of imputation for people who had fewer than 5 runs

```
# students 12, 31, 66
data <- data %>% mutate(runs_error = ifelse(id %in% c(12, 31, 66), 1, 0))
data %>% group_by(runs_error) %>% summarize(means = mean(diff))
```

```
## # A tibble: 2 x 2
##   runs_error means
##        <dbl> <dbl>
## 1          0  6.95
## 2          1 10.0
```

```
data_nre <- data %>% filter(runs_error==0)
model.Vorder.nre <- lme(diff ~ distraction + order, random=~1|id, weights=varIdent(form=~1|order), metho
anova(model.Vorder.nre)
```

```
##             numDF denDF   F-value p-value
## (Intercept)     1   135 167.90829  <.0001
## distraction     2   135   2.20059  0.1147
## order           1   135   3.04346  0.0833
```

```
summary(emmeans(model.Vorder.nre, ~distraction))
```

```
##  distraction emmean    SE df lower.CL upper.CL
##  classical     6.75 0.707 68     5.34     8.16
##  control       7.38 0.736 68     5.91     8.85
##  lyrics        6.76 0.695 68     5.37     8.14
##
## Degrees-of-freedom method: containment
## Confidence level used: 0.95
```

Ontime - Offtime discrepancies

Try fit with calculated value rather than input value.

```
data <- data %>% mutate(calc_diff = ontime - offtime)
model.Vorder.calc <- lme(calc_diff ~ distraction + order, random=~1|id, weights=varIdent(form=~1|order)
anova(model.Vorder.calc)
```

```
##             numDF denDF   F-value p-value
## (Intercept)     1   141 156.59169  <.0001
## distraction     2   141   3.91273  0.0222
## order           1   141   2.52469  0.1143
```

```
summary(emmeans(model.Vorder, ~distraction))
```

```
##  distraction emmean    SE df lower.CL upper.CL
##  classical     6.80 0.721 71     5.37     8.24
##  control       7.66 0.756 71     6.16     9.17
##  lyrics        6.81 0.711 71     5.40     8.23
##
## Degrees-of-freedom method: containment
## Confidence level used: 0.95
```

Check effect of which level when for subjects with discrepancies

```
data <- data %>% mutate(alllevels = ifelse(is.na(alllevels), ";;", alllevels))

data <- data %>% mutate(distraction1 = str_split(alllevels, ";", simplify=T)[,1]) %>%
  mutate(distraction2 = str_split(alllevels, ";", simplify=T)[,2]) %>%
  mutate(distraction3 = str_split(alllevels, ";", simplify=T)[,3])
data <- data %>% mutate(distraction1 = ifelse(distraction1 == "Control (quiet)", "control",
                                ifelse(distraction1 == "Song with lyrics (Shape of You by Ed Sheeran)",
                                ifelse(distraction1 == "Classical (Mozart)", "classical", "")))  ) %>%
                         mutate(distraction2 = ifelse(distraction2 == "Control (quiet)","control",
                                ifelse(distraction2 == "Song with lyrics (Shape of You by Ed Sheeran)","
                                ifelse(distraction2 == "Classical (Mozart)", "classical", "")))  ) %>%
                         mutate(distraction3 = ifelse(distraction3 == "Control (quiet)","control",
                                ifelse(distraction3 == "Song with lyrics (Shape of You by Ed Sheeran)","
                                ifelse(distraction3 == "Classical (Mozart)", "classical", "")))  )
data <- data %>% mutate(newdist = ifelse(order==1, distraction1, ifelse(order==2, distraction2, distrac
data <- data %>% mutate(newdist = ifelse(newdist == "", distraction, newdist))
table(data$newdist)
```

```
##
## classical   control    lyrics
##        72        72        72
```

```
model.Vorder.levels <- lme(diff ~ newdist + order, random=~1|id, weights=varIdent(form=~1|order), metho
anova(model.Vorder.levels)
```

```
##             numDF denDF   F-value p-value
## (Intercept)     1   141 153.59211  <.0001
## newdist         2   141   3.21515  0.0431
## order           1   141   3.96341  0.0484
```

```
summary(emmeans(model.Vorder.levels, ~newdist))
```

```
##  newdist   emmean    SE df lower.CL upper.CL
##  classical   6.78 0.718 71     5.34     8.21
##  control     7.66 0.748 71     6.17     9.16
##  lyrics      6.84 0.709 71     5.43     8.25
##
## Degrees-of-freedom method: containment
## Confidence level used: 0.95
```

For the draft report

```
# Figure 1: Boxplots

# Figure 2: Output for Fixed Effect Model 1
knitr::kable(summary(simple.model)$tTable[,-3],digital=3)
```

	Value	Std.Error	t-value	p-value
(Intercept)	6.406847	0.7124372	8.9928595	0.0000000
distractioncontrol	1.805444	0.7517960	2.4015085	0.0176214

	Value	Std.Error	t-value	p-value
distractionlyrics	0.202750	0.7517960	0.2696875	0.7877922

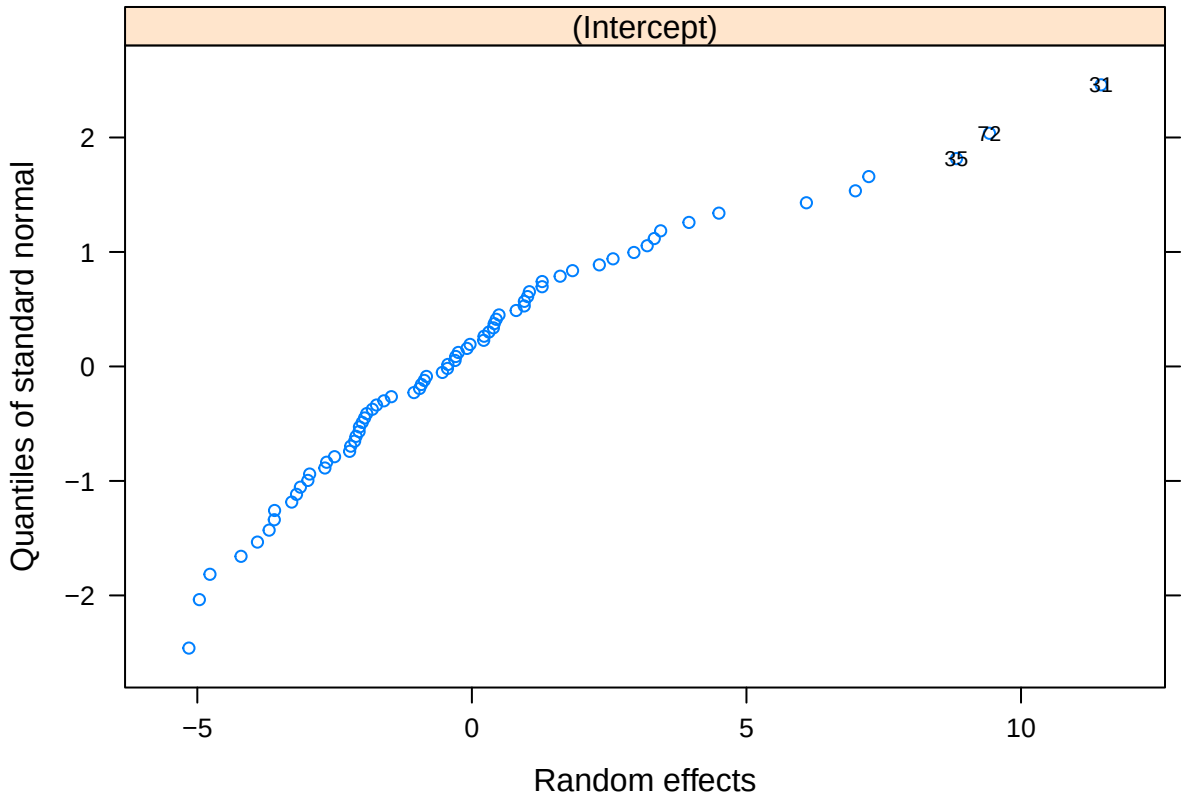
```
# Figure 3: Output for Fixed Effects Model 2
knitr::kable(summary(simple.model.Vun)$tTable[,-3],digital=3)
```

	Value	Std.Error	t-value	p-value
(Intercept)	8.6212286	1.3315172	6.4747407	0.0000000
distractioncontrol	0.6859148	0.8665132	0.7915804	0.4299350
distractionlyrics	-0.0833647	0.7264626	-0.1147543	0.9088031
order	-0.8769906	0.4229488	-2.0735151	0.0399440

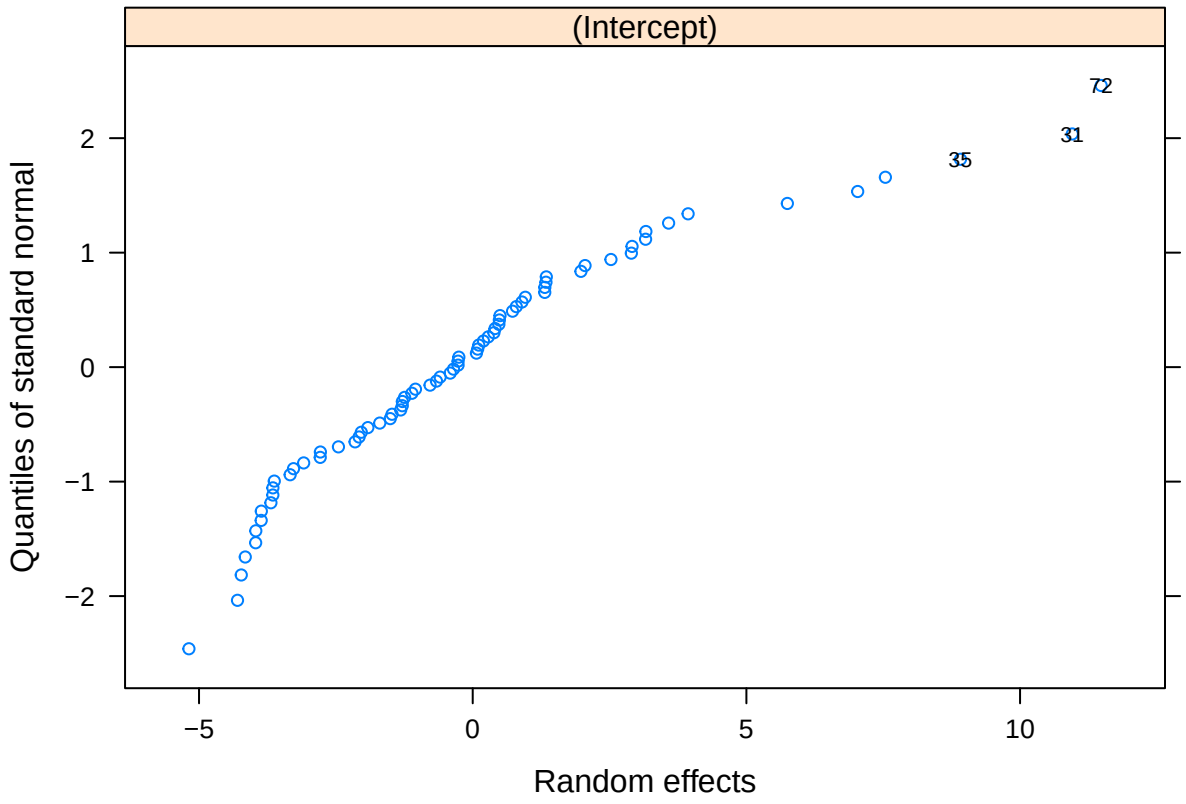
```
# Figure 4: Output for Random Effects Model 1
knitr::kable(VarCorr(simple.model))
```

	Variance	StdDev
(Intercept)	16.1977	4.024637
Residual	20.3471	4.510776

```
# Figure 5: QQ plot of Random Effects Model 1
qqnorm(simple.model, ~ranef(.), id=0.05, cex=0.7)
```




```
# Figure 6: QQ plot of Random Effects Model 2
qqnorm(simple.model.Vun, ~ranef(.), id=0.05, cex=0.7)
```



For the final report

```
final.model <- lme(diff ~ newdist + order + device, random=~1|id,weights=varIdent(form=~1|order), metho

knitr::kable(anova(final.model),digits=2)
```

	numDF	denDF	F-value	p-value
(Intercept)	1	141	155.38	0.00
newdist	2	141	2.99	0.05
order	1	141	4.75	0.03
device	2	69	3.53	0.03

```
knitr::kable(summary(final.model)$tTable[,-3],digital=3)
```

	Value	Std.Error	t-value	p-value
(Intercept)	11.7677268	1.7497848	6.7252422	0.0000000
newdistcontrol	0.6622960	0.8448558	0.7839160	0.4344043
newdistlyrics	0.0160896	0.7235346	0.0222375	0.9822899
order	-0.9012657	0.4123390	-2.1857396	0.0304852
deviceiPad tablet	-3.6384715	1.7900714	-2.0325846	0.0459449
deviceiPhone / iPod	-3.7884337	1.4464453	-2.6191337	0.0108296

```
knitr::kable(VarCorr(final.model))
```

	Variance	StdDev
(Intercept)	14.81129	3.848544
Residual	29.38215	5.420530

```
# Boxplots
par(mfrow=c(1,3))
boxplot(diff~newdist,data = data, ylab = "cognitive flexibility")
boxplot(diff~ order,data = data, ylab = "cognitive flexibility")
boxplot(diff ~ device,data = data, ylab = "cognitive flexibility")
```