Tables, Random Effects and Plots in Multilevel Analysis

Workshop Guide

Kamarul Imran Musa Afiq Amsyar

2025-09-10

Table of contents

1 Table, random effects and plots

1.1 Packages

A few useful packages to further improve the presentation of mixed model results.

Let's load some packages

- `lme4` to analyze mixed models
- `tidyverse` to wrangle data and make plots

```
library(lme4)
library(tidyverse)
```

1.2 Dataset

We we use the built in `sleepstudy` dataset

```
data("sleepstudy")
```

1.3 Random intercept model

We start of with random intercept model

```
model <- lmer(Reaction ~ Days + (1 | Subject),
              data = sleepstudy)
```

1.4 Random slope model

Next, we estimate random slope model

```
model2 <- lmer(Reaction ~ Days + (Days | Subject),
               data = sleepstudy)
```

1.5 Plots

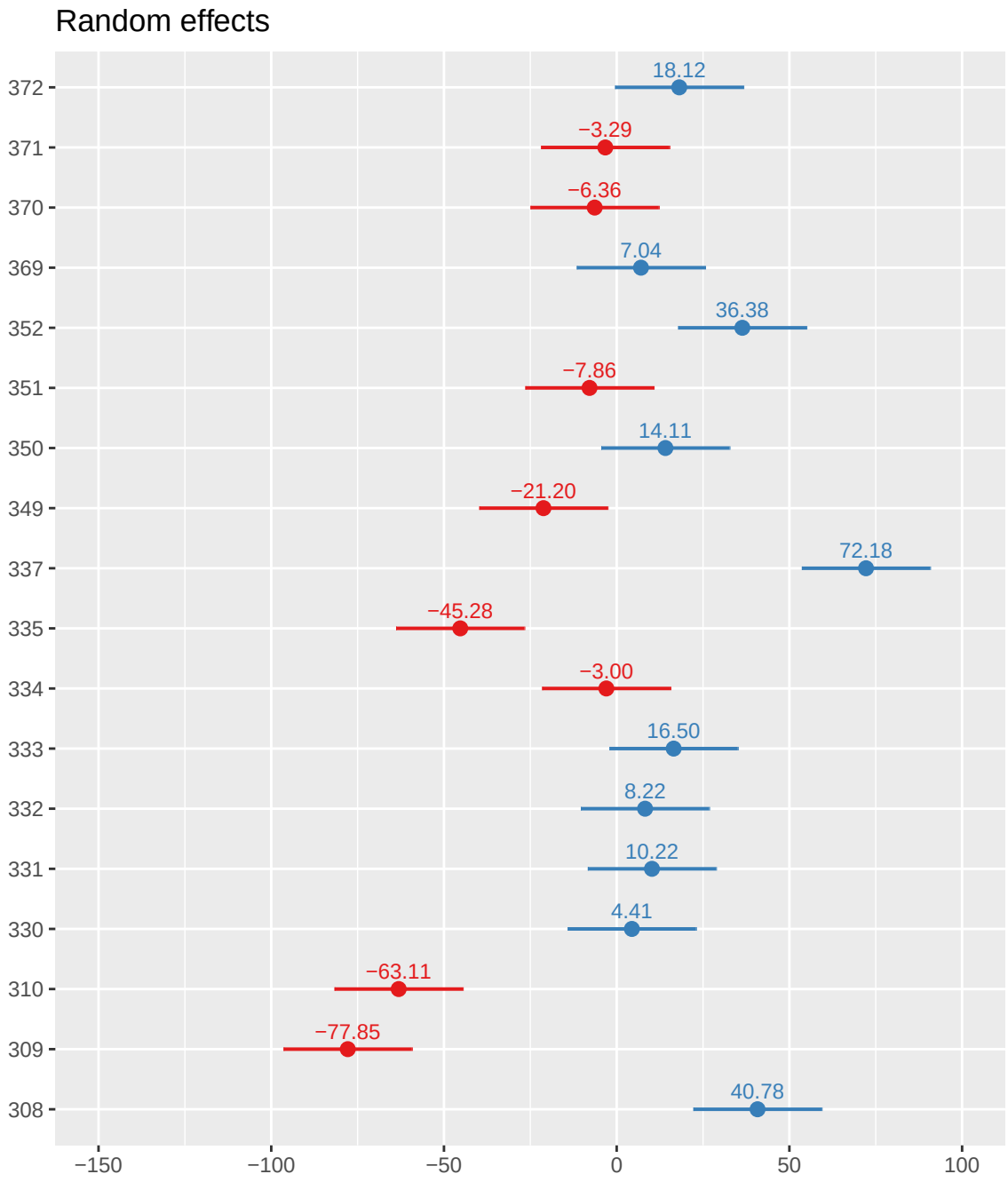
- Load additional packages to make plots for multilevel objects

```
library(sjPlot)
library(lattice)
```

1.5.1 Plot random intercept model using sjPlot

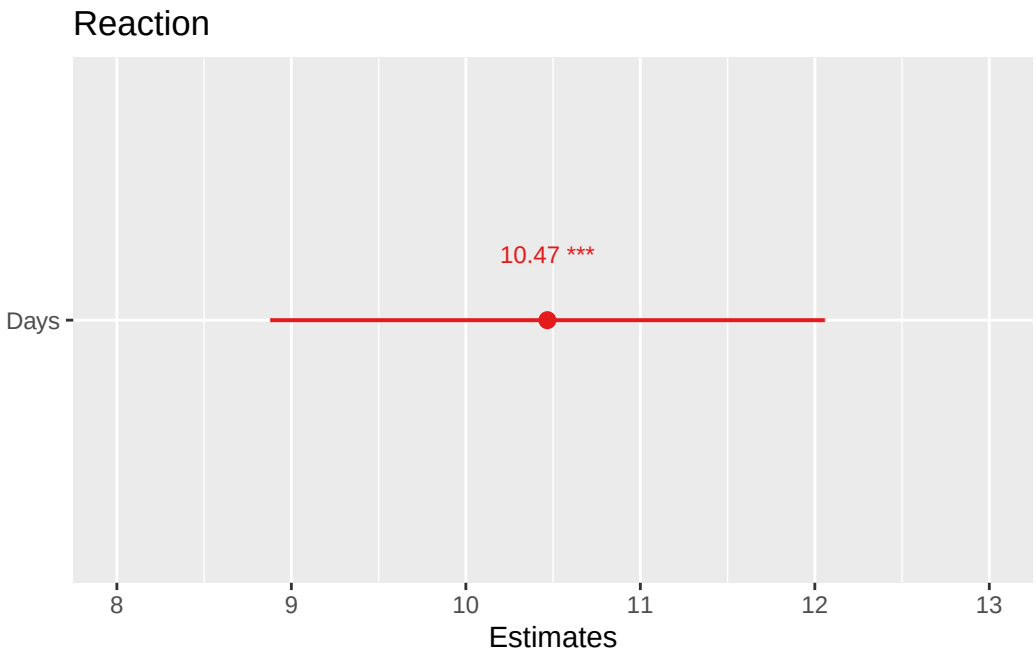
- Plot random effect

```
plot_model(model, type = "re",
           show.values = TRUE,
           value.offset = .3,
           value.size = 3)
```



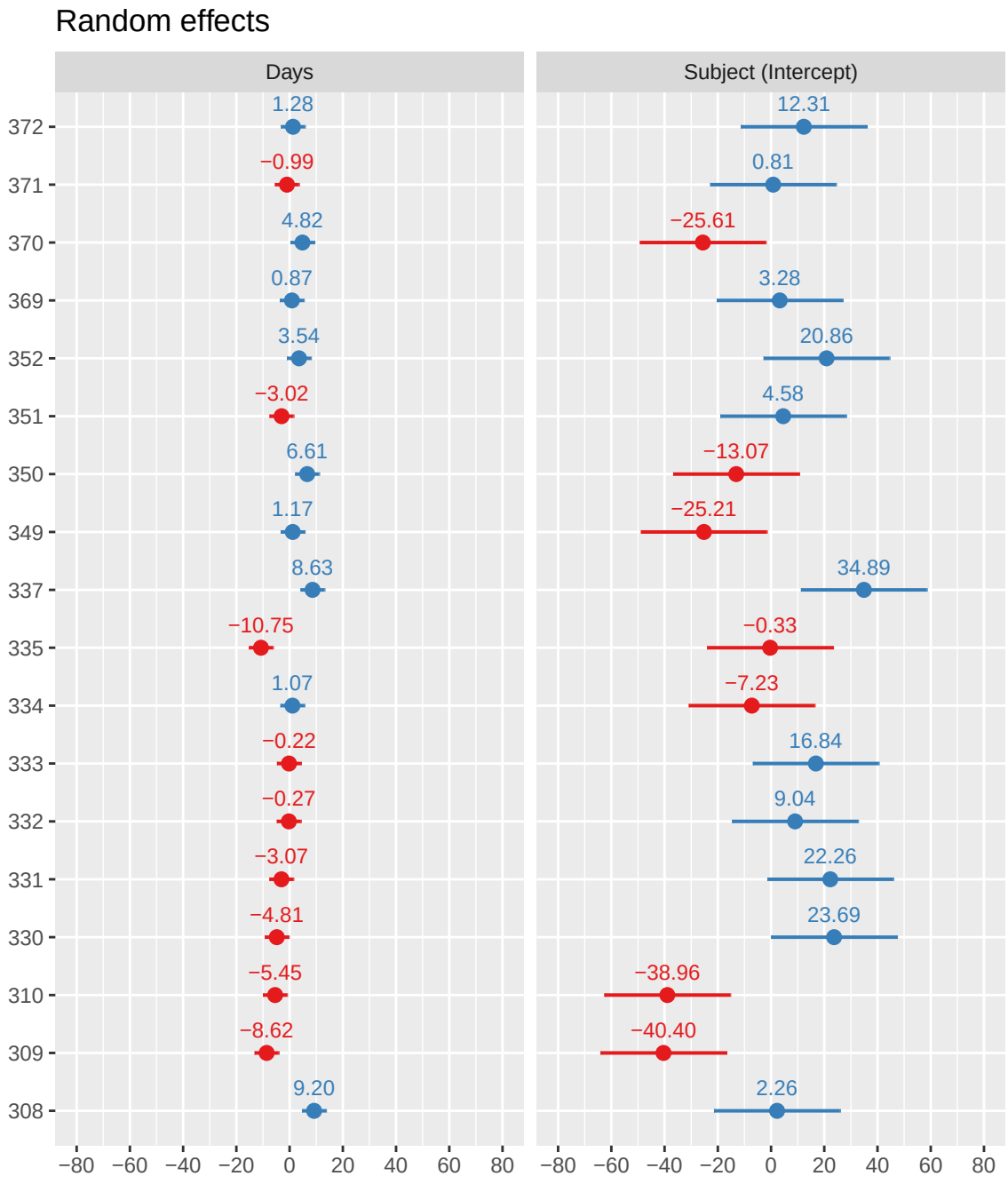
- Plot fixed effect

```
plot_model(model, type = "est",
           show.values = TRUE,
           value.size = 3)
```



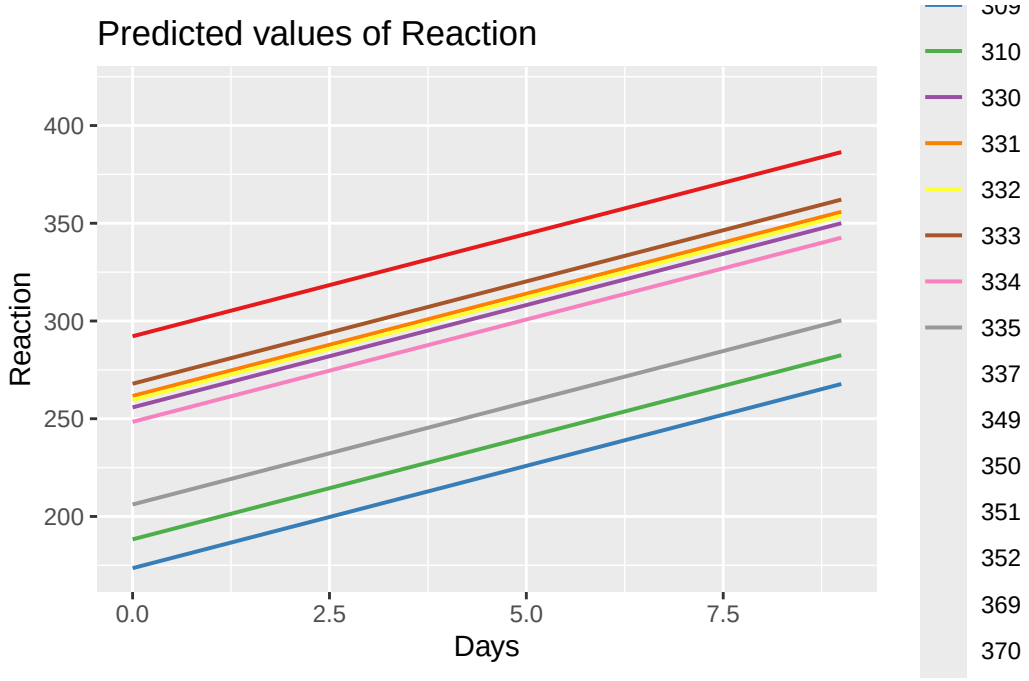
1.5.2 Plot random slope model using sjPlot

```
plot_model(model2, type = "re",
           show.values = TRUE, value.offset = .4,
           value.size = 3)
```

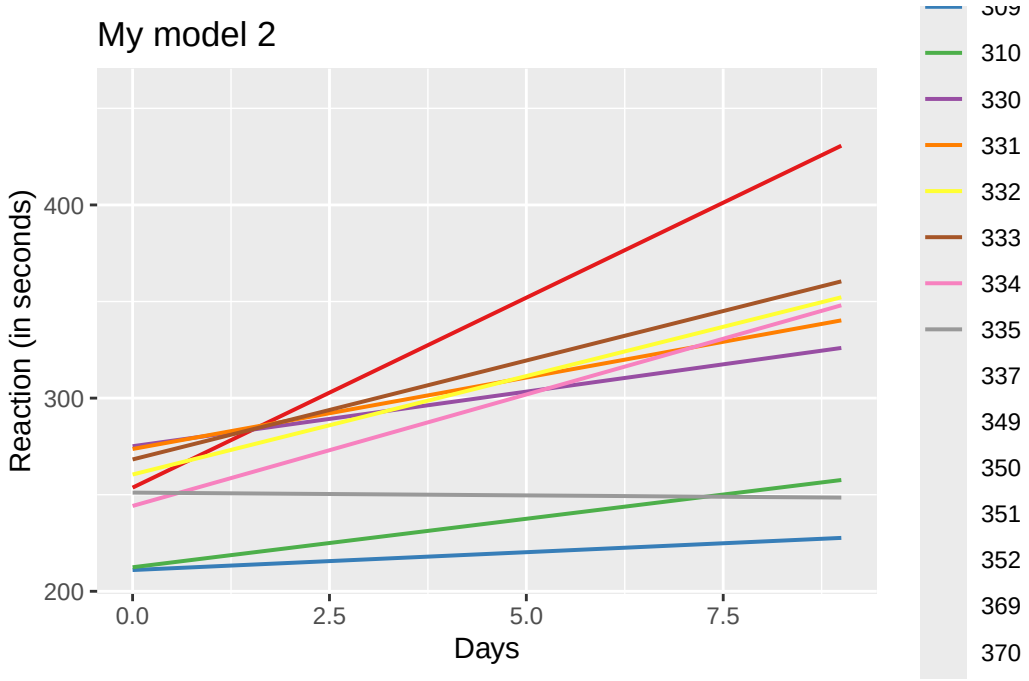

Random effects
Days
Subject (Intercept)
372
371
370
369
352
351
350
349
337
335
334
333
332
331
330
310
309
308
1.28
−0.99
4.82
0.87
3.54
−3.02
6.61
1.17
8.63
−10.75
1.07
−0.22
−0.27
−3.07
−4.81
−5.45
−8.62
9.20
12.31
0.81
−25.61
3.28
20.86
4.58
−13.07
−25.21
34.89
−0.33
−7.23
16.84
9.04
22.26
23.69
−38.96
−40.40
2.26
−80 −60 −40 −20 0 20 40 60 80

1.5.3 Combining random effect and predicted value in a plot

```
plot_model(
  model,
  type = "pred",
  terms = c("Days", "Subject"),
  pred.type = "re",
  ci.lvl = NA
)
```




```
plot_model(
  model2,
  type = "pred",
  terms = c("Days", "Subject"),
  pred.type = "re",
  ci.lvl = NA,
  title = "My model 2",
  axis.title = "Reaction (in seconds)"
)
```

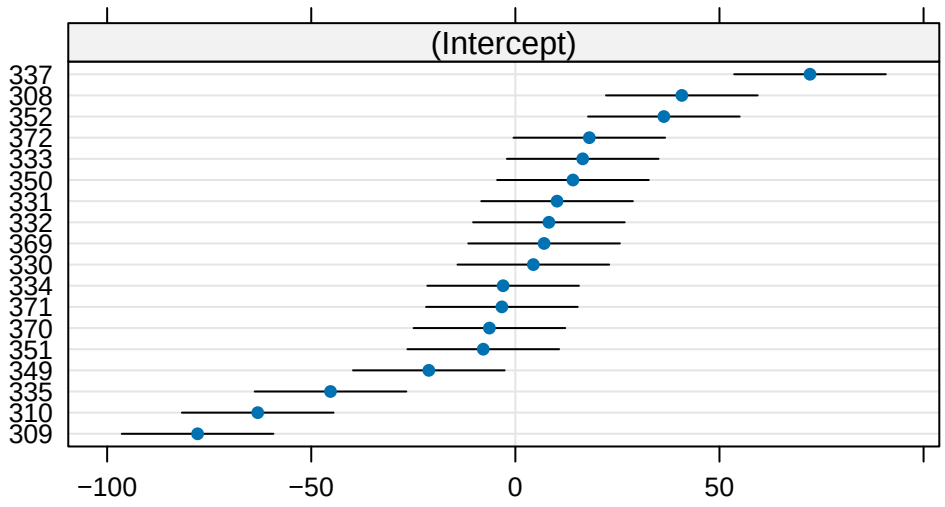


1.5.4 Caterpillar plots

- random intercept (model)

```
dotplot(ranef(model))
```

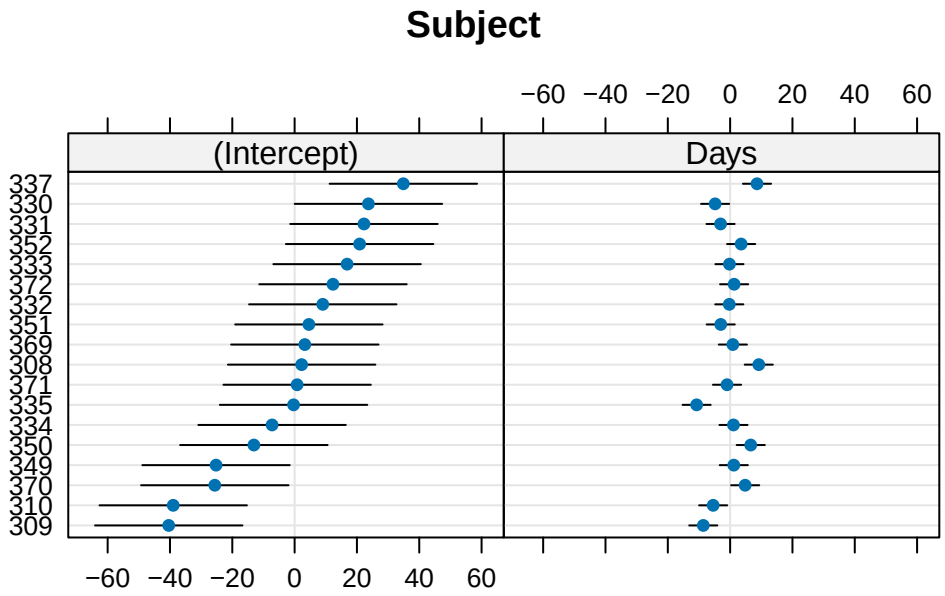
```
$Subject
```



- random slope (model2)

```
dotplot(ranef(model2))
```

```
$Subject
```



1.6 Tables

Useful packages include

```
library(modelsummary)
```

- using **modelsummary** to make results in a table

```
modelsummary(model)
```

```
modelsummary(model2)
```

- we can combine the results into a table

```
modelsummary(list(model, model2))
```

- using tab_model

	(1)
(Intercept)	251.405
	(9.747)
Days	10.467
	(0.804)
SD (Intercept Subject)	37.124
SD (Observations)	30.991
Num.Obs.	180
R2 Marg.	0.280
R2 Cond.	0.704
AIC	1794.5
BIC	1807.2
ICC	0.6
RMSE	29.41

	(1)
(Intercept)	251.405
	(6.825)
Days	10.467
	(1.546)
SD (Intercept Subject)	24.741
SD (Days Subject)	5.922
Cor (Intercept~Days Subject)	0.066
SD (Observations)	25.592
Num.Obs.	180
R2 Marg.	0.279
R2 Cond.	0.799
AIC	1755.6
BIC	1774.8
ICC	0.7
RMSE	23.44

	(1)	(2)
(Intercept)	251.405	251.405
	(9.747)	(6.825)
Days	10.467	10.467
	(0.804)	(1.546)
SD (Intercept Subject)	37.124	24.741
SD (Days Subject)		5.922
Cor (Intercept~Days Subject)		0.066
SD (Observations)	30.991	25.592
Num.Obs.	180	180
R2 Marg.	0.280	0.279
R2 Cond.	0.704	0.799
AIC	1794.5	1755.6
BIC	1807.2	1774.8
ICC	0.6	0.7
RMSE	29.41	23.44

```
tab_model(model)
```

```
tab_model(model2)
```

- combining two tables

```
tab_model(model, model2)
```

2 Hands-on

- Create a new project and name the project
- Install packages
  - General package
  - Data wrangling
  - Read data

```
library(tidyverse)
library(haven)
library(here)
```

- For multilevel
- For presentation

```
library(lme4)
library(sjPlot)
library(modelsummary)
```

- Read data

```
immi <- read_dta('imm10_2.dta')
```

- EDA and data wrangling

```
glimpse(immi)
```

```
Rows: 260
Columns: 9
$ schid    <dbl> 7472, 7472, 7472, 7472, 7472, 7472, 7472, 7472, 7472, 7472, 7~
$ math     <dbl> 48, 48, 53, 42, 43, 57, 33, 64, 36, 56, 48, 48, 44, 35, 50, 3~
$ ses      <dbl> -0.13, -0.39, -0.80, -0.72, -0.74, -0.58, -0.83, -0.51, -0.56~
$ white    <dbl+lbl> 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, ~
$ parented <dbl+lbl> 2, 2, 2, 2, 2, 2, 2, 3, 2, 3, 2, 3, 2, 1, 2, 3, 3, 1, 3, ~
$ public   <dbl+lbl> 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, ~
$ sctype   <dbl+lbl> 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, ~
$ sex      <dbl+lbl> 2, 1, 1, 1, 2, 2, 2, 1, 2, 2, 2, 1, 1, 2, 2, 2, 2, 2, 2, ~
$ schnum   <dbl> 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1~
```

```
immi <-
  immi |>
  mutate(across(where(is.labelled), as_factor),
         schnum = factor(schnum))
```

- linear mixed effect model
  - random intercept
  - and we assume math increase similarly based on ses for all schools

```
ri_immi <-
  lmer(math ~ ses +  white + parented + (1 | schnum),
       data = immi, REML = FALSE)
```

- random slope
- and we assume math increase differently based on ses for all schools

```
rs_immi <-
  lmer(math ~ ses +  white + parented +
         (1 + ses | schnum), data = immi, REML = FALSE)
```

- Presentation
  - Tables

```
tab_model(list(ri_immi, rs_immi))
```

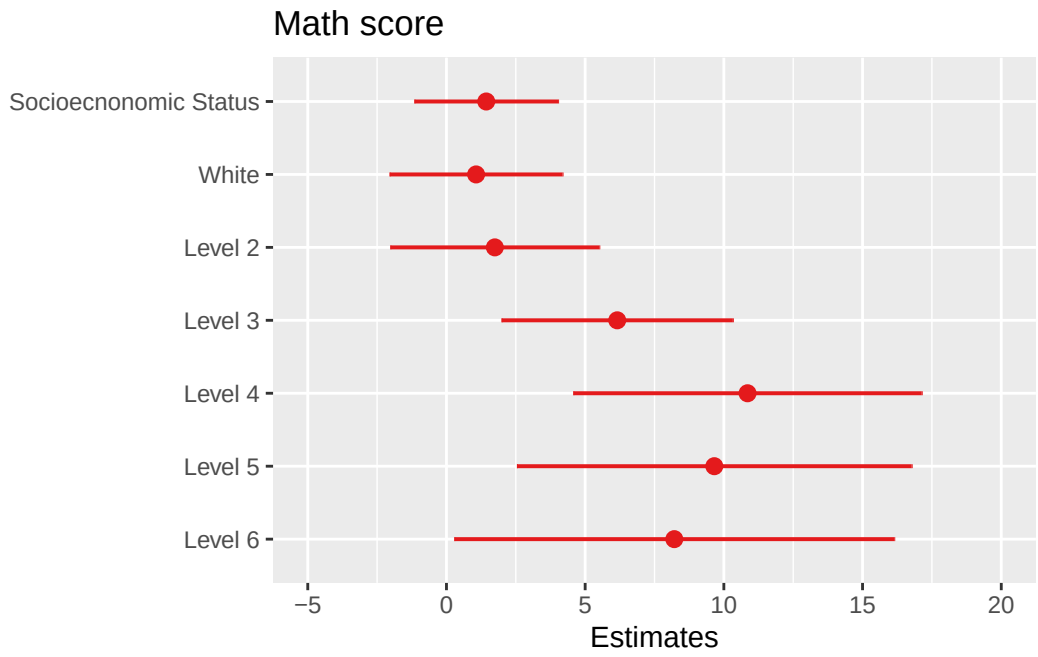
```
modelsummary(list(
  "random intercept" = ri_immi,
  "random slope" = rs_immi),
             fmt = fmt_decimal(digits = 2, pdigits = 2))
```

```
modelsummary(list(
  "random intercept" = ri_immi,
  "random slope" = rs_immi),
             fmt = fmt_decimal(digits = 2, pdigits = 2),
             output = "table.docx")
```

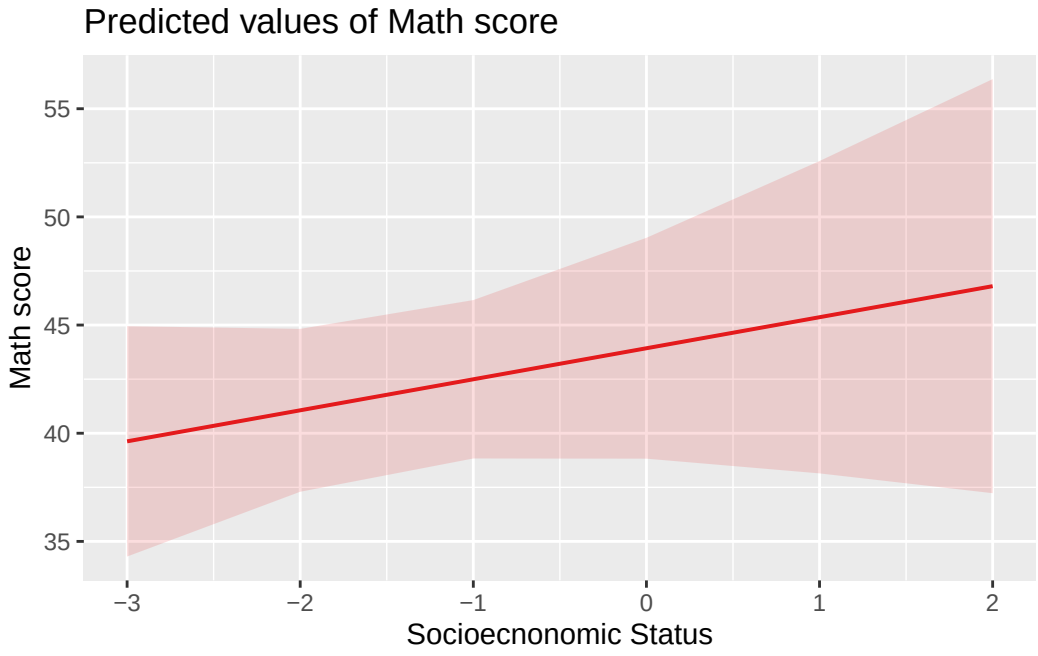
- Plots

```
plot_model(ri_immi,
           type = 'est')
```

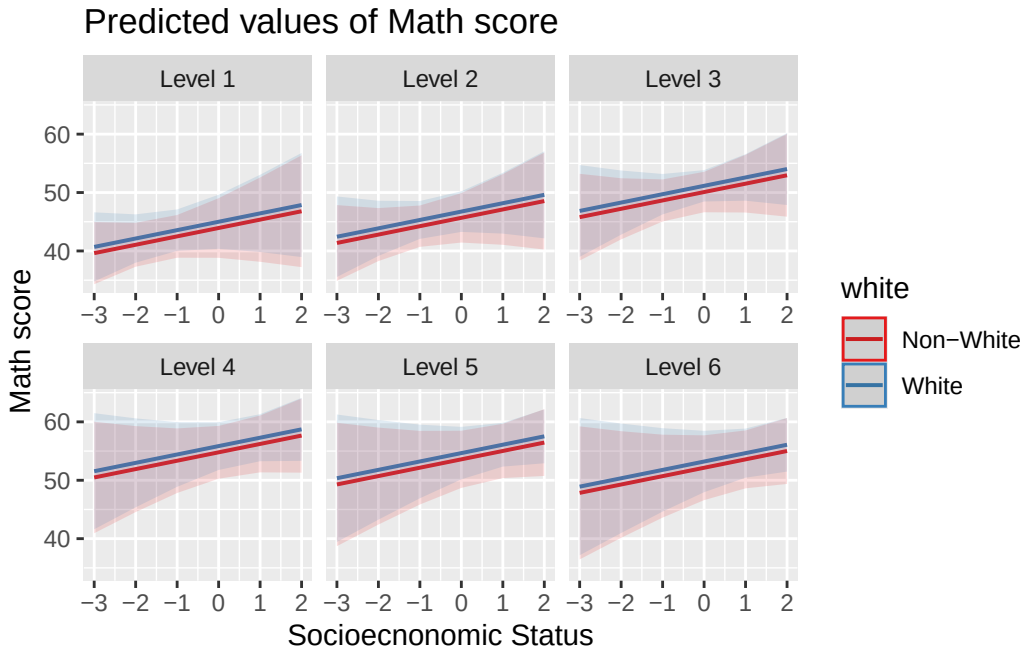
	random intercept	random slope
(Intercept)	43.93	43.45
	(2.59)	(2.54)
ses	1.43	1.34
	(1.31)	(1.41)
whiteWhite	1.07	0.14
	(1.58)	(1.41)
parentedLevel 2	1.74	2.11
	(1.91)	(1.91)
parentedLevel 3	6.16	7.06
	(2.12)	(2.12)
parentedLevel 4	10.85	11.52
	(3.19)	(3.20)
parentedLevel 5	9.66	9.54
	(3.61)	(3.64)
parentedLevel 6	8.21	7.31
	(4.03)	(4.09)
SD (Intercept schnum)	2.86	2.81
SD (ses schnum)		1.58
Cor (Intercept~ses schnum)		1.00
SD (Observations)	7.93	7.93
Num.Obs.	260	260
R2 Marg.	0.266	0.268
R2 Cond.	0.351	
AIC	1827.2	1830.1
BIC	1862.8	1872.8
ICC	0.1	
RMSE	7.81	7.83



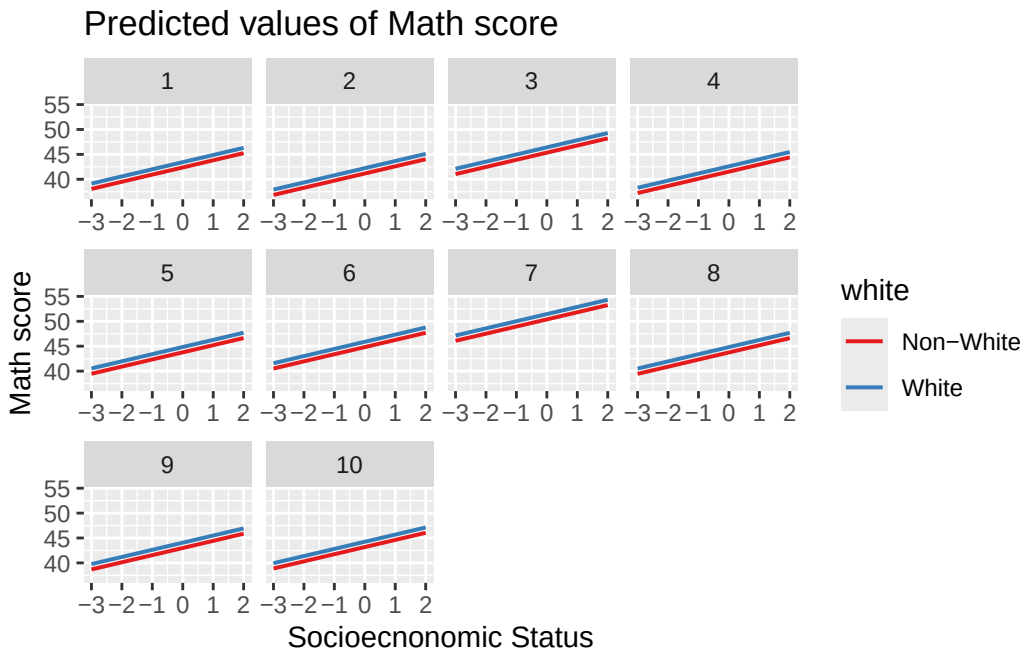

```
plot_model(ri_immi,
           type = 'pred',
           terms = 'ses')
```



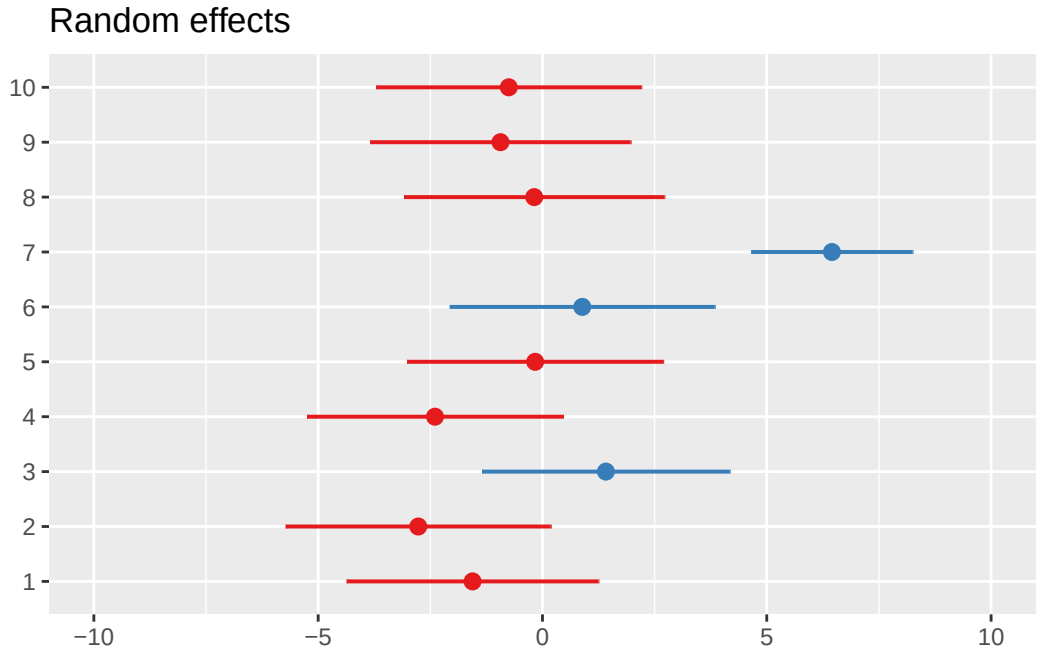
```
plot_model(ri_immi,
           type = 'pred',
           terms = c('ses' , 'white', 'parented'))
```




```
plot_model(ri_immi,
           type = 'pred',
           terms = c('ses' , 'white', 'schnum'),
           pred.type = 're', ci.lvl=NA)
```

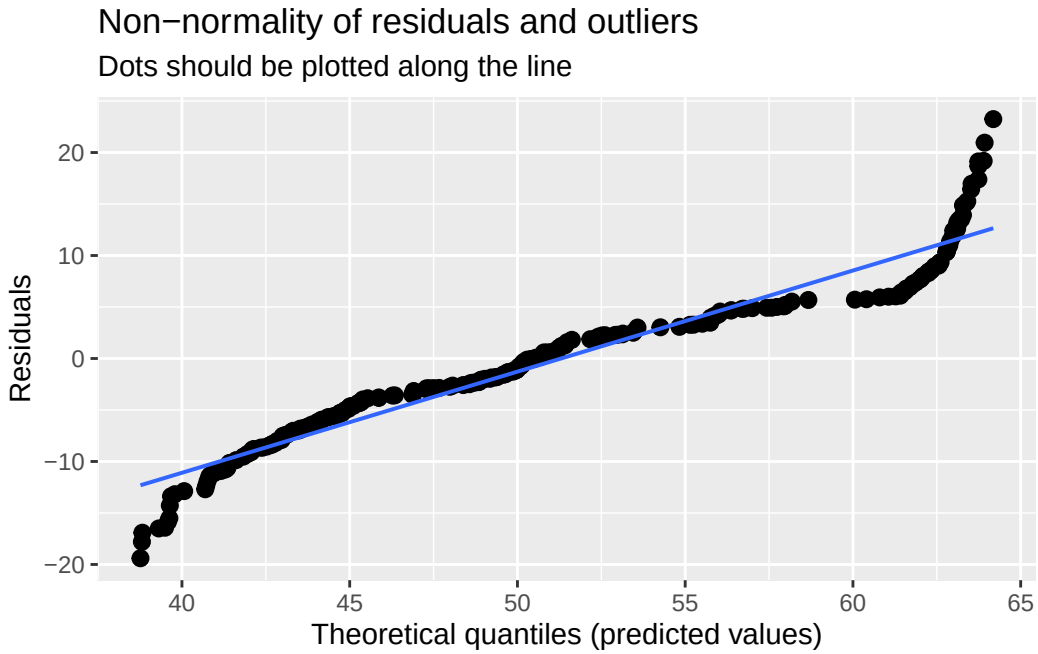



```
plot_model(ri_immi,
           type = 're')
```

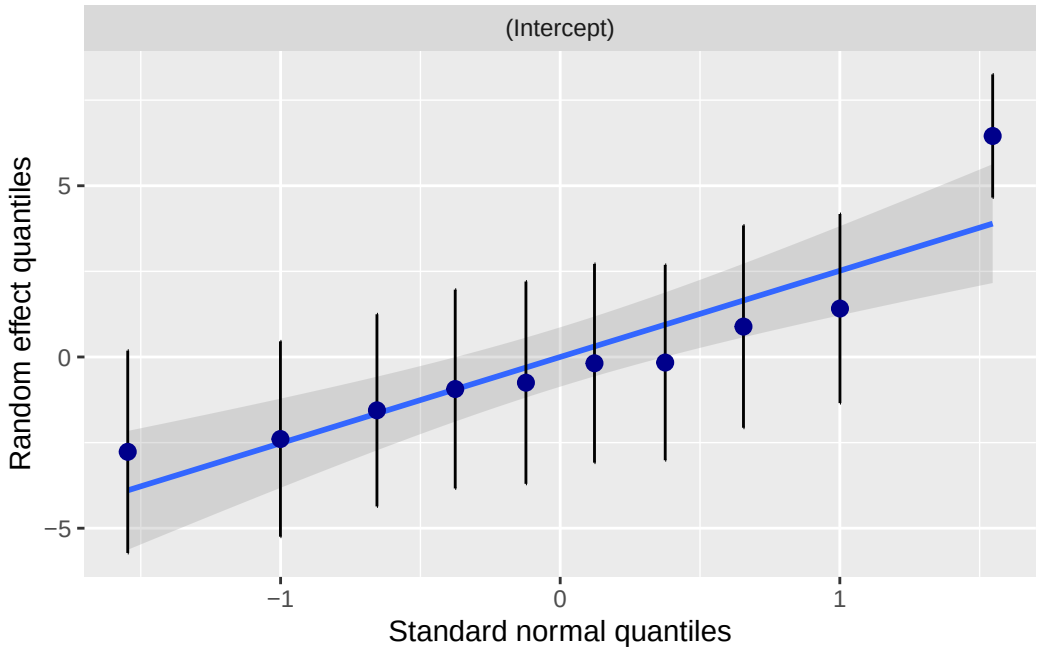


```
plot_model(ri_immi,
           type = 'diag')
```

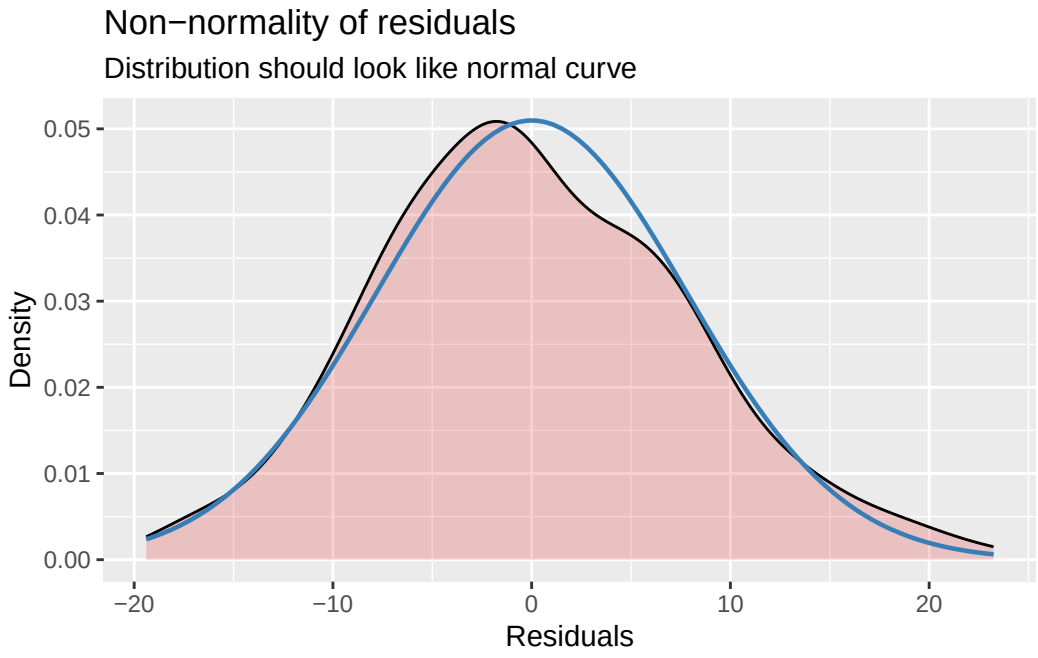
```
[[1]]
```



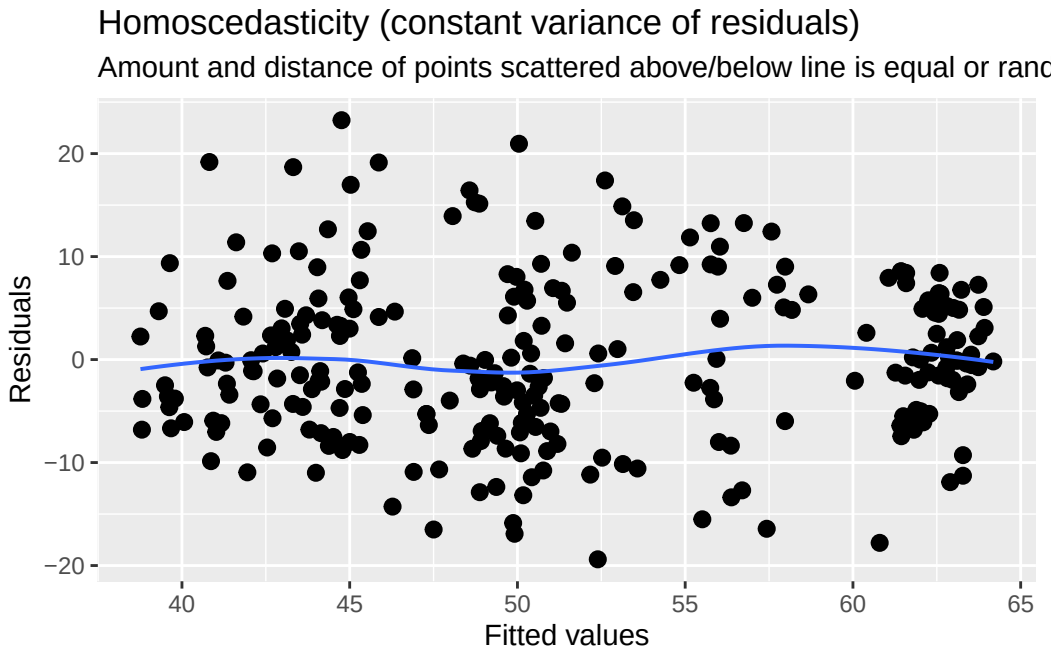

```
[[2]]
[[2]]$schnum
```


(Intercept)
Random effect quantiles
5
0
−5
−1
0
1
Standard normal quantiles

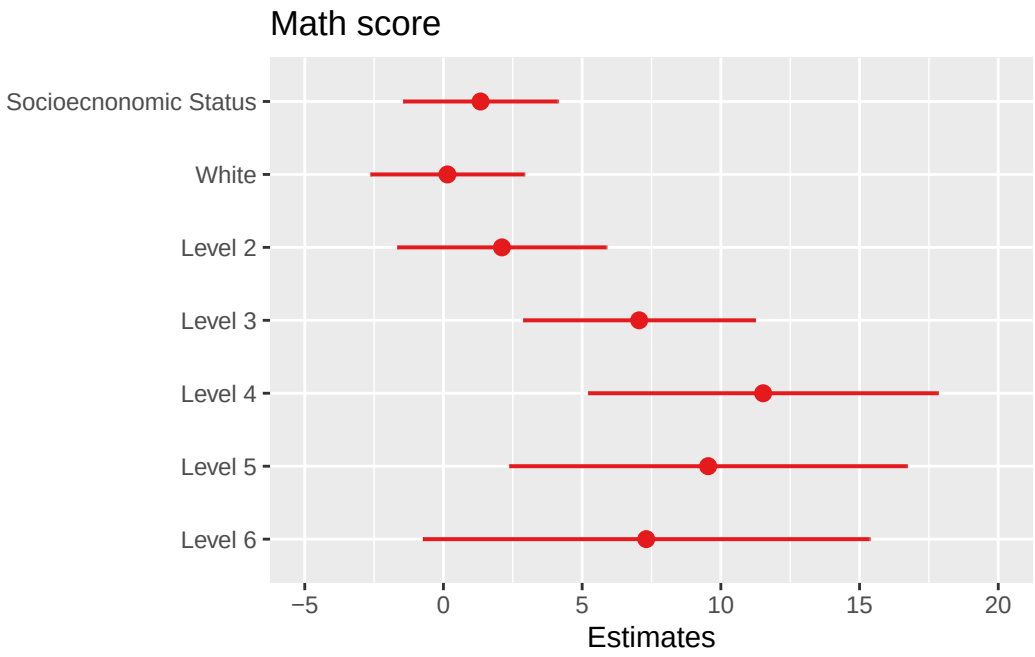
[[3]]


Non−normality of residuals
Distribution should look like normal curve
Density
0.05
0.04
0.03
0.02
0.01
0.00
−20
−10
0
10
20
Residuals

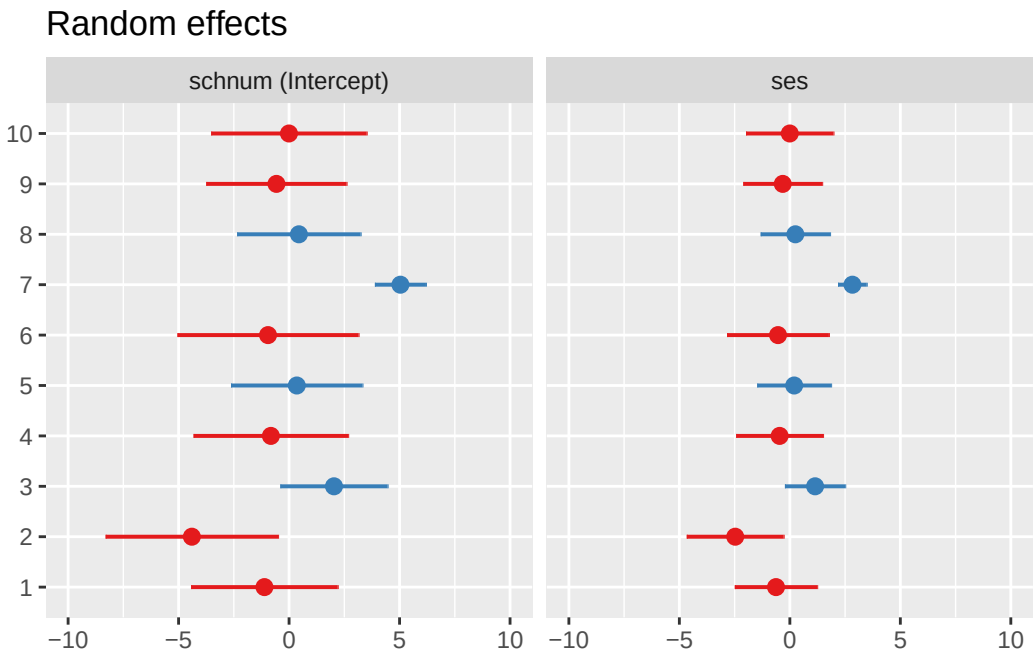
```
[[4]]
```



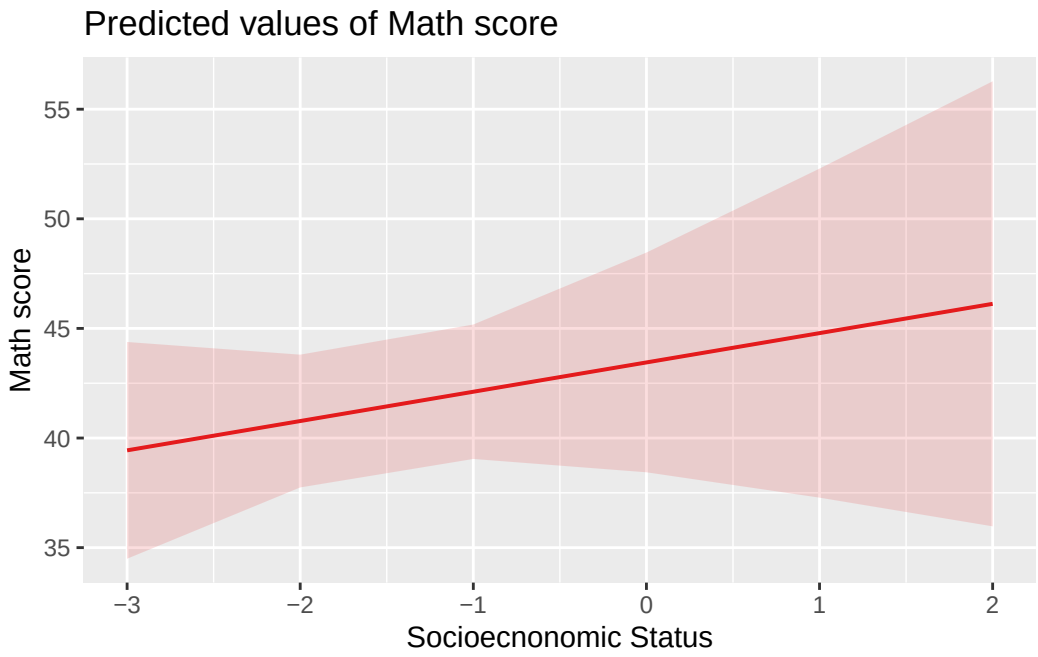

```
plot_model(rs_immi,
           type = 'est')
```



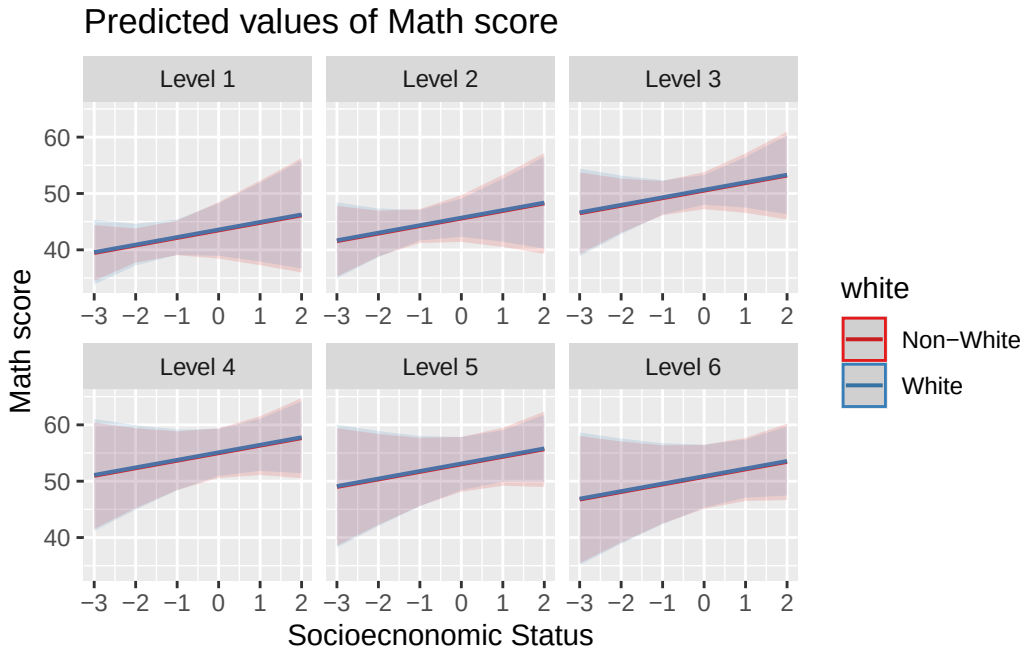

```
plot_model(rs_immi,
           type = 're')
```



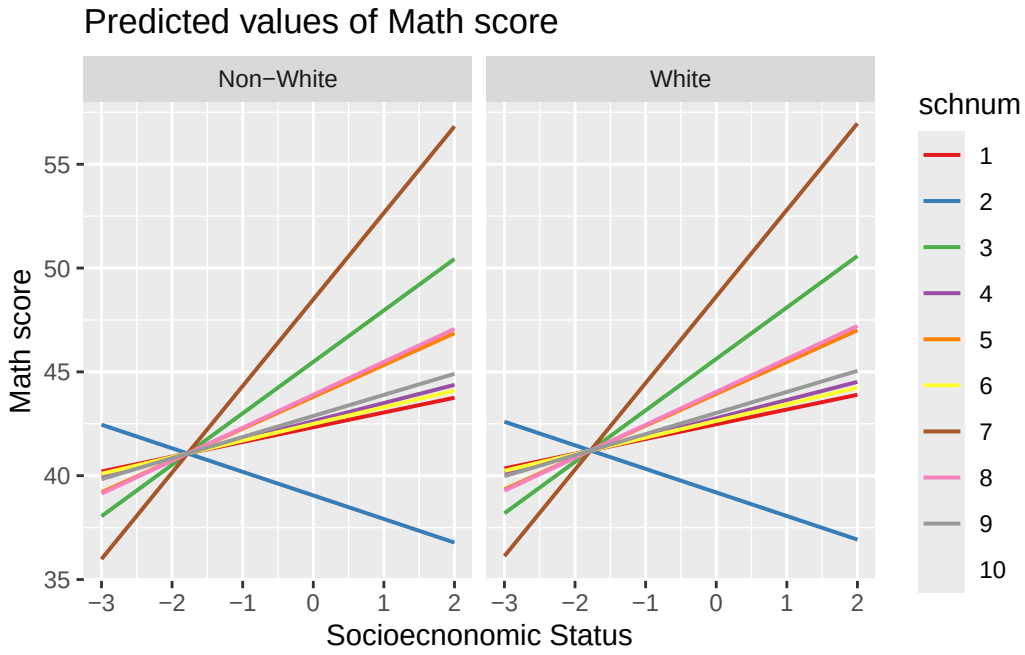
```
plot_model(rs_immi,
           type = 'pred',
           terms = 'ses')
```




```
plot_model(rs_immi,
           type = 'pred',
           terms = c('ses', 'white', 'parented'))
```

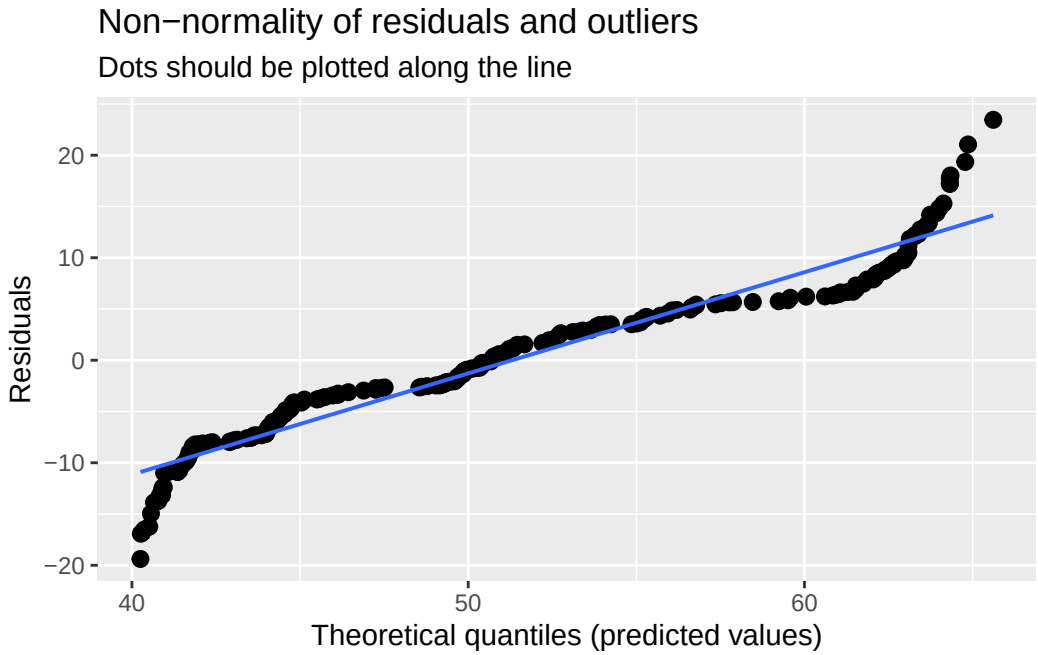



```
plot_model(rs_immi,
           type = 'pred',
           terms = c('ses' , 'schnum', 'white'),
           pred.type = 're', ci.lvl=NA)
```

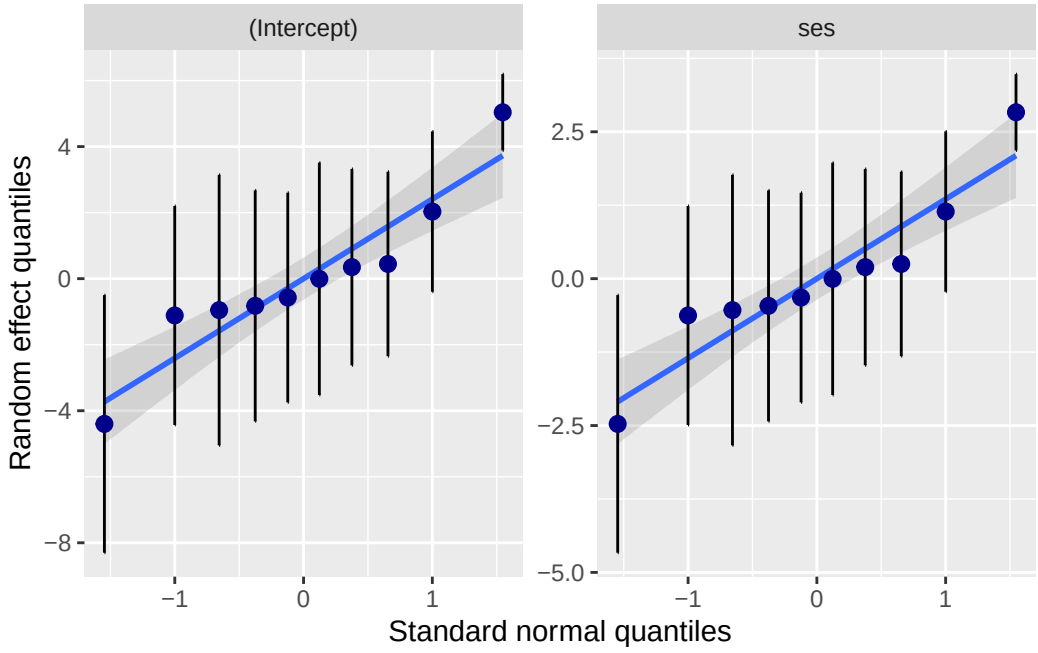



```
plot_model(rs_immi,
           type = 'diag')
```

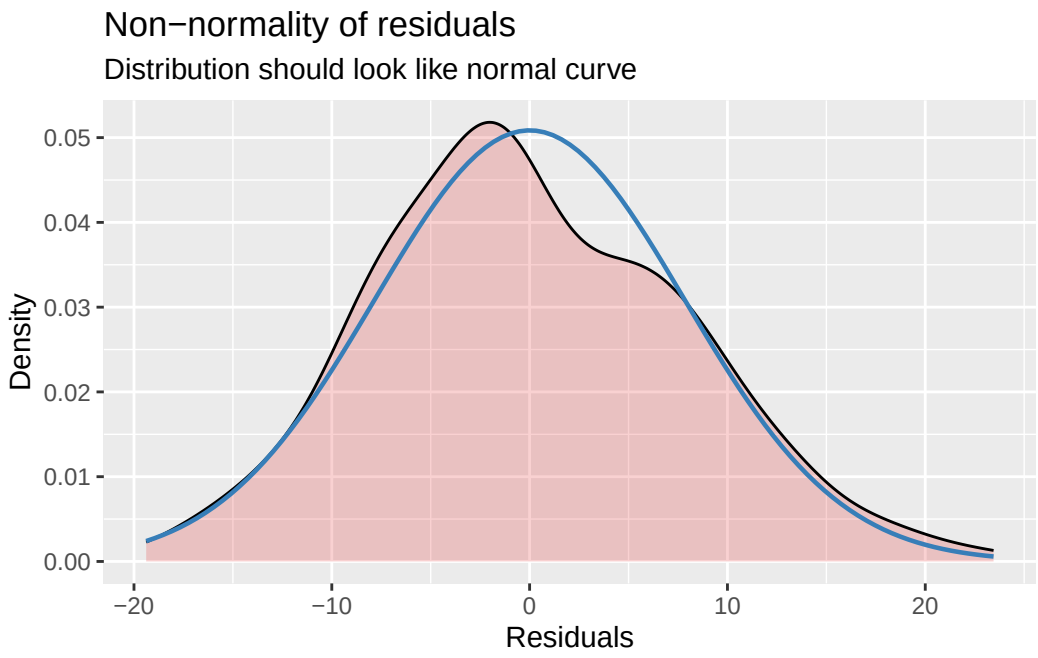
```
[[1]]
```


Non−normality of residuals and outliers
Dots should be plotted along the line
Residuals
20
10
0
−10
−20
40
50
60
Theoretical quantiles (predicted values)

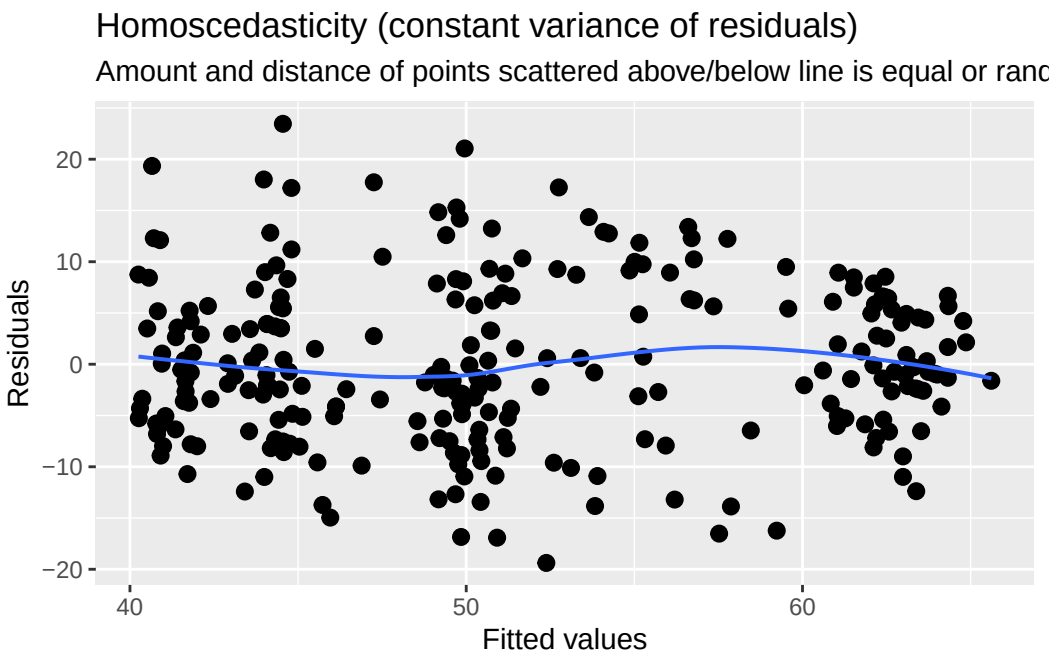
```
[[2]]
[[2]]$schnum
```


(Intercept)
ses
Random effect quantiles
4
0
−4
−8
2.5
0.0
−2.5
−5.0
−1
0
1
Standard normal quantiles

```
[[3]]
```


Non−normality of residuals
Distribution should look like normal curve
Density
0.05
0.04
0.03
0.02
0.01
0.00
−20
−10
0
10
20
Residuals

```
[[4]]
```


Homoscedasticity (constant variance of residuals)
Amount and distance of points scattered above/below line is equal or ranc
Residuals
20
10
0
−10
−20
40
50
60
Fitted values