Group analysis

Load packages

```
pacman::p_load(readr, lme4, emmeans, yarrr, ggplot2, dplyr, sjPlot)
```

Load data

```
amp = read_csv("amp.csv")
```

```
## Rows: 320 Columns: 7
```

```
## -- Column specification --------------------------------------------------------
## Delimiter: ","
## chr (4): Time, Channel, Deviant, Group
## dbl (3): ID, Amplitude, DeviantLevel
```

```
##
## i Use `spec()` to retrieve the full column specification for this data.
## i Specify the column types or set `show_col_types = FALSE` to quiet this message.
```

```
amp_all = read_csv("amp_all.csv")
```

```
## Rows: 576 Columns: 7
```

```
## -- Column specification --------------------------------------------------------
## Delimiter: ","
## chr (3): Channel, Deviant, Group
## dbl (4): ID, DeviantLevel, Amplitude.T1, Amplitude.T2
```

```
##
## i Use `spec()` to retrieve the full column specification for this data.
## i Specify the column types or set `show_col_types = FALSE` to quiet this message.
```

```
lat = read_csv("lat.csv")
```

```
## Rows: 320 Columns: 7
```

```
## -- Column specification --------------------------------------------------------
## Delimiter: ","
## chr (4): Time, Channel, Deviant, Group
## dbl (3): ID, Latency_peak, DeviantLevel

##
## i Use `spec()` to retrieve the full column specification for this data.
## i Specify the column types or set `show_col_types = FALSE` to quiet this message.
```

```
lat_all = read_csv("lat_all.csv")
```

```
## Rows: 576 Columns: 7

## -- Column specification --------------------------------------------------------
## Delimiter: ","
## chr (3): Channel, Deviant, Group
## dbl (4): ID, DeviantLevel, Latency_peak.T1, Latency_peak.T2

##
## i Use `spec()` to retrieve the full column specification for this data.
## i Specify the column types or set `show_col_types = FALSE` to quiet this message.
```

```
All_behav = read_csv("All_behav.csv")
```

```
## Rows: 752 Columns: 6

## -- Column specification --------------------------------------------------------
## Delimiter: ","
## chr (3): Round, Deviant, Group
## dbl (3): ID, DeviantLevel, AvCor

##
## i Use `spec()` to retrieve the full column specification for this data.
## i Specify the column types or set `show_col_types = FALSE` to quiet this message.
```

```
amp$ID=as.factor(amp$ID)
amp$Deviant=as.factor(amp$Deviant)
amp$DeviantLevel=as.factor(amp$DeviantLevel)
amp$Group=as.factor(amp$Group)

amp_all$ID=as.factor(amp_all$ID)
amp_all$Deviant=as.factor(amp_all$Deviant)
amp_all$DeviantLevel=as.factor(amp_all$DeviantLevel)
amp_all$Group[amp_all$Group =="CI_ex"] = "CIx"
amp_all$Group=as.factor(amp_all$Group)


lat$ID=as.factor(lat$ID)
lat$Deviant=as.factor(lat$Deviant)
lat$DeviantLevel=as.factor(lat$DeviantLevel)
lat$Group=as.factor(lat$Group)
```

```
lat_all$ID=as.factor(lat_all$ID)
lat_all$Deviant=as.factor(lat_all$Deviant)
lat_all$DeviantLevel=as.factor(lat_all$DeviantLevel)
lat_all$Group[lat_all$Group =="CI_ex"] = "CIx"
lat_all$Group=as.factor(lat_all$Group)


All_behav$ID=as.factor(All_behav$ID)
All_behav$Deviant=as.factor(All_behav$Deviant)
All_behav$DeviantLevel=as.factor(All_behav$DeviantLevel)
All_behav$Group[All_behav$Group =="CIex"] = "CIx"
All_behav$Group=as.factor(All_behav$Group)
```

Hierarchical mixed effects modeling - MMN Amplitude (T2)

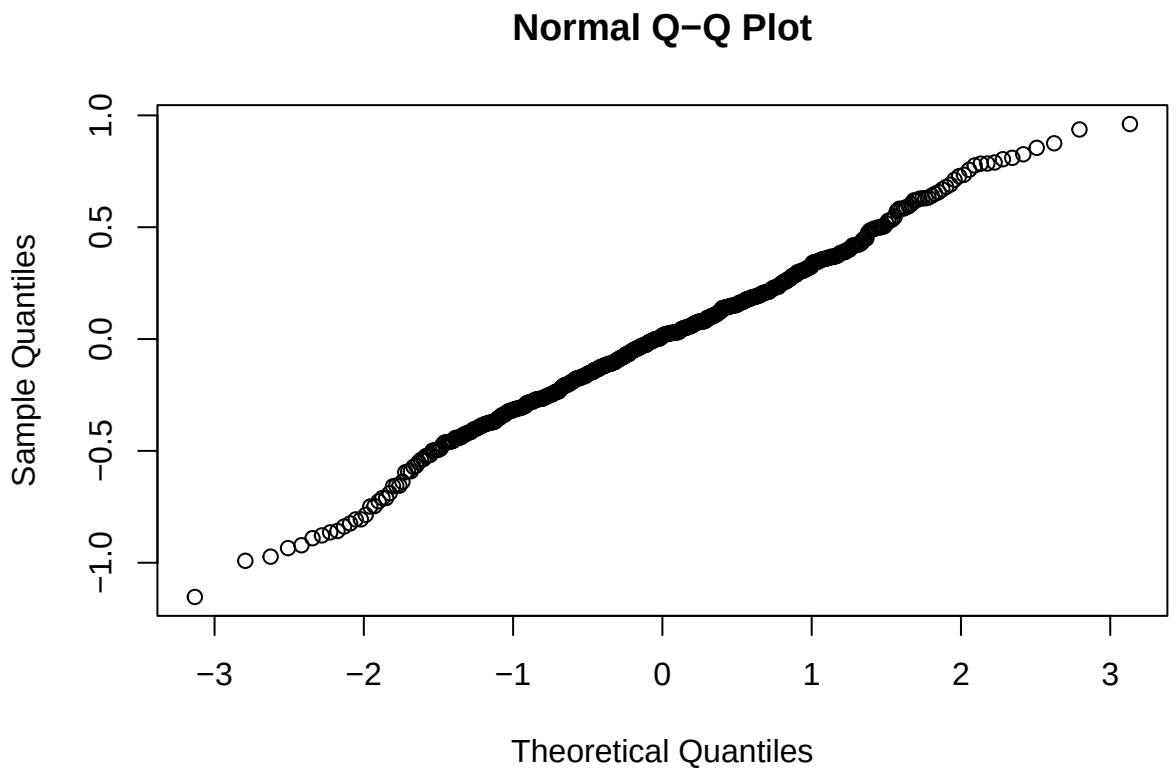
```
M0=lmer(Amplitude.T2~1+(1|ID), data=amp_all, REML = FALSE, control = lmerControl(optimizer = "nloptwrap

M1=lmer(Amplitude.T2~Deviant+(1|ID), data=amp_all, REML = FALSE, control = lmerControl(optimizer = "nlo

M2=lmer(Amplitude.T2~Deviant+DeviantLevel+(1|ID), data=amp_all, REML = FALSE, control = lmerControl(opt

M3=lmer(Amplitude.T2~Deviant+DeviantLevel+Group+(1|ID), data=amp_all, REML = FALSE, control = lmerContr

M4=lmer(Amplitude.T2~Deviant*DeviantLevel+Group+(1|ID), data=amp_all, REML = FALSE, control = lmerContr

M5=lmer(Amplitude.T2~Deviant*DeviantLevel+Deviant*Group+(1|ID), data=amp_all, REML = FALSE, control = l

M6=lmer(Amplitude.T2~Deviant*DeviantLevel+Deviant*Group+DeviantLevel*Group+(1|ID), data=amp_all, REML =

M7=lmer(Amplitude.T2~Deviant*Group*DeviantLevel+(1|ID), data=amp_all, REML = FALSE, control = lmerContr

#comparing models
anova = anova(M0,M1,M2,M3,M4,M5,M6,M7)
anova
```

```
## Data: amp_all
## Models:
## M0: Amplitude.T2 ~ 1 + (1 | ID)
## M1: Amplitude.T2 ~ Deviant + (1 | ID)
## M2: Amplitude.T2 ~ Deviant + DeviantLevel + (1 | ID)
## M3: Amplitude.T2 ~ Deviant + DeviantLevel + Group + (1 | ID)
## M4: Amplitude.T2 ~ Deviant * DeviantLevel + Group + (1 | ID)
## M5: Amplitude.T2 ~ Deviant * DeviantLevel + Deviant * Group + (1 | ID)
## M6: Amplitude.T2 ~ Deviant * DeviantLevel + Deviant * Group + DeviantLevel * Group + (1 | ID)
## M7: Amplitude.T2 ~ Deviant * Group * DeviantLevel + (1 | ID)
##    npar    AIC    BIC  logLik deviance   Chisq Df Pr(>Chisq)
## M0    3 630.01 643.08 -312.00   624.01
## M1    6 595.29 621.43 -291.64   583.29 40.7199  3  7.498e-09 ***
## M2    9 588.03 627.23 -285.01   570.03 13.2616  3   0.004104 **
## M3   11 580.13 628.05 -279.07   558.13 11.8963  2   0.002611 **
```

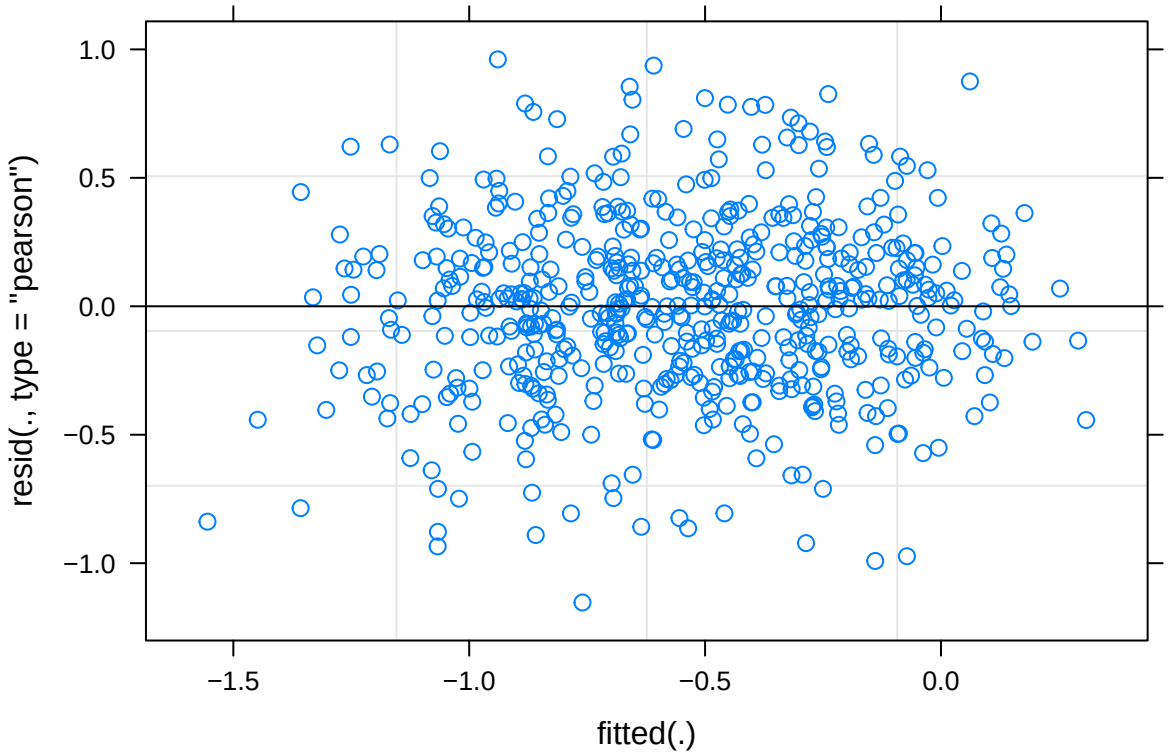
```
## M4   20 560.60 647.72 -260.30   520.60 37.5337  9  2.113e-05 ***
## M5   26 564.79 678.05 -256.40   512.79  7.8036  6   0.252851
## M6   32 566.77 706.17 -251.39   502.77 10.0219  6   0.123732
## M7   50 584.80 802.61 -242.40   484.80 17.9704 18   0.457605
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

Best model

```
qqnorm(resid(M4))
```




```
plot(M4)
```



Post-hoc analysis

```
emm_g <- emmeans(M4, pairwise ~ Group, adjust = "none")
emm_g[[2]]
```

```
##  contrast       estimate    SE   df t.ratio p.value
##  CI_re - CIx       0.413 0.132 39.3   3.126  0.0033
##  CI_re - NH_old    0.429 0.130 39.3   3.296  0.0021
##  CIx - NH_old      0.016 0.117 39.3   0.137  0.8920
##
## Results are averaged over the levels of: Deviant, DeviantLevel
## Degrees-of-freedom method: kenward-roger
```

```
confint(rbind(emm_g[[2]]), adjust ="none")
```

```
##  contrast       estimate    SE   df lower.CL upper.CL
##  CI_re - CIx       0.413 0.132 39.3    0.146    0.680
##  CI_re - NH_old    0.429 0.130 39.3    0.166    0.692
##  CIx - NH_old      0.016 0.117 39.3   -0.221    0.253
##
## Results are averaged over some or all of the levels of: Deviant, DeviantLevel
## Degrees-of-freedom method: kenward-roger
## Confidence level used: 0.95
```

```
#Per deviant - T2
emm_r <- emmeans(M5, pairwise ~ Group)
```

```
## NOTE: Results may be misleading due to involvement in interactions
```

```
emm_rc <- emm_r[[2]]

emm_d <- emmeans(M5, pairwise ~ Deviant)
```

```
## NOTE: Results may be misleading due to involvement in interactions
```

```
emm_dc <- emm_d[[2]]

#Time by deviant interaction

emm_r.d <- emmeans(M5, pairwise ~ Group | Deviant)
IC_r.d <- contrast(emm_r.d[[1]], method = "pairwise")

emm_d.r <- emmeans(M5, pairwise ~ Deviant | Group)
IC_d.r <- contrast(emm_d.r[[1]], method = "pairwise")

rbind(IC_r.d[c(4:6,10:12)], adjust = "none")
```

```
##  contrast       Deviant estimate    SE   df t.ratio p.value
##  CI_re - CIx    Pitch     0.3871 0.148 63.1   2.614  0.0112
##  CI_re - NH_old Pitch     0.4061 0.146 63.1   2.783  0.0071
##  CIx - NH_old   Pitch     0.0190 0.132 63.1   0.144  0.8856
##  CI_re - CIx    Timbre    0.4269 0.148 63.1   2.882  0.0054
##  CI_re - NH_old Timbre    0.4065 0.146 63.1   2.786  0.0070
##  CIx - NH_old   Timbre   -0.0204 0.132 63.1  -0.155  0.8772
##
## Results are averaged over some or all of the levels of: DeviantLevel
## Degrees-of-freedom method: kenward-roger
```

```
confint(rbind(IC_r.d[c(4:6,10:12)],  adjust = 'none'))
```

```
##  contrast       Deviant estimate    SE   df lower.CL upper.CL
##  CI_re - CIx    Pitch     0.3871 0.148 63.1   0.0912    0.683
##  CI_re - NH_old Pitch     0.4061 0.146 63.1   0.1145    0.698
##  CIx - NH_old   Pitch     0.0190 0.132 63.1  -0.2439    0.282
##  CI_re - CIx    Timbre    0.4269 0.148 63.1   0.1309    0.723
##  CI_re - NH_old Timbre    0.4065 0.146 63.1   0.1149    0.698
##  CIx - NH_old   Timbre   -0.0204 0.132 63.1  -0.2833    0.242
##
## Results are averaged over some or all of the levels of: DeviantLevel
## Degrees-of-freedom method: kenward-roger
## Confidence level used: 0.95
```

Hierarchical mixed effects modeling - MMN Amplitude (T1)

```
M0=lmer(Amplitude.T1~1+(1|ID), data=amp_all, REML = FALSE, control = lmerControl(optimizer = "nloptwrap

M1=lmer(Amplitude.T1~Deviant+(1|ID), data=amp_all, REML = FALSE, control = lmerControl(optimizer = "nlo

M2=lmer(Amplitude.T1~Deviant+DeviantLevel+(1|ID), data=amp_all, REML = FALSE, control = lmerControl(opt

M3=lmer(Amplitude.T1~Deviant+DeviantLevel+Group+(1|ID), data=amp_all, REML = FALSE, control = lmerContr

M4=lmer(Amplitude.T1~Deviant*DeviantLevel+Group+(1|ID), data=amp_all, REML = FALSE, control = lmerContr

M5=lmer(Amplitude.T1~Deviant*DeviantLevel+Deviant*Group+(1|ID), data=amp_all, REML = FALSE, control = l

M6=lmer(Amplitude.T1~Deviant*DeviantLevel+Deviant*Group+DeviantLevel*Group+(1|ID), data=amp_all, REML =

M7=lmer(Amplitude.T1~Deviant*Group*DeviantLevel+(1|ID), data=amp_all, REML = FALSE, control = lmerContr

#comparing models
anova = anova(M0,M1,M2,M3,M4,M5,M6,M7)
anova
```

```
## Data: amp_all
## Models:
## M0: Amplitude.T1 ~ 1 + (1 | ID)
## M1: Amplitude.T1 ~ Deviant + (1 | ID)
## M2: Amplitude.T1 ~ Deviant + DeviantLevel + (1 | ID)
## M3: Amplitude.T1 ~ Deviant + DeviantLevel + Group + (1 | ID)
## M4: Amplitude.T1 ~ Deviant * DeviantLevel + Group + (1 | ID)
## M5: Amplitude.T1 ~ Deviant * DeviantLevel + Deviant * Group + (1 | ID)
## M6: Amplitude.T1 ~ Deviant * DeviantLevel + Deviant * Group + DeviantLevel * Group + (1 | ID)
## M7: Amplitude.T1 ~ Deviant * Group * DeviantLevel + (1 | ID)
##    npar    AIC    BIC  logLik deviance   Chisq Df Pr(>Chisq)
## M0    3 634.14 647.21 -314.07   628.14
## M1    6 605.95 632.08 -296.97   593.95 34.1921  3  1.805e-07 ***
## M2    9 594.90 634.10 -288.45   576.90 17.0476  3   0.000691 ***
## M3   11 585.36 633.28 -281.68   563.36 13.5376  2   0.001149 **
## M4   20 562.58 649.70 -261.29   522.58 40.7849  9  5.474e-06 ***
## M5   26 568.60 681.86 -258.30   516.60  5.9738  6   0.426128
## M6   32 573.92 713.32 -254.96   509.92  6.6811  6   0.351348
## M7   50 593.28 811.09 -246.64   493.28 16.6373 18   0.548160
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
emm_r <- emmeans(M5, pairwise ~ Group)
```

```
## NOTE: Results may be misleading due to involvement in interactions
```

```
emm_rc <- emm_r[[2]]

emm_d <- emmeans(M5, pairwise ~ Deviant)
```

```
## NOTE: Results may be misleading due to involvement in interactions
```

```
emm_dc <- emm_d[[2]]

#Per deviant - T1
emm_r <- emmeans(M5, pairwise ~ Group)
```

```
## NOTE: Results may be misleading due to involvement in interactions
```

```
emm_rc <- emm_r[[2]]

emm_d <- emmeans(M5, pairwise ~ Deviant)
```

```
## NOTE: Results may be misleading due to involvement in interactions
```

```
emm_dc <- emm_d[[2]]

#Time by deviant interaction

emm_r.d <- emmeans(M5, pairwise ~ Group | Deviant)
IC_r.d <- contrast(emm_r.d[[1]], method = "pairwise")

emm_d.r <- emmeans(M5, pairwise ~ Deviant | Group)
IC_d.r <- contrast(emm_d.r[[1]], method = "pairwise")

rbind(IC_r.d[c(4:6,10:12)], adjust = "none")
```

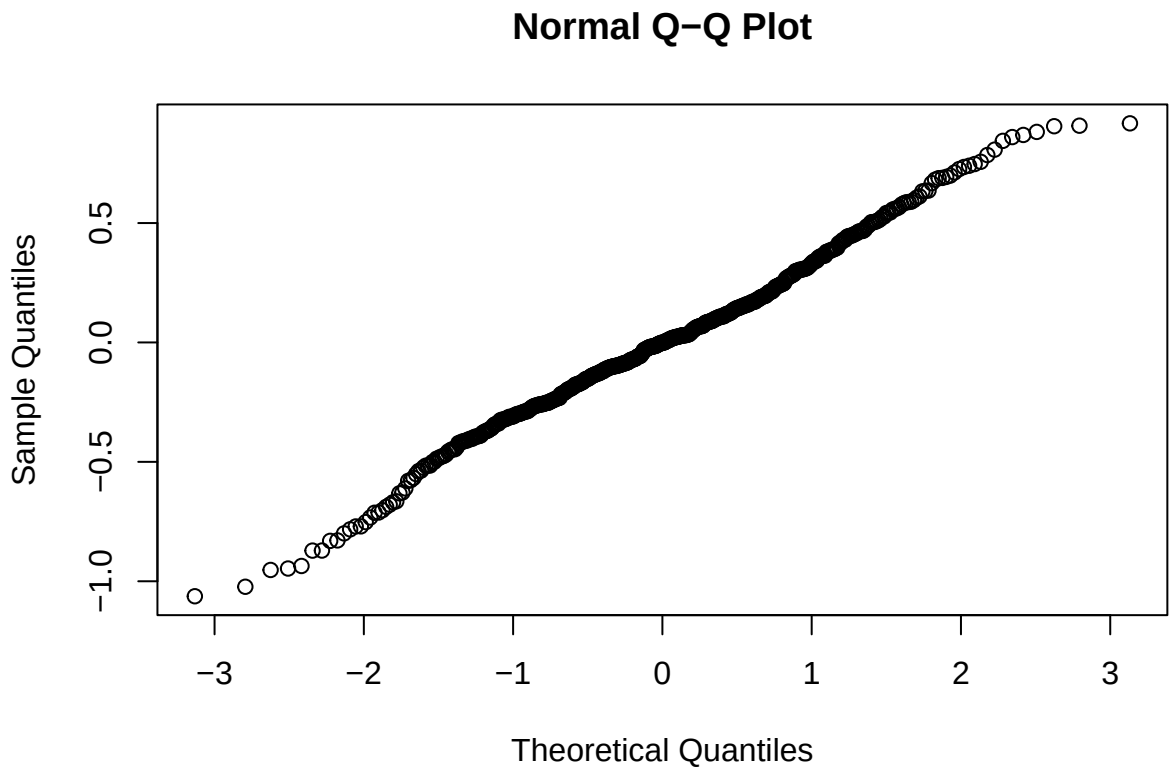
```
##  contrast       Deviant estimate    SE df t.ratio p.value
##  CI_re - CIx    Pitch     0.5481 0.159 59   3.456  0.0010
##  CI_re - NH_old Pitch     0.5672 0.156 59   3.629  0.0006
##  CIx - NH_old   Pitch     0.0190 0.141 59   0.135  0.8932
##  CI_re - CIx    Timbre    0.5883 0.159 59   3.709  0.0005
##  CI_re - NH_old Timbre    0.5679 0.156 59   3.634  0.0006
##  CIx - NH_old   Timbre   -0.0204 0.141 59  -0.145  0.8853
##
## Results are averaged over some or all of the levels of: DeviantLevel
## Degrees-of-freedom method: kenward-roger
```

```
confint(rbind(IC_r.d[c(4:6,10:12)],  adjust = 'none'))
```

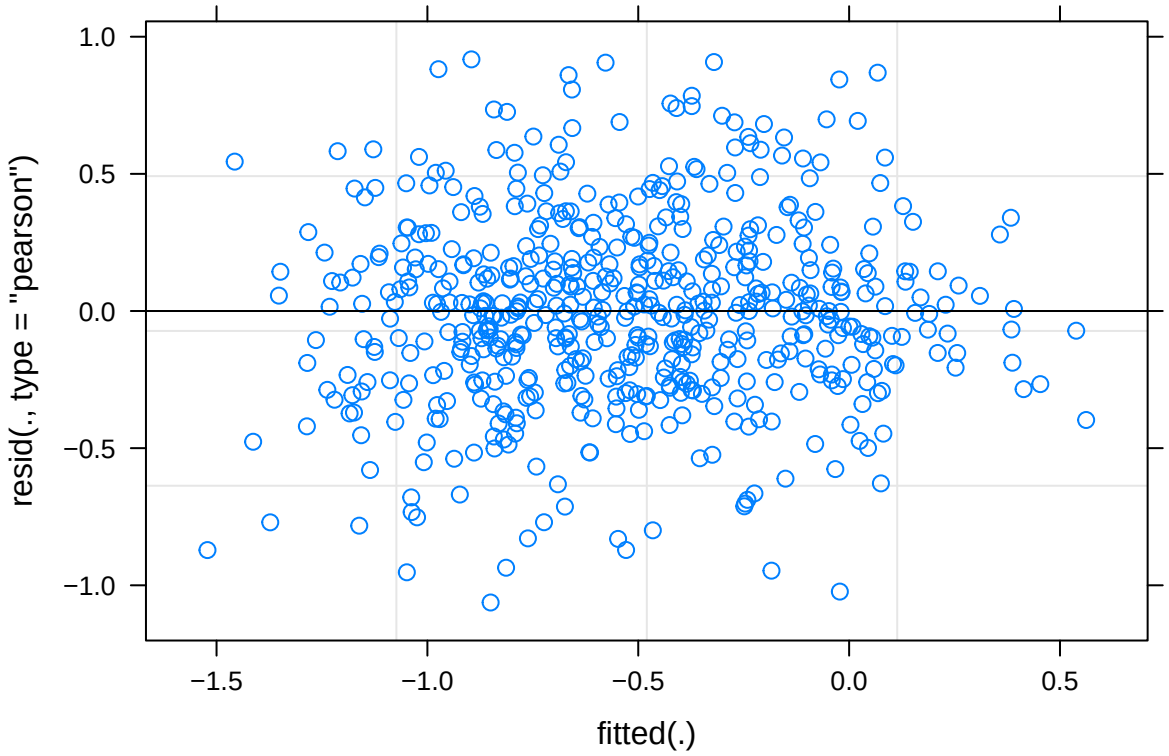
```
##  contrast       Deviant estimate    SE df lower.CL upper.CL
##  CI_re - CIx    Pitch     0.5481 0.159 59    0.231    0.866
##  CI_re - NH_old Pitch     0.5672 0.156 59    0.254    0.880
##  CIx - NH_old   Pitch     0.0190 0.141 59   -0.263    0.301
##  CI_re - CIx    Timbre    0.5883 0.159 59    0.271    0.906
##  CI_re - NH_old Timbre    0.5679 0.156 59    0.255    0.881
##  CIx - NH_old   Timbre   -0.0204 0.141 59   -0.302    0.261
##
## Results are averaged over some or all of the levels of: DeviantLevel
## Degrees-of-freedom method: kenward-roger
## Confidence level used: 0.95
```

Best model

```
qqnorm(resid(M4))
```




```
plot(M4)
```



Post-hoc analysis

```
emm_g <- emmeans(M4, pairwise ~ Group, adjust = "none")
emm_g[[2]]
```

```
##  contrast       estimate    SE   df t.ratio p.value
##  CI_re - CIx       0.487 0.144 39.3   3.386  0.0016
##  CI_re - NH_old    0.503 0.142 39.3   3.549  0.0010
##  CIx - NH_old      0.016 0.128 39.3   0.126  0.9007
##
## Results are averaged over the levels of: Deviant, DeviantLevel
## Degrees-of-freedom method: kenward-roger
```

```
confint(rbind(emm_g[[2]]), adjust ="none")
```

```
##  contrast       estimate    SE   df lower.CL upper.CL
##  CI_re - CIx       0.487 0.144 39.3    0.196    0.778
##  CI_re - NH_old    0.503 0.142 39.3    0.216    0.789
##  CIx - NH_old      0.016 0.128 39.3   -0.242    0.274
##
## Results are averaged over some or all of the levels of: Deviant, DeviantLevel
## Degrees-of-freedom method: kenward-roger
## Confidence level used: 0.95
```

Plot

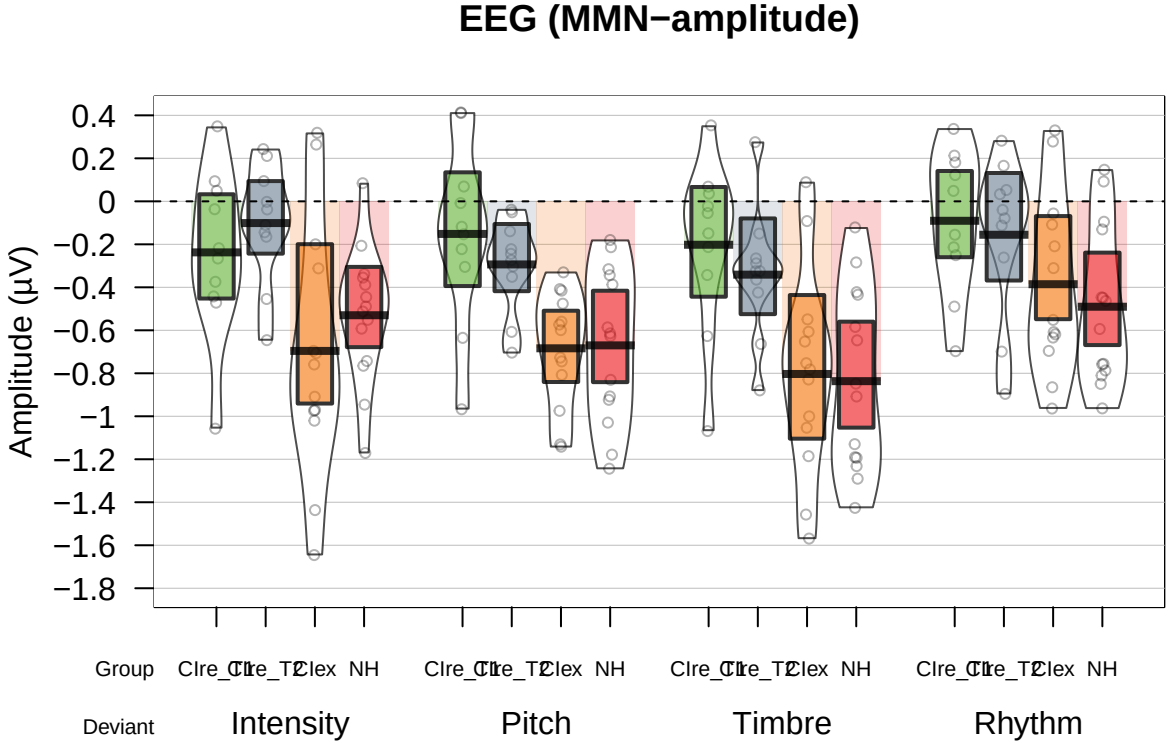
```
ID_plot_data = read_csv("ID_plot_data_amp.csv")
```

```
## Rows: 188 Columns: 5
```

```
## -- Column specification --------------------------------------------------------
## Delimiter: ","
## chr (3): Group, Time, Deviant
## dbl (2): ID, Amp
```

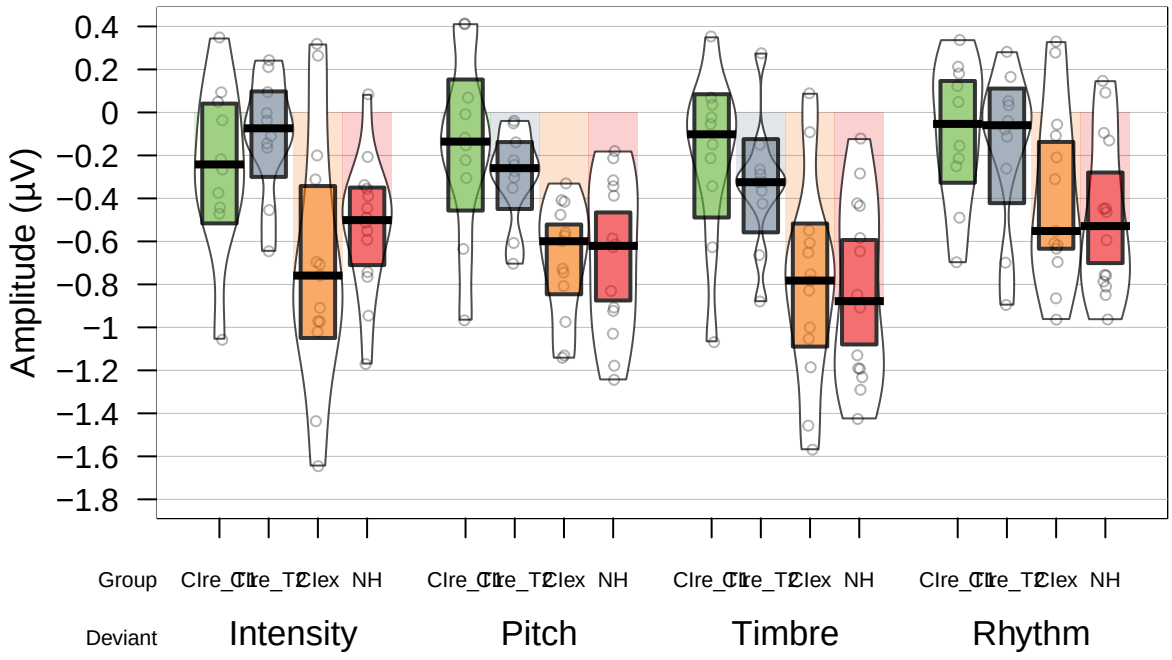
```
##
## i Use `spec()` to retrieve the full column specification for this data.
## i Specify the column types or set `show_col_types = FALSE` to quiet this message.
```

```
pirat = ID_plot_data
pirat$Group[pirat$Time =="CIre_T1"]=gsub("CI_re", "CIre_T1", pirat$Group[pirat$Time =="CIre_T1"])
pirat$Group[pirat$Time =="CIre_T2"]=gsub("CI_re", "CIre_T2", pirat$Group[pirat$Time =="CIre_T2"])
pirat$Group=ordered(pirat$Group, levels=c("CIre_T1", "CIre_T2", "CIex", "NH"))
pirat$Deviant=ordered(pirat$Deviant, levels=c("Intensity", "Pitch", "Timbre", "Rhythm"))

pirateplot(formula = Amp ~ Group + Deviant, data = pirat, main = "EEG (MMN-amplitude)", xlab = "Group",y
  abline(a=0, b=0, lwd=1, lty="dashed")
```



```
## integer(0)
```

```
pirateplot(formula = Amp ~ Group + Deviant, data = pirat, xlab = "Group",ylab="Amplitude (µV)", ylim= c
  abline(a=33,33, b=0, lwd=1, lty="dashed")
```




```
## integer(0)
```

Hierarchical mixed effects modeling - Latency (T2)

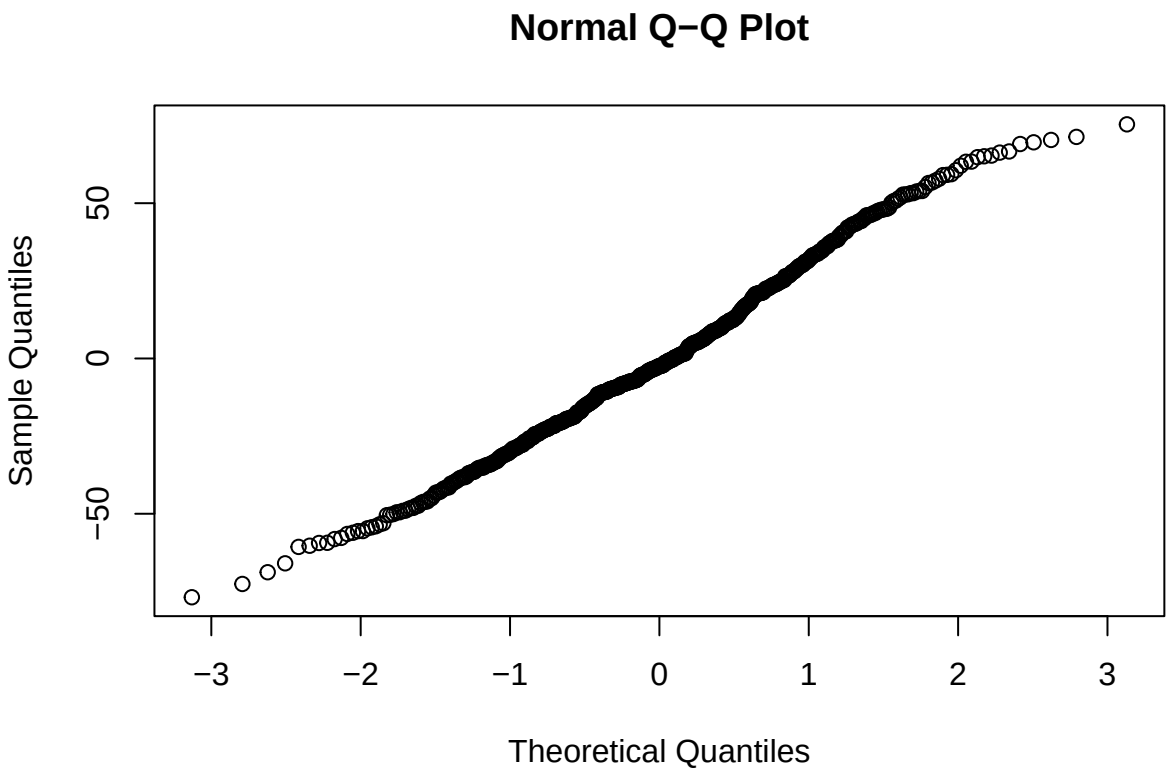
```
M0=lmer(Latency_peak.T2~1+(1|ID), data=lat_all, REML = FALSE, control = lmerControl(optimizer = "nloptw
M1=lmer(Latency_peak.T2~Deviant+(1|ID), data=lat_all, REML = FALSE, control = lmerControl(optimizer = "
M2=lmer(Latency_peak.T2~Deviant+DeviantLevel+(1|ID), data=lat_all, REML = FALSE, control = lmerControl(
M3=lmer(Latency_peak.T2~Deviant+DeviantLevel+Group+(1|ID), data=lat_all, REML = FALSE, control = lmerCo
M4=lmer(Latency_peak.T2~Deviant*DeviantLevel+Group+(1|ID), data=lat_all, REML = FALSE, control = lmerCo
M5=lmer(Latency_peak.T2~Deviant*DeviantLevel+Deviant*Group+(1|ID), data=lat_all, REML = FALSE, control =
M6=lmer(Latency_peak.T2~Deviant*DeviantLevel+Deviant*Group+DeviantLevel*Group+(1|ID), data=lat_all, REM
```

```
M7=lmer(Latency_peak.T2~Deviant*DeviantLevel*Group+(1|ID), data=lat_all, REML = FALSE, control = lmerCo

#comparing models
anova = anova(M0,M1,M2,M3,M4,M5,M6, M7)
anova
```

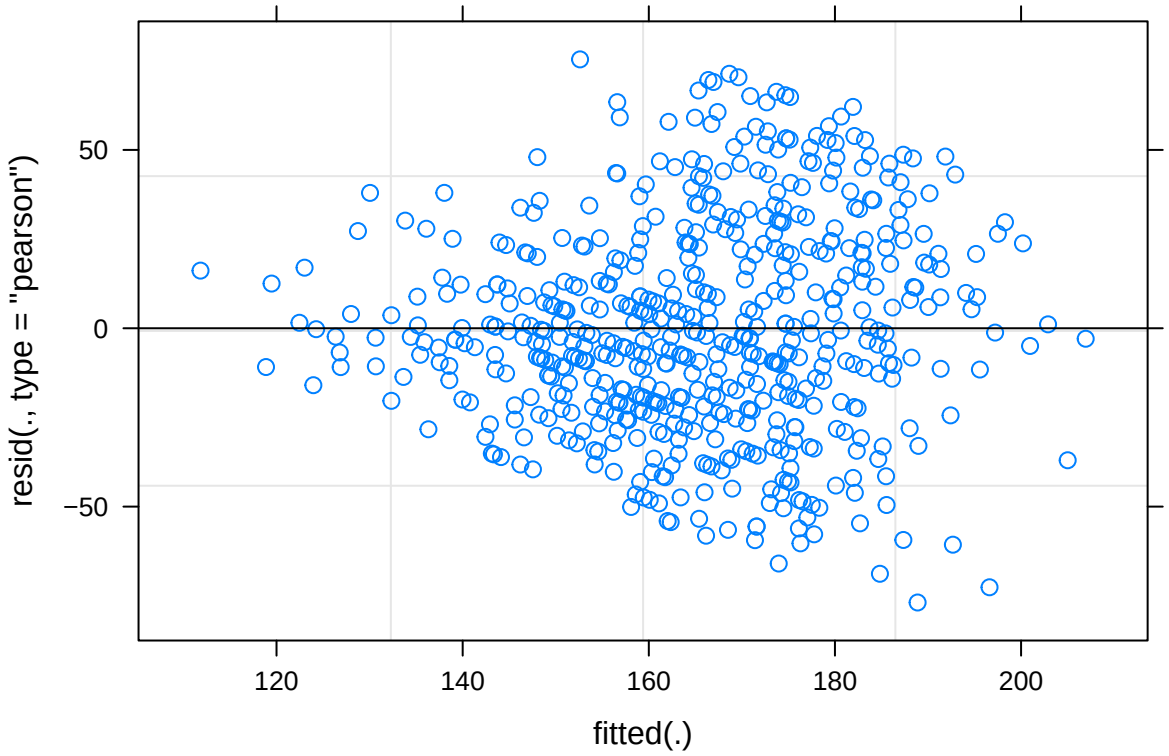
```
## Data: lat_all
## Models:
## M0: Latency_peak.T2 ~ 1 + (1 | ID)
## M1: Latency_peak.T2 ~ Deviant + (1 | ID)
## M2: Latency_peak.T2 ~ Deviant + DeviantLevel + (1 | ID)
## M3: Latency_peak.T2 ~ Deviant + DeviantLevel + Group + (1 | ID)
## M4: Latency_peak.T2 ~ Deviant * DeviantLevel + Group + (1 | ID)
## M5: Latency_peak.T2 ~ Deviant * DeviantLevel + Deviant * Group + (1 | ID)
## M6: Latency_peak.T2 ~ Deviant * DeviantLevel + Deviant * Group + DeviantLevel * Group + (1 | ID)
## M7: Latency_peak.T2 ~ Deviant * DeviantLevel * Group + (1 | ID)
##    npar    AIC    BIC  logLik deviance   Chisq Df Pr(>Chisq)
## M0    3 5647.3 5660.4 -2820.7   5641.3
## M1    6 5645.7 5671.8 -2816.9   5633.7  7.5894  3  0.0553056 .
## M2    9 5648.2 5687.3 -2815.1   5630.2  3.5513  3  0.3141733
## M3   11 5632.1 5680.0 -2805.1   5610.1 20.0574  2  4.411e-05 ***
## M4   20 5628.1 5715.2 -2794.1   5588.1 21.9737  9  0.0089626 **
## M5   26 5616.1 5729.3 -2782.1   5564.1 23.9943  6  0.0005235 ***
## M6   32 5624.6 5763.8 -2780.3   5560.6  3.5498  6  0.7373360
## M7   50 5646.3 5863.8 -2773.1   5546.3 14.3246 18  0.7076967
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

Best model

```
qqnorm(resid(M5))
```


Normal Q−Q Plot
Sample Quantiles
50
0
−50
−3
−2
−1
0
1
2
3
Theoretical Quantiles

```
plot(M5)
```



Post-hoc analysis

```
emm_g <- emmeans(M5, pairwise ~ Group)
```

```
## NOTE: Results may be misleading due to involvement in interactions
```

```
emm_gc <- emm_g[[2]]

emm_d <- emmeans(M5, pairwise ~ Deviant)
```

```
## NOTE: Results may be misleading due to involvement in interactions
```

```
emm_dc <- emm_d[[2]]

#Group by deviant interaction

emm_g.d <- emmeans(M5, pairwise ~ Group | Deviant)
IC_g.d <- contrast(emm_g.d[[1]], method = "pairwise")

rbind(IC_g.d, adjust = "none")
```

```
##  Deviant   contrast       estimate   SE  df t.ratio p.value
```

```
##  Intensity CI_re - CIx       18.56 7.91 173   2.346  0.0201
##  Intensity CI_re - NH_old    13.33 7.80 173   1.710  0.0890
##  Intensity CIx - NH_old      -5.23 7.03 173  -0.744  0.4578
##  Pitch     CI_re - CIx        3.38 7.91 173   0.428  0.6694
##  Pitch     CI_re - NH_old    24.43 7.80 173   3.133  0.0020
##  Pitch     CIx - NH_old      21.04 7.03 173   2.994  0.0032
##  Rhythm    CI_re - CIx       17.43 7.96 176   2.190  0.0299
##  Rhythm    CI_re - NH_old    44.00 7.82 174   5.628  <.0001
##  Rhythm    CIx - NH_old      26.56 7.11 179   3.738  0.0002
##  Timbre    CI_re - CIx       19.78 7.91 173   2.499  0.0134
##  Timbre    CI_re - NH_old    23.42 7.80 173   3.004  0.0031
##  Timbre    CIx - NH_old       3.64 7.03 173   0.518  0.6049
##
## Results are averaged over some or all of the levels of: DeviantLevel
## Degrees-of-freedom method: kenward-roger
```

```
confint(rbind(IC_g.d), adjust ="none")
```

```
##  Deviant   contrast       estimate   SE  df lower.CL upper.CL
##  Intensity CI_re - CIx       18.56 7.91 173     2.95    34.18
##  Intensity CI_re - NH_old    13.33 7.80 173    -2.06    28.72
##  Intensity CIx - NH_old      -5.23 7.03 173   -19.10     8.64
##  Pitch     CI_re - CIx        3.38 7.91 173   -12.23    19.00
##  Pitch     CI_re - NH_old    24.43 7.80 173     9.04    39.82
##  Pitch     CIx - NH_old      21.04 7.03 173     7.17    34.92
##  Rhythm    CI_re - CIx       17.43 7.96 176     1.72    33.15
##  Rhythm    CI_re - NH_old    44.00 7.82 174    28.57    59.43
##  Rhythm    CIx - NH_old      26.56 7.11 179    12.54    40.58
##  Timbre    CI_re - CIx       19.78 7.91 173     4.16    35.40
##  Timbre    CI_re - NH_old    23.42 7.80 173     8.03    38.81
##  Timbre    CIx - NH_old       3.64 7.03 173   -10.23    17.52
##
## Results are averaged over some or all of the levels of: DeviantLevel
## Degrees-of-freedom method: kenward-roger
## Confidence level used: 0.95
```

Plot

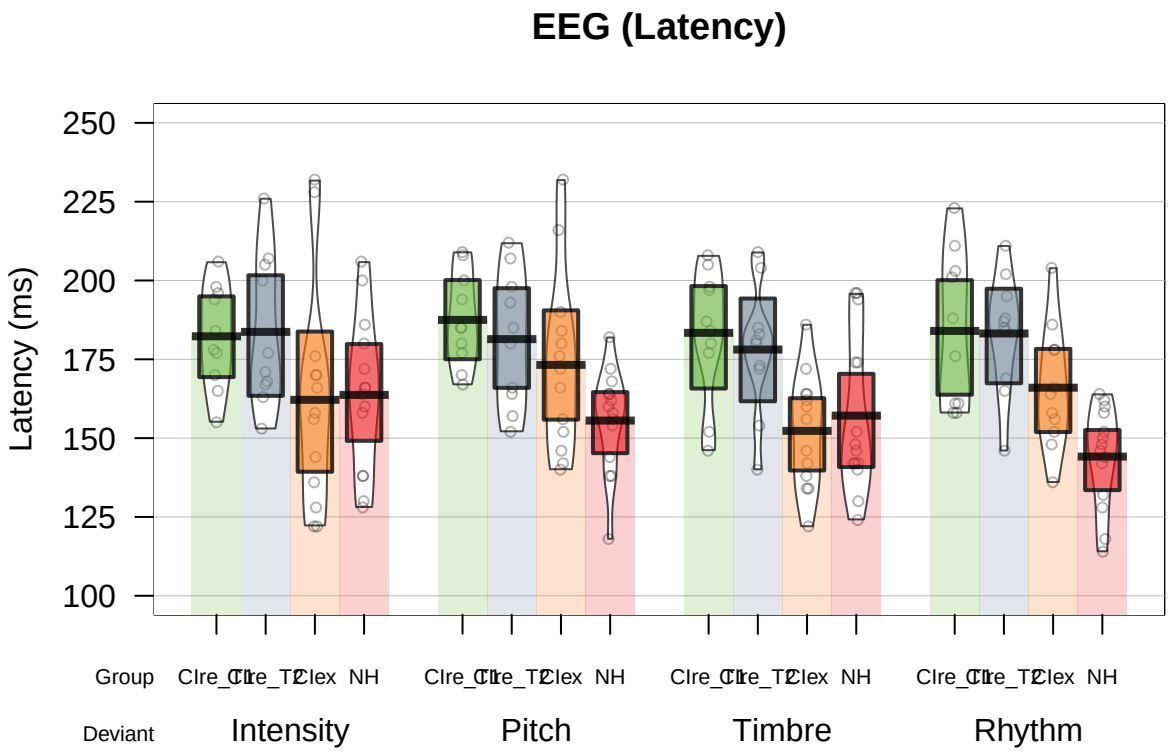
```
ID_plot_data = read_csv("ID_plot_data_lat.csv")
```

```
## Rows: 188 Columns: 5
```

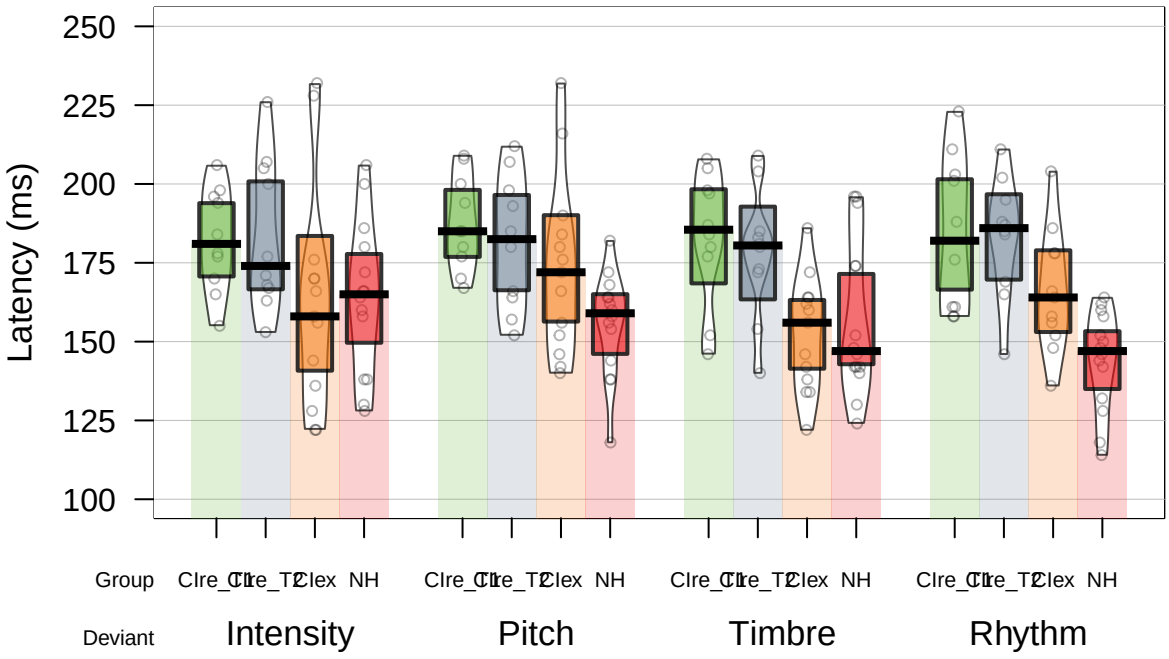
```
## -- Column specification --------------------------------------------------------
## Delimiter: ","
## chr (3): Group, Time, Deviant
## dbl (2): ID, Lat
```

```
##
## i Use `spec()` to retrieve the full column specification for this data.
## i Specify the column types or set `show_col_types = FALSE` to quiet this message.
```

```
pirat = ID_plot_data
pirat$Group[pirat$Time =="CIre_T1"]=gsub("CI_re", "CIre_T1", pirat$Group[pirat$Time =="CIre_T1"])
pirat$Group[pirat$Time =="CIre_T2"]=gsub("CI_re", "CIre_T2", pirat$Group[pirat$Time =="CIre_T2"])
pirat$Group=ordered(pirat$Group, levels=c("CIre_T1", "CIre_T2", "CIex", "NH"))
pirat$Deviant=ordered(pirat$Deviant, levels=c("Intensity", "Pitch", "Timbre", "Rhythm"))

pirateplot(formula = Lat ~ Group + Deviant, data = pirat, main = "EEG (Latency)", xlab = "Group",ylab="
```




```
pirateplot(formula = Lat ~ Group + Deviant, data = pirat, xlab = "Group",ylab="Latency (ms)", ylim= c(1
  abline(a=33,33, b=0, lwd=1, lty="dashed")
```




```
## integer(0)
```

Hierarchical mixed effects modeling - Behavioral (T2)

```
M0=glmer(cbind(AvCor*6,6)~1+(1|ID), data=All_behav[All_behav$Group!="CIre_T1",], family="binomial", con

M1=glmer(cbind(AvCor*6,6)~Deviant+(1|ID), data=All_behav[All_behav$Group!="CIre_T1",], family="binomial

M2=glmer(cbind(AvCor*6,6)~Deviant+DeviantLevel+(1|ID), data=All_behav[All_behav$Group!="CIre_T1",], fam

M3=glmer(cbind(AvCor*6,6)~Deviant+DeviantLevel+Group+(1|ID), data=All_behav[All_behav$Group!="CIre_T1",

M4=glmer(cbind(AvCor*6,6)~Deviant*DeviantLevel+Group+(1|ID), data=All_behav[All_behav$Group!="CIre_T1",

M5=glmer(cbind(AvCor*6,6)~Deviant*DeviantLevel+Deviant*Group+(1|ID), data=All_behav[All_behav$Group!="C

M6=glmer(cbind(AvCor*6,6)~Deviant*DeviantLevel+Deviant*Group+DeviantLevel*Group+(1|ID), data=All_behav[

M7=glmer(cbind(AvCor*6,6)~Deviant*DeviantLevel*Group+(1|ID), data=All_behav[All_behav$Group!="CIre_T1",


#Comparing models
```

```
anova = anova(M0, M1, M2, M3, M4, M5, M6, M7)
anova
```

```
## Data: All_behav[All_behav$Group != "CIre_T1", ]
## Models:
## M0: cbind(AvCor * 6, 6) ~ 1 + (1 | ID)
## M1: cbind(AvCor * 6, 6) ~ Deviant + (1 | ID)
## M2: cbind(AvCor * 6, 6) ~ Deviant + DeviantLevel + (1 | ID)
## M3: cbind(AvCor * 6, 6) ~ Deviant + DeviantLevel + Group + (1 | ID)
## M4: cbind(AvCor * 6, 6) ~ Deviant * DeviantLevel + Group + (1 | ID)
## M5: cbind(AvCor * 6, 6) ~ Deviant * DeviantLevel + Deviant * Group + (1 | ID)
## M6: cbind(AvCor * 6, 6) ~ Deviant * DeviantLevel + Deviant * Group + DeviantLevel * Group + (1 | ID)
## M7: cbind(AvCor * 6, 6) ~ Deviant * DeviantLevel * Group + (1 | ID)
##    npar    AIC    BIC  logLik deviance    Chisq Df Pr(>Chisq)
## M0    2 3285.4 3294.2 -1640.7   3281.4
## M1    5 3148.9 3170.9 -1569.4   3138.9 142.4992  3  < 2.2e-16 ***
## M2    8 3023.4 3058.6 -1503.7   3007.4 131.5106  3  < 2.2e-16 ***
## M3   10 3013.1 3057.2 -1496.5   2993.1  14.2959  2  0.0007865 ***
## M4   19 3000.5 3084.3 -1481.2   2962.5  30.5746  9  0.0003501 ***
## M5   25 2989.8 3100.0 -1469.9   2939.8  22.7072  6  0.0009007 ***
## M6   31 2999.6 3136.4 -1468.8   2937.6   2.1518  6  0.9052200
## M7   49 3028.3 3244.4 -1465.2   2930.3   7.3054 18  0.9872880
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

Post-hoc analysis

```
emm_g <- emmeans(M5, pairwise ~ Group)
```

```
## NOTE: Results may be misleading due to involvement in interactions
```

```
emm_gc <- emm_g[[2]]

emm_d <- emmeans(M5, pairwise ~ Deviant)
```

```
## NOTE: Results may be misleading due to involvement in interactions
```

```
emm_dc <- emm_d[[2]]

#Group by deviant interaction


emm_g.d <- emmeans(M5, pairwise ~ Group | Deviant, type = "response")
IC_g.d <- contrast(emm_g.d[[1]], method = "pairwise")

rbind(IC_g.d, adjust = "none")
```

```
##  Deviant   contrast      odds.ratio     SE  df null z.ratio p.value
##  Intensity CIre_T2 / CIx      0.700 0.0723 Inf    1  -3.456  0.0005
```

```
##  Intensity CIre_T2 / NH       0.571 0.0597 Inf    1  -5.354  <.0001
##  Intensity CIx / NH           0.817 0.0743 Inf    1  -2.227  0.0260
##  Pitch     CIre_T2 / CIx      1.017 0.1045 Inf    1   0.161  0.8719
##  Pitch     CIre_T2 / NH       0.747 0.0778 Inf    1  -2.798  0.0051
##  Pitch     CIx / NH           0.735 0.0665 Inf    1  -3.404  0.0007
##  Rhythm    CIre_T2 / CIx      0.950 0.0974 Inf    1  -0.499  0.6177
##  Rhythm    CIre_T2 / NH       0.953 0.0989 Inf    1  -0.463  0.6434
##  Rhythm    CIx / NH           1.003 0.0906 Inf    1   0.034  0.9728
##  Timbre    CIre_T2 / CIx      0.889 0.0912 Inf    1  -1.151  0.2496
##  Timbre    CIre_T2 / NH       0.762 0.0792 Inf    1  -2.611  0.0090
##  Timbre    CIx / NH           0.858 0.0775 Inf    1  -1.697  0.0898
##
## Results are averaged over some or all of the levels of: DeviantLevel
## Tests are performed on the log odds ratio scale
```

```
confint(rbind(IC_g.d), adjust ="none")
```

```
##  Deviant   contrast      odds.ratio     SE  df asymp.LCL asymp.UCL
##  Intensity CIre_T2 / CIx      0.700 0.0723 Inf     0.571     0.857
##  Intensity CIre_T2 / NH       0.571 0.0597 Inf     0.466     0.701
##  Intensity CIx / NH           0.817 0.0743 Inf     0.683     0.976
##  Pitch     CIre_T2 / CIx      1.017 0.1045 Inf     0.831     1.244
##  Pitch     CIre_T2 / NH       0.747 0.0778 Inf     0.609     0.916
##  Pitch     CIx / NH           0.735 0.0665 Inf     0.616     0.878
##  Rhythm    CIre_T2 / CIx      0.950 0.0974 Inf     0.777     1.162
##  Rhythm    CIre_T2 / NH       0.953 0.0989 Inf     0.778     1.168
##  Rhythm    CIx / NH           1.003 0.0906 Inf     0.840     1.197
##  Timbre    CIre_T2 / CIx      0.889 0.0912 Inf     0.727     1.086
##  Timbre    CIre_T2 / NH       0.762 0.0792 Inf     0.622     0.935
##  Timbre    CIx / NH           0.858 0.0775 Inf     0.719     1.024
##
## Results are averaged over some or all of the levels of: DeviantLevel
## Confidence level used: 0.95
## Intervals are back-transformed from the log odds ratio scale
```

Plots behavioral

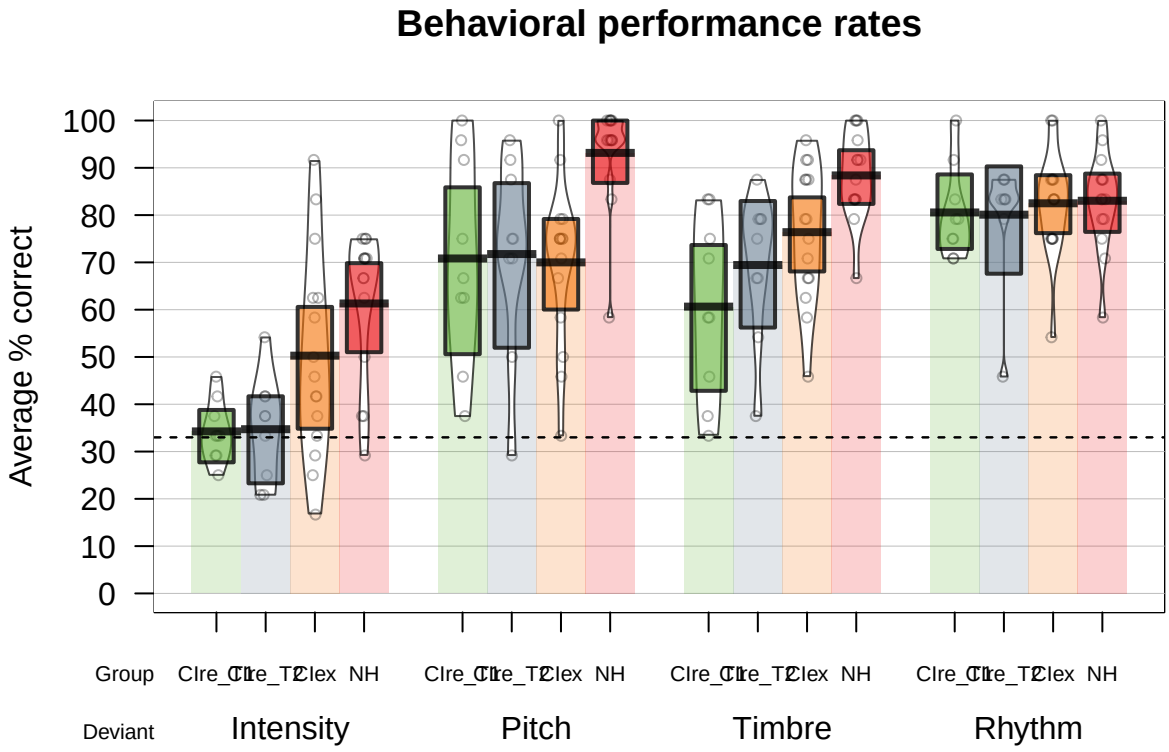
```
ID_plot_data = read_csv("ID_plot_data_behav.csv")
```

```
## Rows: 188 Columns: 5
```

```
## -- Column specification --------------------------------------------------------
## Delimiter: ","
## chr (3): Group, Round, Deviant
## dbl (2): ID, AvCor
```

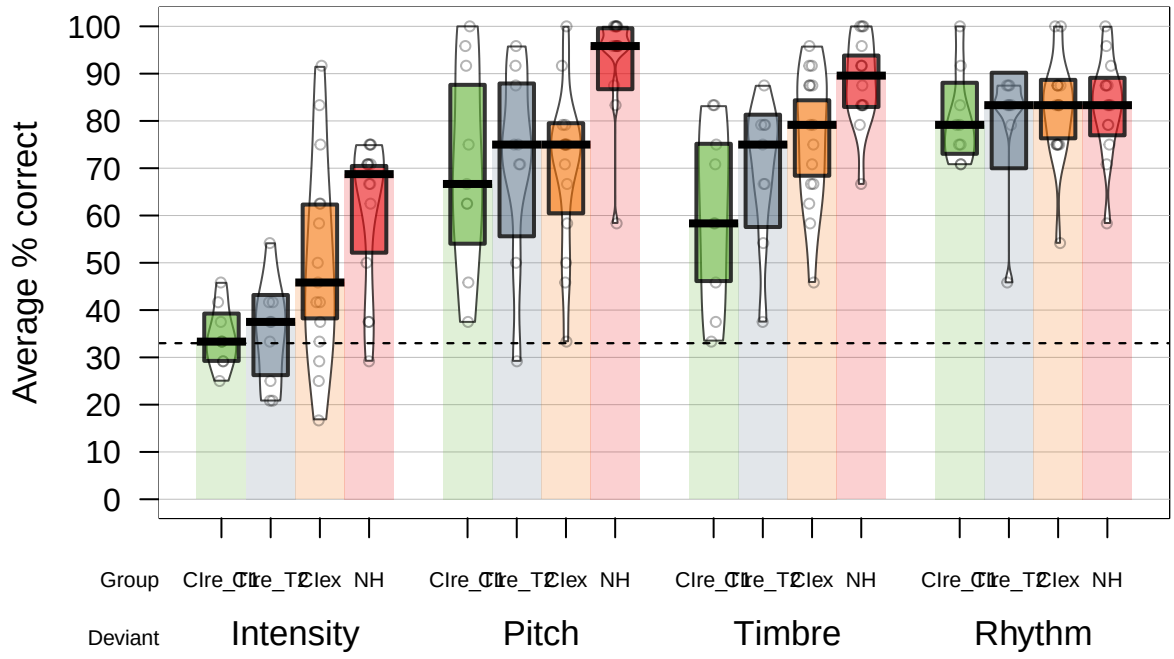
```
##
## i Use `spec()` to retrieve the full column specification for this data.
## i Specify the column types or set `show_col_types = FALSE` to quiet this message.
```

```
ID_plot_data$Group=ordered(ID_plot_data$Group, levels=c("CIre_T1", "CIre_T2", "CIex", "NH"))
ID_plot_data$Deviant=ordered(ID_plot_data$Deviant, levels=c("Intensity", "Pitch", "Timbre", "Rhythm"))

## Creating pirateplot
pirateplot(formula = AvCor ~ Group + Deviant, data = ID_plot_data, main = "Behavioral performance rates
  abline(a=33,33, b=0, lwd=1, lty="dashed")
```




```
## integer(0)
```

```
pirateplot(formula = AvCor ~ Group + Deviant, data = ID_plot_data, xlab = "Group",ylab="Average % corre
  abline(a=33,33, b=0, lwd=1, lty="dashed")
```


Average % correct
100
90
80
70
60
50
40
30
20
10
0
Group
Deviant
Intensity
Pitch
Timbre
Rhythm
NH

```
## integer(0)
```