

# Modality effects in a signalling game

## Intro

This script uses data compiled by *analyseData.R*.

## Load libraries

```
library(lme4)
library(sjPlot)
library(ggplot2)
library(lattice)
library(influence.ME)
```

## Load data

```
d = read.csv("../data/FinalSignalData.csv")
```

Work out number of turns in each trial.

```
# Number of turns in each trial
numTurns = tapply(d$turnString, d$trialString,
                  function(X){length(unique(X))})
d$numOfTurns = numTurns[d$trialString]
```

We don't need info on every signal in each turn, just the trial time. Keep only 1st signal in each trial.

```
d = d[!duplicated(d$trialString),]
```

## Descriptive stats

Here is a graph showing the distribution of trial lengths by conditions:

The distribution of trial times is very skewed:

```
hist(d$trialLength)
```

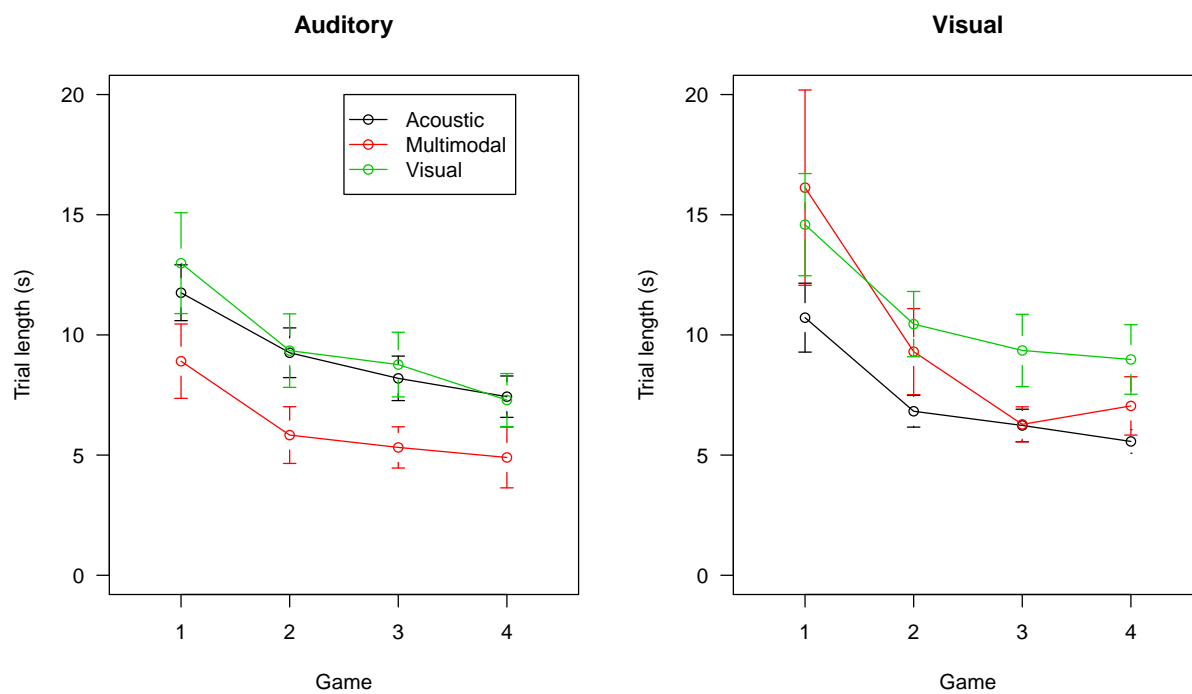
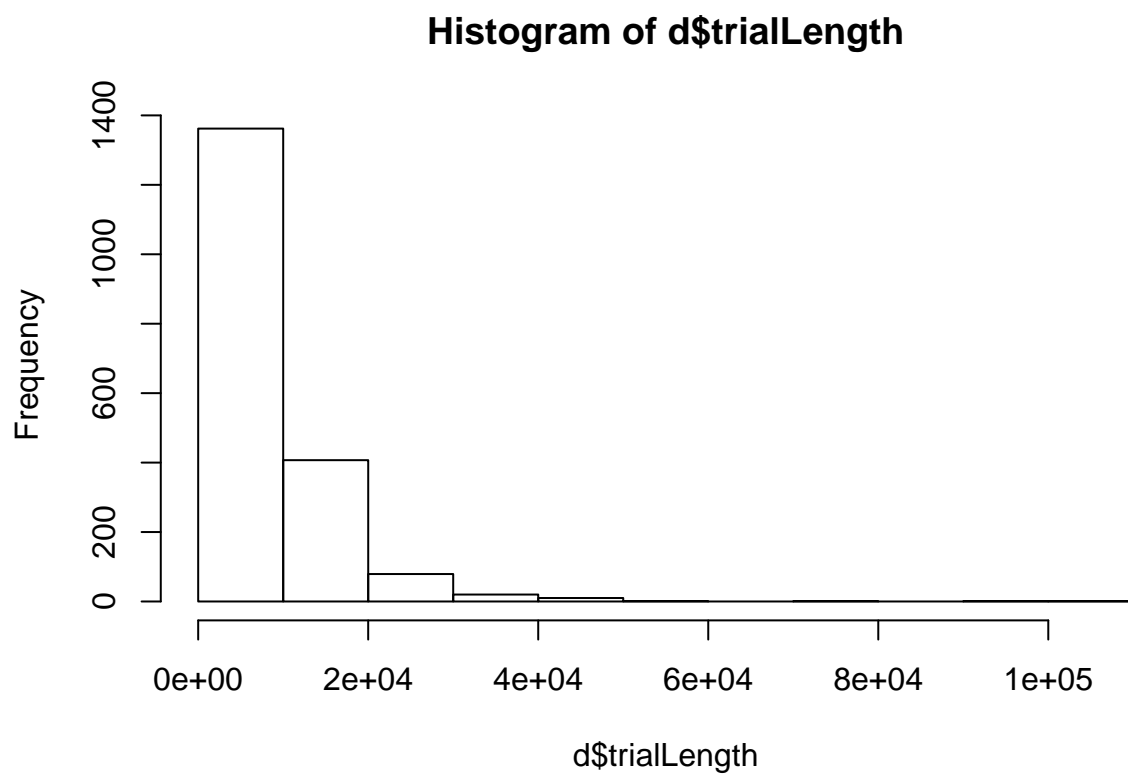
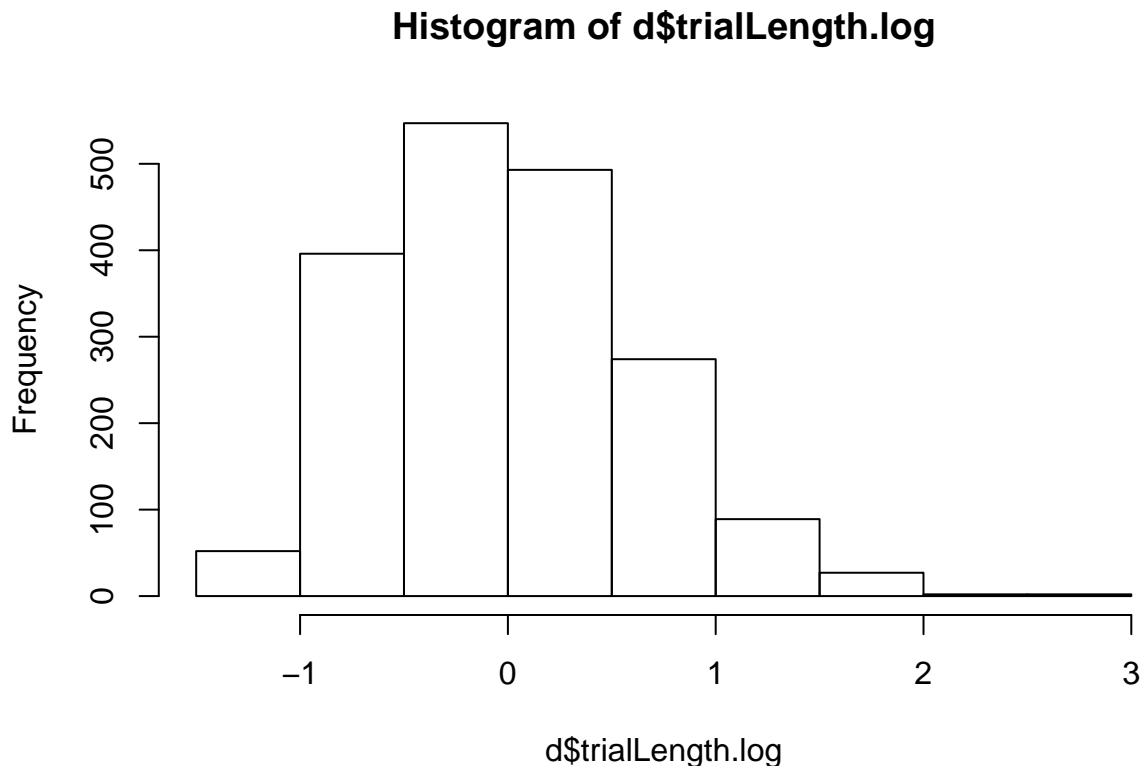


Figure 1: The efficiency of trials in different conditions



So we transform it using a log transform, then center the data.

```
d$trialLength.log = log(d$trialLength)
meanLogTrialLength = mean(d$trialLength.log)
d$trialLength.log = d$trialLength.log - meanLogTrialLength
hist(d$trialLength.log)
```



Make a variable to represent proportion of games played:

```
# Make a variable that represents the number of trials played
d$trialTotal = d$trial + (d$game * (max(d$trial)+1))
# Convert to proportion of games played, so that estimates reflect change per game.
d$trialTotal = d$trialTotal / 16
# Center the trialTotal variable so intercept reflects after the first game
d$trialTotal = d$trialTotal - 2
```

Make a variable for which stimuli the players experienced first.

```
firstBlock = tapply(as.character(d$condition), d$dyadNumber, head, n=1)
d$firstBlock = as.factor(firstBlock[match(d$dyadNumber, names(firstBlock))])
```

Reorder some levels so that the intercept reflects the most frequent condition.

```
d$incorrect = !d$correct
```

```
turnD = read.csv("../data/Final_Turn_data.csv")
turnD = turnD[turnD$turnType=="T1",]
turnD = turnD[turnD$role == "Director",]
d$multimodal = turnD[match(d$trialString, turnD$trialString),]$turnModalityType == "multi"
d$multimodal[is.na(d$multimodal)] = F
```

## Mixed models

Make a series of models with random effects for dyad, director (nested within dyad) and item.

Not all random slopes are appropriate. For example, items are used in only one stimulus condition, so a random slope for condition by item is not appropriate. Similarly, each dyad only plays in one modality condition.

It is reasonable to have a random slope for trial by dyad, but this caused unreliable model convergence, so is not included.

The final random slopes were for condition and incorrectness by dyad/player, and modality condition by item.

```
# No fixed effects
m0 = lmer(trialLength.log ~ 1 +
          (1 + condition + incorrect |dyadNumber/playerId) +
          (1 + modalityCondition|itemId),
          data=d, REML = FALSE)

# Add modality condition
modality = lmer(trialLength.log ~ 1 + modalityCondition +
                (1 + condition + incorrect |dyadNumber/playerId) +
                (1 + modalityCondition|itemId),
                data=d, REML = FALSE)

# Add stimulus condition
cond = lmer(trialLength.log ~ 1 + modalityCondition + condition +
            (1 + condition + incorrect |dyadNumber/playerId) +
            (1 + modalityCondition|itemId),
            data=d, REML = FALSE)

# Add trial total
game = lmer(trialLength.log ~ 1 + modalityCondition + condition + trialTotal +
            (1 + condition + incorrect |dyadNumber/playerId) +
            (1 + modalityCondition|itemId),
            data=d, REML = FALSE)

# Add interaction between condition and stimulus condition
modXcond = lmer(trialLength.log ~ 1 + modalityCondition * condition + trialTotal +
                (1 + condition + incorrect |dyadNumber/playerId) +
                (1 + modalityCondition|itemId),
                data=d, REML = FALSE)

# Add interaction between condition and trial
conXgame = lmer(trialLength.log ~ 1 + (modalityCondition * condition) + trialTotal +
                (trialTotal:condition) +
                (1 + condition + incorrect |dyadNumber/playerId) +
                (1 + modalityCondition|itemId),
                data=d, REML = FALSE)

# Add interaction between modality and trial
modXgame = lmer(trialLength.log ~ 1 + (modalityCondition * condition) + trialTotal +
                (trialTotal:condition) + (modalityCondition:game) +
                (1 + condition + incorrect |dyadNumber/playerId) +
                (1 + modalityCondition|itemId),
                data=d, REML = FALSE)

# Add 3-way interaction
moXcoXga = lmer(trialLength.log ~ 1 + modalityCondition * condition * trialTotal +
                (1 + condition + incorrect |dyadNumber/playerId) +
                (1 + modalityCondition|itemId),
```

```

    data=d, REML = FALSE)

# Add number of turns
nTurns = lmer(trialLength.log ~ 1 + modalityCondition * condition * trialTotal +
              numberOfTurns +
              (1 + condition + incorrect |dyadNumber/playerId) +
              (1 + modalityCondition|itemId),
              data=d, REML = FALSE)

# interaction between turns and modality
nTurnXmo = lmer(trialLength.log ~ 1 + modalityCondition * condition * trialTotal +
                numberOfTurns*modalityCondition +
                (1 + condition + incorrect |dyadNumber/playerId) +
                (1 + modalityCondition|itemId),
                data=d, REML = FALSE)

nTurnXco = lmer(trialLength.log ~ 1 + modalityCondition * condition * trialTotal +
                numberOfTurns*modalityCondition+ numberOfTurns:condition +
                (1 + condition + incorrect |dyadNumber/playerId) +
                (1 + modalityCondition|itemId),
                data=d, REML = FALSE)

tuXmoXco = lmer(trialLength.log ~ 1 + modalityCondition * condition * trialTotal +
                numberOfTurns*modalityCondition*condition +
                (1 + condition + incorrect |dyadNumber/playerId) +
                (1 + modalityCondition|itemId),
                data=d, REML = FALSE)

# Add whether the response was incorrect
incor = lmer(trialLength.log ~ 1 + modalityCondition * condition * trialTotal +
              numberOfTurns*modalityCondition*condition +
              incorrect +
              (1 + condition + incorrect |dyadNumber/playerId) +
              (1 + modalityCondition|itemId),
              data=d, REML = FALSE)

# Add the interaction between modality and incorrectness
moXincor = lmer(trialLength.log ~ 1 + modalityCondition * condition * trialTotal +
                numberOfTurns*modalityCondition*condition +
                incorrect + (modalityCondition:incorrect) +
                (1 + condition + incorrect |dyadNumber/playerId) +
                (1 + modalityCondition|itemId),
                data=d, REML = FALSE)

# Add the interaction between condition and incorrectness
coXincor = lmer(trialLength.log ~ 1 + modalityCondition * condition * trialTotal +
                numberOfTurns*modalityCondition*condition +
                incorrect + (modalityCondition:incorrect) +
                (condition:incorrect) +
                (1 + condition + incorrect |dyadNumber/playerId) +
                (1 + modalityCondition|itemId),
                data=d, REML = FALSE)

# Add the three-way interaction between condition, modality and incorrectness
coXmoXin = lmer(trialLength.log ~ 1 + modalityCondition * condition * trialTotal +
                 numberOfTurns*modalityCondition*condition +
                 (incorrect*condition*modalityCondition)+

```

```

      (1 + condition + incorrect |dyadNumber/playerId) +
      (1 + modalityCondition|itemId),
      data=d, REML = FALSE)

# Add multimodal signal

multim = lmer(trialLength.log ~ 1 + modalityCondition * condition * trialTotal +
      numberOfTurns*modalityCondition*condition +
      (incorrect*condition*modalityCondition)+
      multimodal +
      (1 + condition + incorrect |dyadNumber/playerId) +
      (1 + modalityCondition|itemId),
      data=d, REML = FALSE)

multiXco = lmer(trialLength.log ~ 1 + modalityCondition * condition * trialTotal +
      numberOfTurns*modalityCondition*condition +
      (incorrect*condition*modalityCondition)+
      multimodal*condition +
      (1 + condition + incorrect |dyadNumber/playerId) +
      (1 + modalityCondition|itemId),
      data=d, REML = FALSE)

# Add the quadratic effect of trial
gamQuad = lmer(trialLength.log ~ 1 + modalityCondition * condition * trialTotal +
      I(trialTotal^2) +
      numberOfTurns*modalityCondition*condition +
      (incorrect*condition*modalityCondition)+
      multimodal*condition +
      (1 + condition + incorrect |dyadNumber/playerId) +
      (1 + modalityCondition|itemId),
      data=d, REML = FALSE)

# Add interaction between quadratic effect of trial and modality
modXgamQ = lmer(trialLength.log ~ 1 + modalityCondition * condition * trialTotal +
      I(trialTotal^2) +
      numberOfTurns*modalityCondition*condition +
      (incorrect*condition*modalityCondition)+
      multimodal*condition +
      (modalityCondition:I(trialTotal^2)) +
      (1 + condition + incorrect |dyadNumber/playerId) +
      (1 + modalityCondition|itemId),
      data=d, REML = FALSE)

# Add block order
block = lmer(trialLength.log ~ 1 + modalityCondition * condition * trialTotal +
      I(trialTotal^2) +
      numberOfTurns*modalityCondition*condition +
      (incorrect*condition*modalityCondition)+
      multimodal*condition +
      (modalityCondition:I(trialTotal^2)) +
      firstBlock +
      (1 + condition + incorrect |dyadNumber/playerId) +
      (1 + modalityCondition|itemId),
      data=d, REML = FALSE)

# Add interaction between block order and modality

```

```

blocXmod = lmer(trialLength.log ~ 1 + modalityCondition * condition * trialTotal +
  I(trialTotal^2) +
  numberOfTurns*modalityCondition*condition +
  (incorrect*condition*modalityCondition)+
  multimodal*condition +
  (modalityCondition:I(trialTotal^2)) +
  firstBlock * modalityCondition +
  (1 + condition + incorrect |dyadNumber/playerId) +
  (1 + modalityCondition|itemId),
  data=d, REML = TRUE)  # Last model is REML to get estimates

```

## Results

Compare the fit of the models:

```
modelComparison = anova(m0,modality,cond,game,modXcond,conXgame, modXgame,
  moXcoXga,nTurns,nTurnXmo,nTurnXco,tuXmoXco,
  incor,moXincor,coXincor,coXmoXin,
  multim,multiXco,
  gamQuad,modXgamQ,block, blocXmod)
```

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

```
modelComparison
```

```
## Data: d
## Models:
## m0: trialLength.log ~ 1 + (1 + condition + incorrect | dyadNumber/playerId) +
## m0:      (1 + modalityCondition | itemId)
## modality: trialLength.log ~ 1 + modalityCondition + (1 + condition + incorrect |
## modality:      dyadNumber/playerId) + (1 + modalityCondition | itemId)
## cond: trialLength.log ~ 1 + modalityCondition + condition + (1 + condition +
## cond:      incorrect | dyadNumber/playerId) + (1 + modalityCondition |
## cond:      itemId)
## game: trialLength.log ~ 1 + modalityCondition + condition + trialTotal +
## game:      (1 + condition + incorrect | dyadNumber/playerId) + (1 +
## game:      modalityCondition | itemId)
## modXcond: trialLength.log ~ 1 + modalityCondition * condition + trialTotal +
## modXcond:      (1 + condition + incorrect | dyadNumber/playerId) + (1 +
## modXcond:      modalityCondition | itemId)
## conXgame: trialLength.log ~ 1 + (modalityCondition * condition) + trialTotal +
## conXgame:      (trialTotal:condition) + (1 + condition + incorrect | dyadNumber/playerId) +
## conXgame:      (1 + modalityCondition | itemId)
## modXgame: trialLength.log ~ 1 + (modalityCondition * condition) + trialTotal +
## modXgame:      (trialTotal:condition) + (modalityCondition:game) + (1 +
## modXgame:      condition + incorrect | dyadNumber/playerId) + (1 + modalityCondition |
## modXgame:      itemId)
## moXcoXga: trialLength.log ~ 1 + modalityCondition * condition * trialTotal +
## moXcoXga:      (1 + condition + incorrect | dyadNumber/playerId) + (1 +
## moXcoXga:      modalityCondition | itemId)
## nTurns: trialLength.log ~ 1 + modalityCondition * condition * trialTotal +
## nTurns:      numberOfTurns + (1 + condition + incorrect | dyadNumber/playerId) +
## nTurns:      (1 + modalityCondition | itemId)
## nTurnXmo: trialLength.log ~ 1 + modalityCondition * condition * trialTotal +
## nTurnXmo:      numberOfTurns * modalityCondition + (1 + condition + incorrect |
## nTurnXmo:      dyadNumber/playerId) + (1 + modalityCondition | itemId)
## nTurnXco: trialLength.log ~ 1 + modalityCondition * condition * trialTotal +
## nTurnXco:      numberOfTurns * modalityCondition + numberOfTurns:condition +
## nTurnXco:      (1 + condition + incorrect | dyadNumber/playerId) + (1 +
## nTurnXco:      modalityCondition | itemId)
## tuXmoXco: trialLength.log ~ 1 + modalityCondition * condition * trialTotal +
## tuXmoXco:      numberOfTurns * modalityCondition * condition + (1 + condition +
## tuXmoXco:      incorrect | dyadNumber/playerId) + (1 + modalityCondition |
## tuXmoXco:      itemId)
## incor: trialLength.log ~ 1 + modalityCondition * condition * trialTotal +
## incor:      numberOfTurns * modalityCondition * condition + incorrect +
```



```

## incor:      (1 + condition + incorrect | dyadNumber/playerId) + (1 +
## incor:      modalityCondition | itemId)
## moXincor: trialLength.log ~ 1 + modalityCondition * condition * trialTotal +
## moXincor:      numberOfTurns * modalityCondition * condition + incorrect +
## moXincor:      (modalityCondition:incorrect) + (1 + condition + incorrect |
## moXincor:      dyadNumber/playerId) + (1 + modalityCondition | itemId)
## coXincor: trialLength.log ~ 1 + modalityCondition * condition * trialTotal +
## coXincor:      numberOfTurns * modalityCondition * condition + incorrect +
## coXincor:      (modalityCondition:incorrect) + (condition:incorrect) + (1 +
## coXincor:      condition + incorrect | dyadNumber/playerId) + (1 + modalityCondition |
## coXincor:      itemId)
## coXmoXin: trialLength.log ~ 1 + modalityCondition * condition * trialTotal +
## coXmoXin:      numberOfTurns * modalityCondition * condition + (incorrect *
## coXmoXin:      condition * modalityCondition) + (1 + condition + incorrect |
## coXmoXin:      dyadNumber/playerId) + (1 + modalityCondition | itemId)
## multim: trialLength.log ~ 1 + modalityCondition * condition * trialTotal +
## multim:      numberOfTurns * modalityCondition * condition + (incorrect *
## multim:      condition * modalityCondition) + multimodal + (1 + condition +
## multim:      incorrect | dyadNumber/playerId) + (1 + modalityCondition |
## multim:      itemId)
## multiXco: trialLength.log ~ 1 + modalityCondition * condition * trialTotal +
## multiXco:      numberOfTurns * modalityCondition * condition + (incorrect *
## multiXco:      condition * modalityCondition) + multimodal * condition +
## multiXco:      (1 + condition + incorrect | dyadNumber/playerId) + (1 +
## multiXco:      modalityCondition | itemId)
## gamQuad: trialLength.log ~ 1 + modalityCondition * condition * trialTotal +
## gamQuad:      I(trialTotal^2) + numberOfTurns * modalityCondition * condition +
## gamQuad:      (incorrect * condition * modalityCondition) + multimodal *
## gamQuad:      condition + (1 + condition + incorrect | dyadNumber/playerId) +
## gamQuad:      (1 + modalityCondition | itemId)
## modXgamQ: trialLength.log ~ 1 + modalityCondition * condition * trialTotal +
## modXgamQ:      I(trialTotal^2) + numberOfTurns * modalityCondition * condition +
## modXgamQ:      (incorrect * condition * modalityCondition) + multimodal *
## modXgamQ:      condition + (modalityCondition:I(trialTotal^2)) + (1 + condition +
## modXgamQ:      incorrect | dyadNumber/playerId) + (1 + modalityCondition |
## modXgamQ:      itemId)
## block: trialLength.log ~ 1 + modalityCondition * condition * trialTotal +
## block:      I(trialTotal^2) + numberOfTurns * modalityCondition * condition +
## block:      (incorrect * condition * modalityCondition) + multimodal *
## block:      condition + (modalityCondition:I(trialTotal^2)) + firstBlock +
## block:      (1 + condition + incorrect | dyadNumber/playerId) + (1 +
## block:      modalityCondition | itemId)
## blocXmod: trialLength.log ~ 1 + modalityCondition * condition * trialTotal +
## blocXmod:      I(trialTotal^2) + numberOfTurns * modalityCondition * condition +
## blocXmod:      (incorrect * condition * modalityCondition) + multimodal *
## blocXmod:      condition + (modalityCondition:I(trialTotal^2)) + firstBlock *
## blocXmod:      modalityCondition + (1 + condition + incorrect | dyadNumber/playerId) +
## blocXmod:      (1 + modalityCondition | itemId)
##
##      Df      AIC      BIC    logLik deviance    Chisq Chi Df Pr(>Chisq)
## m0      20 2694.4 2805.2 -1327.21  2654.4
## modality 22 2696.0 2817.9 -1326.01  2652.0    2.4050      2  0.300444
## cond     23 2697.3 2824.7 -1325.65  2651.3    0.7147      1  0.397881
## game     24 2309.0 2441.9 -1130.48  2261.0 390.3345      1 < 2.2e-16 ***
## modXcond 26 2301.2 2445.2 -1124.59  2249.2 11.7749      2  0.002774 **

```

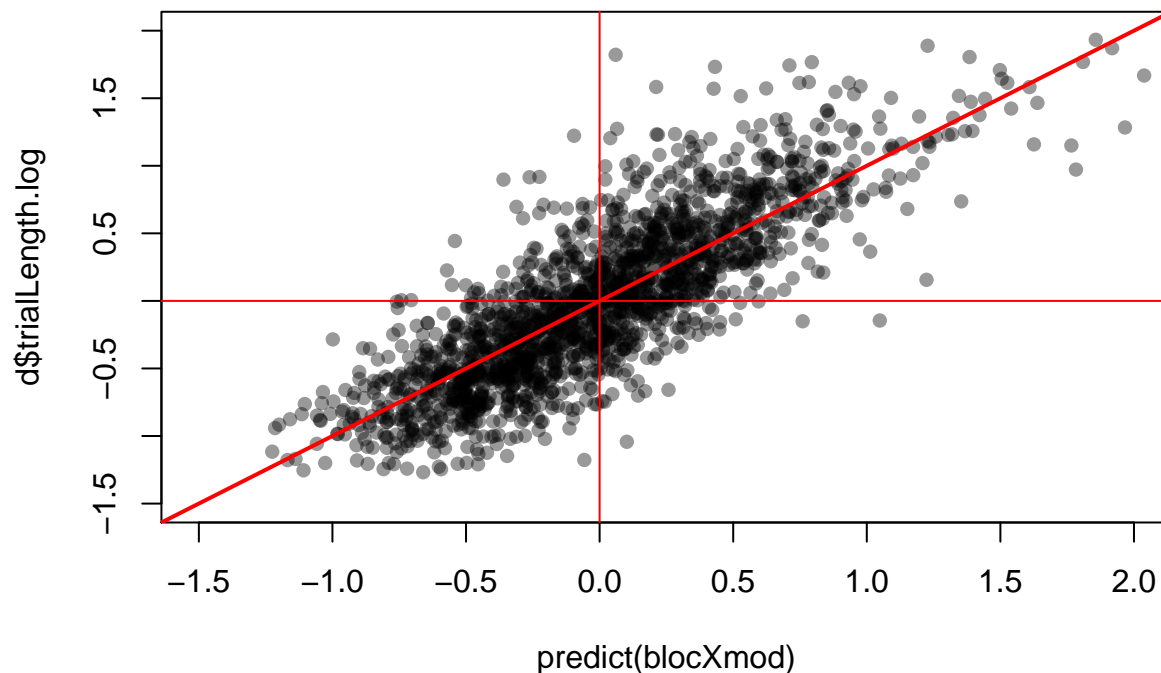
```
## conXgame 27 2302.9 2452.4 -1124.44 2248.9 0.3160 1 0.574037
## modXgame 30 2303.3 2469.5 -1121.66 2243.3 5.5434 3 0.136068
## moXcoXga 31 2302.1 2473.9 -1120.06 2240.1 3.2019 1 0.073555 .
## nTurns 32 1770.7 1948.0 -853.34 1706.7 533.4469 1 < 2.2e-16 ***
## nTurnXmo 34 1771.5 1959.8 -851.74 1703.5 3.2037 2 0.201520
## nTurnXco 35 1773.3 1967.2 -851.66 1703.3 0.1503 1 0.698245
## tuXmoXco 37 1764.9 1969.9 -845.46 1690.9 12.4089 2 0.002020 **
## incor 38 1749.8 1960.3 -836.89 1673.8 17.1470 1 3.46e-05 ***
## moXincor 40 1747.6 1969.2 -833.82 1667.6 6.1391 2 0.046443 *
## coXincor 41 1749.5 1976.6 -833.74 1667.5 0.1580 1 0.691023
## coXmoXin 43 1752.4 1990.6 -833.20 1666.4 1.0732 2 0.584729
## multim 44 1754.2 1998.0 -833.09 1666.2 0.2102 1 0.646596
## multiXco 45 1756.2 2005.5 -833.09 1666.2 0.0040 1 0.949623
## gamQuad 46 1705.8 1960.7 -806.90 1613.8 52.3775 1 4.58e-13 ***
## modXgamQ 48 1702.3 1968.2 -803.14 1606.3 7.5191 2 0.023294 *
## block 49 1704.0 1975.5 -803.03 1606.0 0.2392 1 0.624798
## blocXmod 51 1706.6 1989.2 -802.31 1604.6 1.4385 2 0.487121
## ---
## Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

Pick final model for estimates:

```
finalModel = blocXmod
```

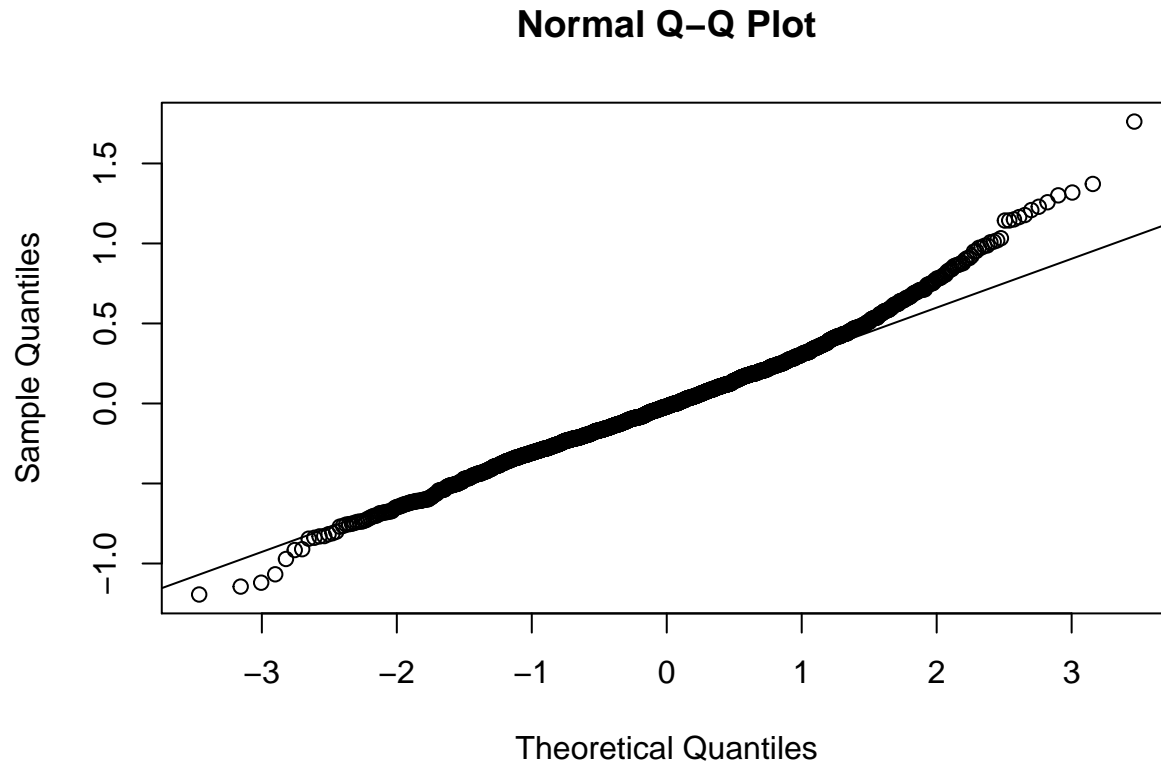
Check model predictions. The model predictions are in the right range and direction, fitting linear quite well:

```
plot(predict(blocXmod),d$trialLength.log, pch=16, col=rgb(0,0,0,0.4),
      ylim=c(-1.5,2),xlim=c(-1.5,2))
abline(a=0,b=1, col=2, lwd=2)
abline(h=0, col=2)
abline(v=0, col=2)
```



The residuals are ok, though it tends to do worse at higher values. This is expected from using the log scale.

```
qqnorm(resid(blocXmod))
qqline(resid(blocXmod))
```



## Plot the fixed effects

Relabel the effects:

```
feLabels = matrix(c(
  "(Intercept)"           , "Intercept"           , NA,
  "modalityConditionvisual" , "Visual modality", "modality",
  "modalityConditionvocal"  , "Acoustic modality", "modality",
  "conditionVisual"        , "Visual stimuli", "cond",
  "trialTotal"             , "Game", "game",
  "modalityConditionvisual:conditionVisual" , "Visual modality:Visual stimuli", "modXcond",
  "modalityConditionvocal:conditionVisual" , "Acoustic modality:Visual stimuli", "modXcond",
  "modalityConditionvisual:trialTotal"      , "Visual modality:Game", "modXgame",
  "modalityConditionvocal:trialTotal"      , "Acoustic modality:Game", "modXgame",
  "conditionVisual:trialTotal"             , "Visual stimuli:Game", "conXgame",
  "modalityConditionvisual:conditionVisual:trialTotal" , "Visual modality:Visual stimuli:Game", "moXcoXga",
  "modalityConditionvocal:conditionVisual:trialTotal" , "Acoustic modality:Visual stimuli:Game", "moXcoXga",
  "incorrectTRUE", "Incorrect", "incor",
  "modalityConditionvisual:incorrectTRUE", "Visual modality:Incorrect", "moXincor",
  "modalityConditionvocal:incorrectTRUE", "Acoustic modality:Incorrect", "moXincor",
  "modalityConditionvisual:I(trialTotal^2)" , "Visual modality:Game^2", "modXgamQ",
  "modalityConditionvocal:I(trialTotal^2)" , "Acoustic modality:Game^2", "modXgamQ",
  "I(trialTotal^2)", "Game^2", "gamQuad",
  "firstBlockVisual", "Visual stims first", "block",
  "modalityConditionvisual:firstBlockVisual", "Visual modality:Visual stim first", "blocXmod",
```

```

"modalityConditionvocal:firstBlockVisual","Acoustic modality:Visual stim first","blocXmod",
"conditionVisual:incorrectTRUE","Visual stimuli:incorrect","coXincor",
"modalityConditionvisual:conditionVisual:incorrectTRUE","Visual modality:Visual stimuli:incorrect","coXincor",
"modalityConditionvocal:conditionVisual:incorrectTRUE","Acoustic modality:Visual stimuli:incorrect","coXincor",

"modalityConditionvisual:conditionVisual:numberOfTurns","VisualModality:Visual stim:NumTurns","tuXmoXco",
"modalityConditionvocal:conditionVisual:numberOfTurns","Vocal Modality:Visual stim:NumTurns","tuXmoXco",
"conditionVisual:numberOfTurns","Visual stim:NumTurns","nTurnXco",
"modalityConditionvisual:numberOfTurns","VisualModality:NumTurns","nTurnXmo",
"modalityConditionvocal:numberOfTurns","Vocal Modality:NumTurns","nTurnXmo",
"numberOfTurns","Number of turns","nTurns",
"multimodalTRUE","Multimodal T1","multim",
"conditionVisual:multimodalTRUE","VisualStim:MultimodalT1","multiXco"
), ncol=3, byrow = T)

```

```

feLabels2 = as.vector(feLabels[match(names(fixef(finalModel)),feLabels[,1]),2])
feModel = as.vector(feLabels[match(names(fixef(finalModel)),feLabels[,1]),3])

```

```

sig = modelComparison$`Pr(>Chisq)`
names(sig) = rownames(modelComparison)

```

```

sig.data = data.frame(estimate = fixef(finalModel),
                      y=1:length(fixef(finalModel)),
                      sig=sig[feModel])

```

```

cols= c("black",'red')
sig.data$pointCol = cols[1]
sig.data$pointCol[!is.na(sig.data$sig)] =
  cols[1 + (sig.data$sig[!is.na(sig.data$sig)] < 0.05)]
# Mark marginal effects
#sig.data$pointCol[!is.na(sig.data$sig) &
#                      sig.data$sig < 0.1 &
#                      sig.data$sig >=0.05] = "orange"

sig.data$fade = sig.data$sig > 0.05

```

Plot the strength of the fixed effects:

```

x = sjp.lmer(finalModel, 'fe',
             show.intercept = T,
             sort.est=NULL,
             axis.labels = feLabels2[2:length(feLabels2)],
             xlab="Trial time (log ms)",
             geom.colors = c(1,1),
             show.p=F,
             show.values = F,
             p.kr = FALSE,
             string.interc="Intercept",
             prnt.plot = F)

```

```

## Warning: replacing previous import 'lme4::sigma' by 'stats::sigma' when
## loading 'pbkrtest'

```

```

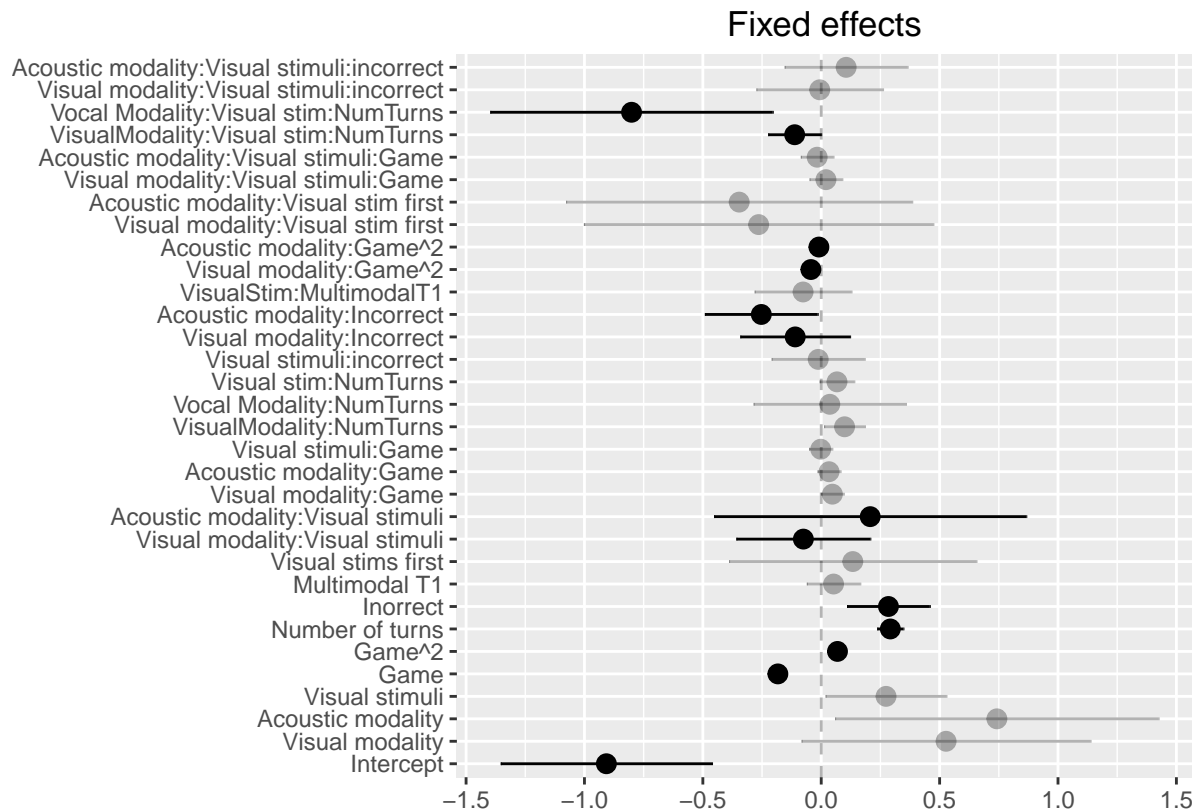
## Computing p-values via Wald-statistics approximation (treating t as Wald z).

```

```
## Warning: Deprecated, use tibble::rownames_to_column() instead.
```

```
x$plot.list[[1]]$data$fade = sig.data$fade
```

```
x$plot.list[[1]]
```



Attempt plot with axes in milliseconds.

```
convertEst = function(X){
  exp(meanLogTrialLength+X) - exp(meanLogTrialLength)
}

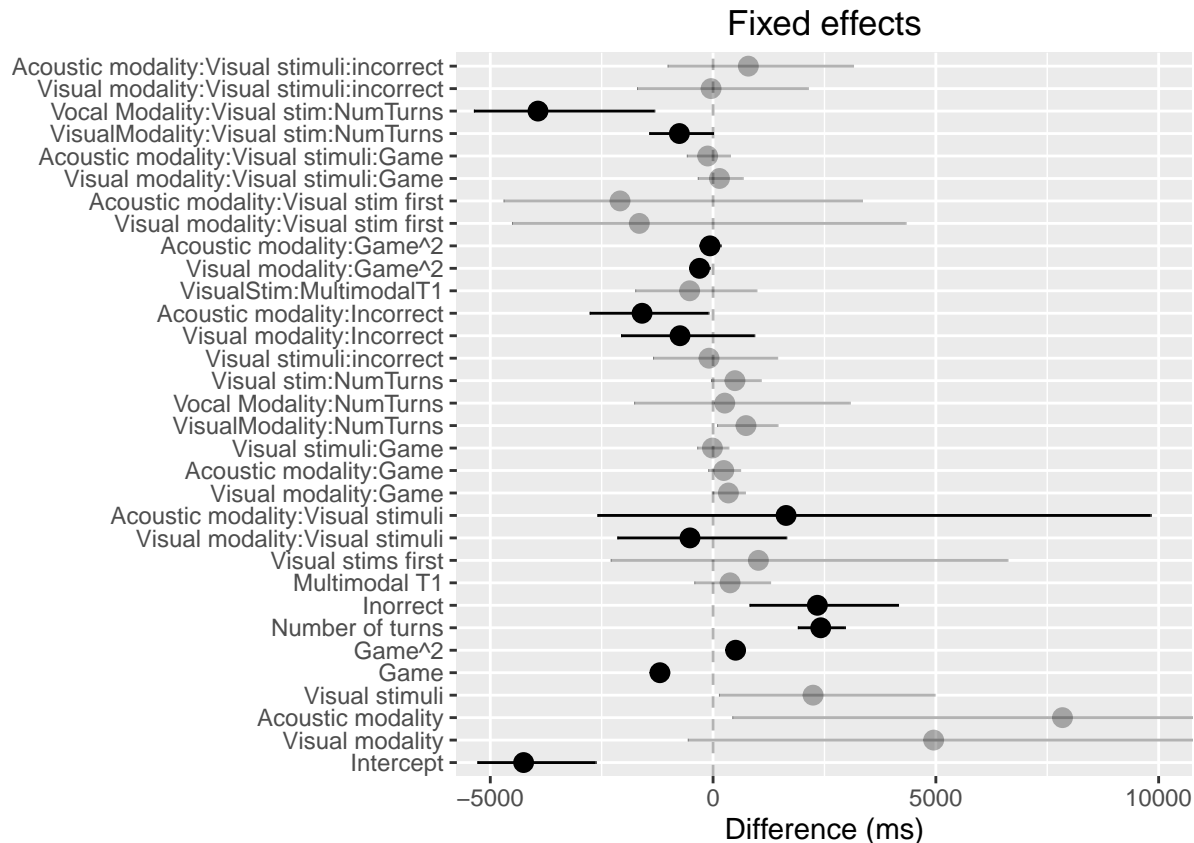
x$plot.list[[1]]$data$estimate =convertEst(x$plot.list[[1]]$data$estimate)
x$plot.list[[1]]$data$conf.low = convertEst(x$plot.list[[1]]$data$conf.low)
x$plot.list[[1]]$data$conf.high = convertEst(x$plot.list[[1]]$data$conf.high)

sig.data2 = sig.data
#sig.data2$estimate = x$plot.list[[1]]$data$estimate

x$plot.list[[1]]$data$fade = sig.data2$fade

x$plot.list[[1]] +
  scale_y_continuous(name="Difference (ms)" ) +
  scale_x_discrete(labels=feLabels2) +
  #geom_point(data=sig.data2,aes(y=estimate,x=y,fade=fade), color=sig.data$pointCol) +
  coord_flip(ylim=c(-5000,10000))

## Scale for 'x' is already present. Adding another scale for 'x', which
## will replace the existing scale.
```

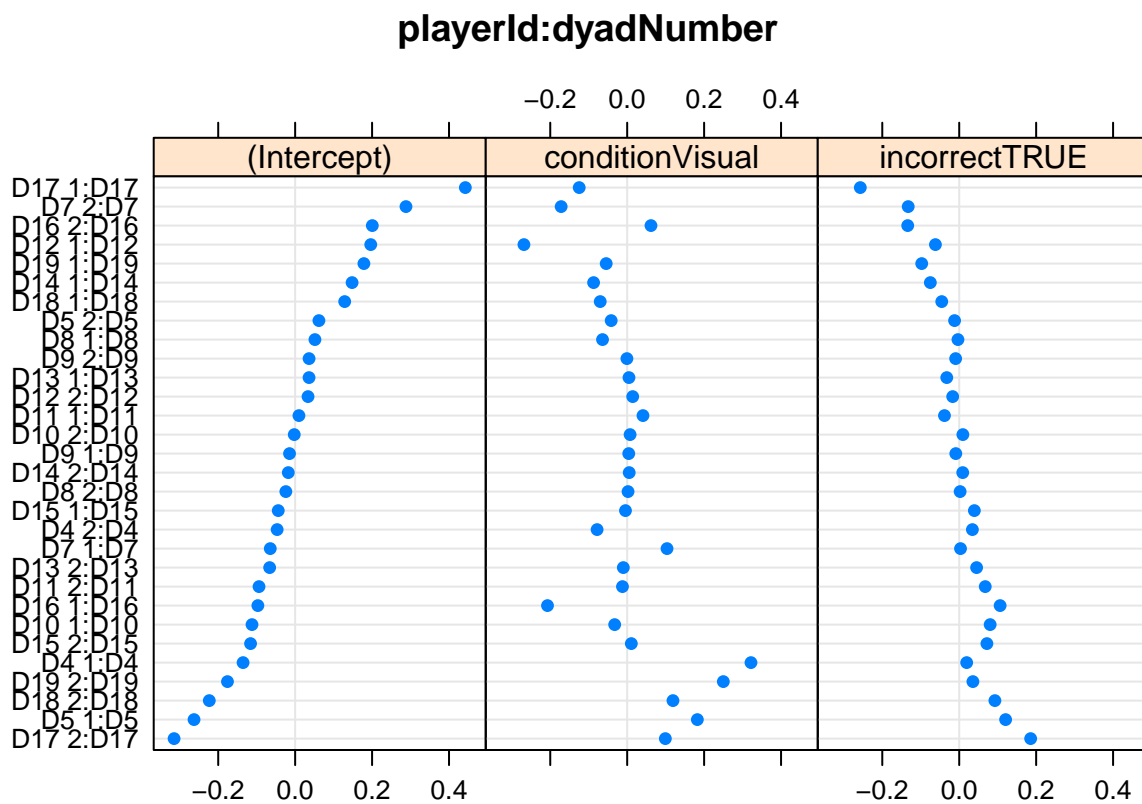


## Random effects

There is a reasonable amount of variation in the random effects, suggesting that dyads and players differ. This justifies the use of mixed effects modelling.

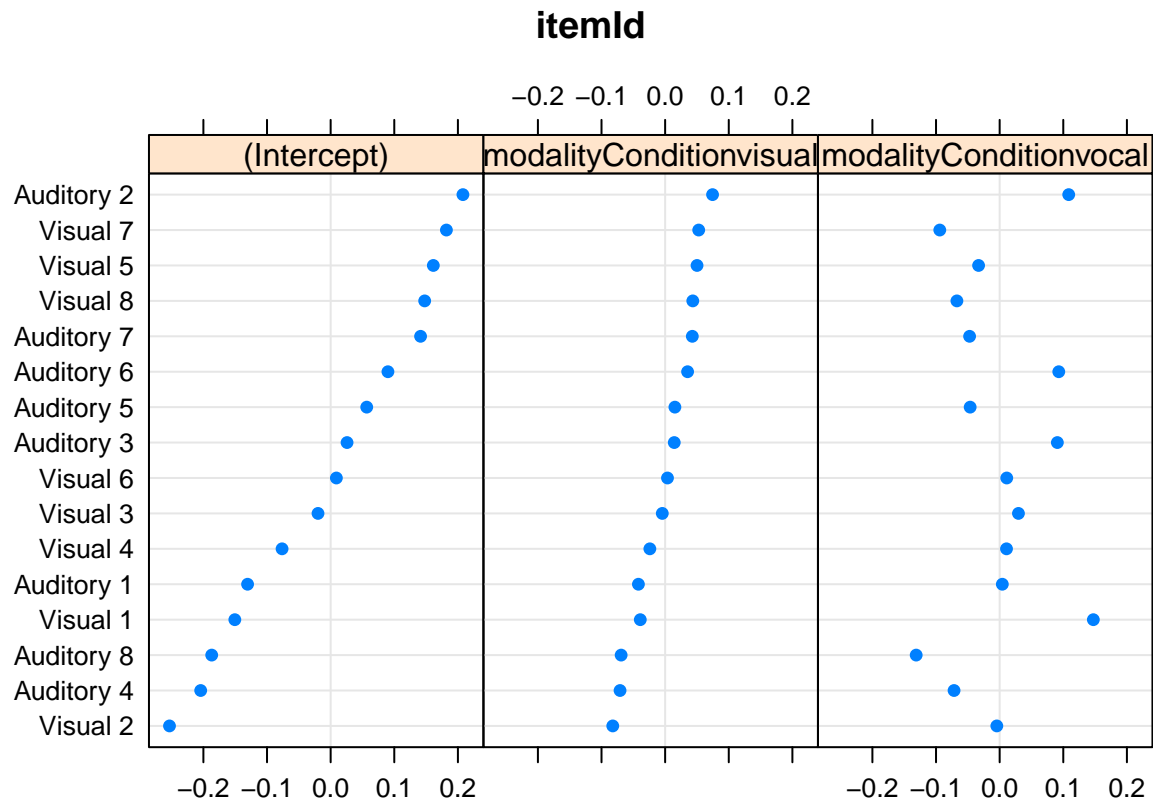
```
dotplot(ranef(finalModel))
```

```
## $`playerId:dyadNumber`
```

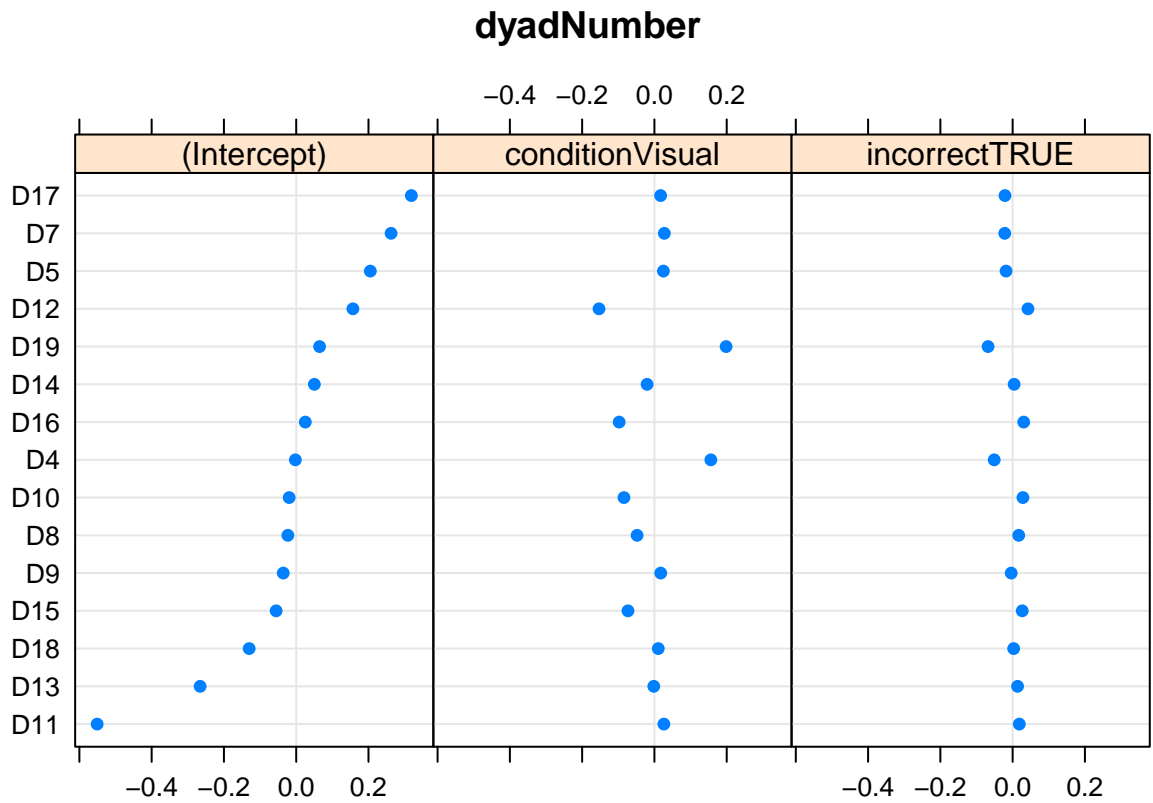


```
##
```

```
## $ItemId
```



##  
## \$dyadNumber





qq-plots of random effects

```
sjp.lmer(finalModel, type = "re.qq")
```

## Testing for normal distribution. Dots should be plotted along the line.

