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$numberOfTurns = numTurns[d$trialString]
```

Variable for length of first T1

```
T1L = tapply(d[d$turnType=="T1",]$turnLength,
             d[d$turnType=="T1",]$trialString, head, n=1)
d$T1Length = T1L[d$trialString]
d$T1Length[is.na(d$T1Length)] = mean(d$T1Length,na.rm=T)
d$T1Length.log = log(d$T1Length)
d$T1Length.log = d$T1Length.log - mean(d$T1Length.log)
```

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)
```

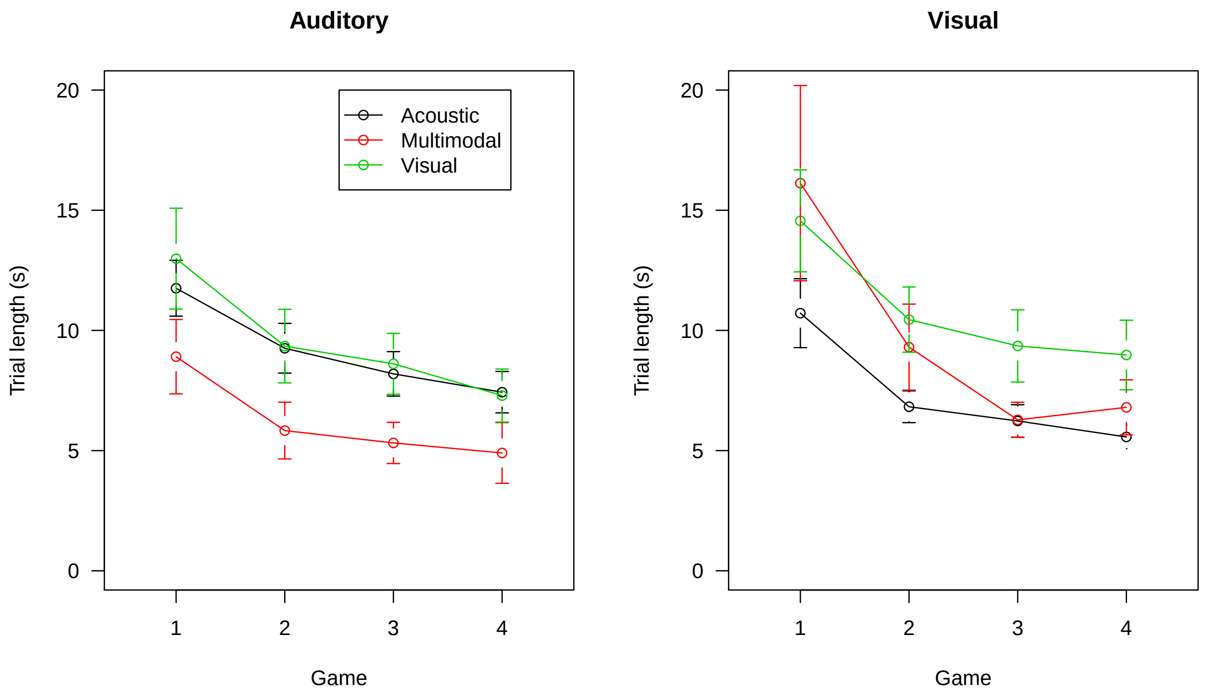
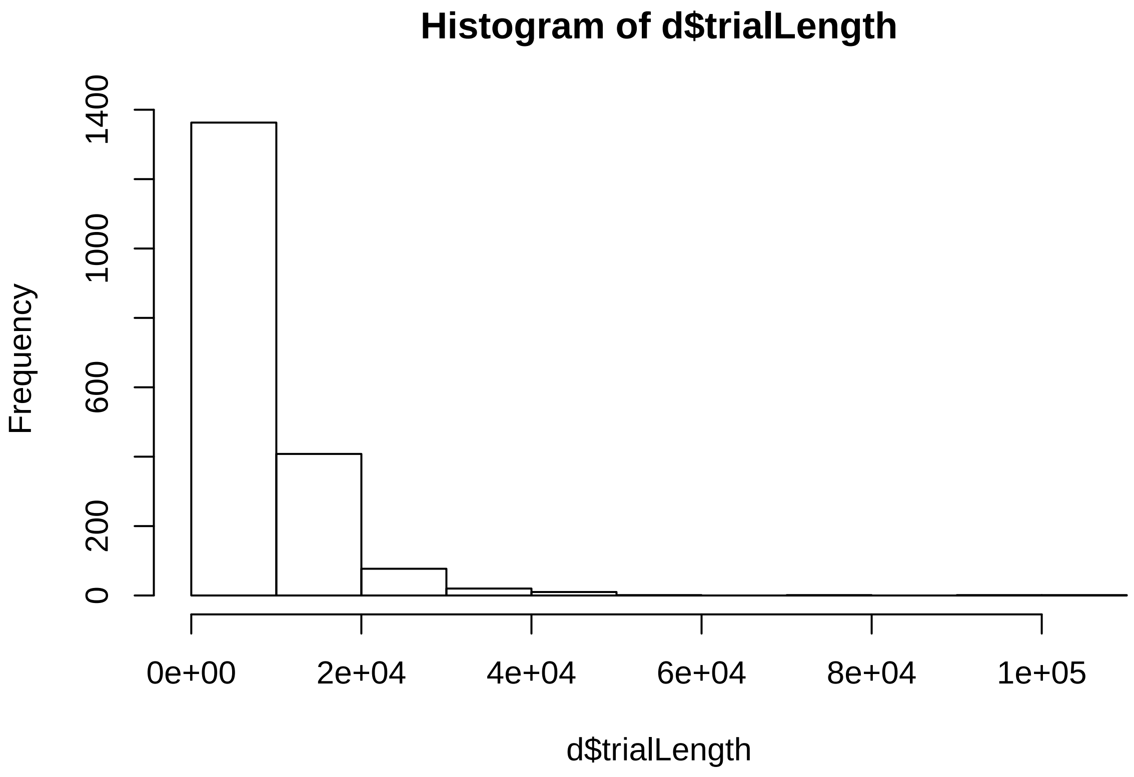
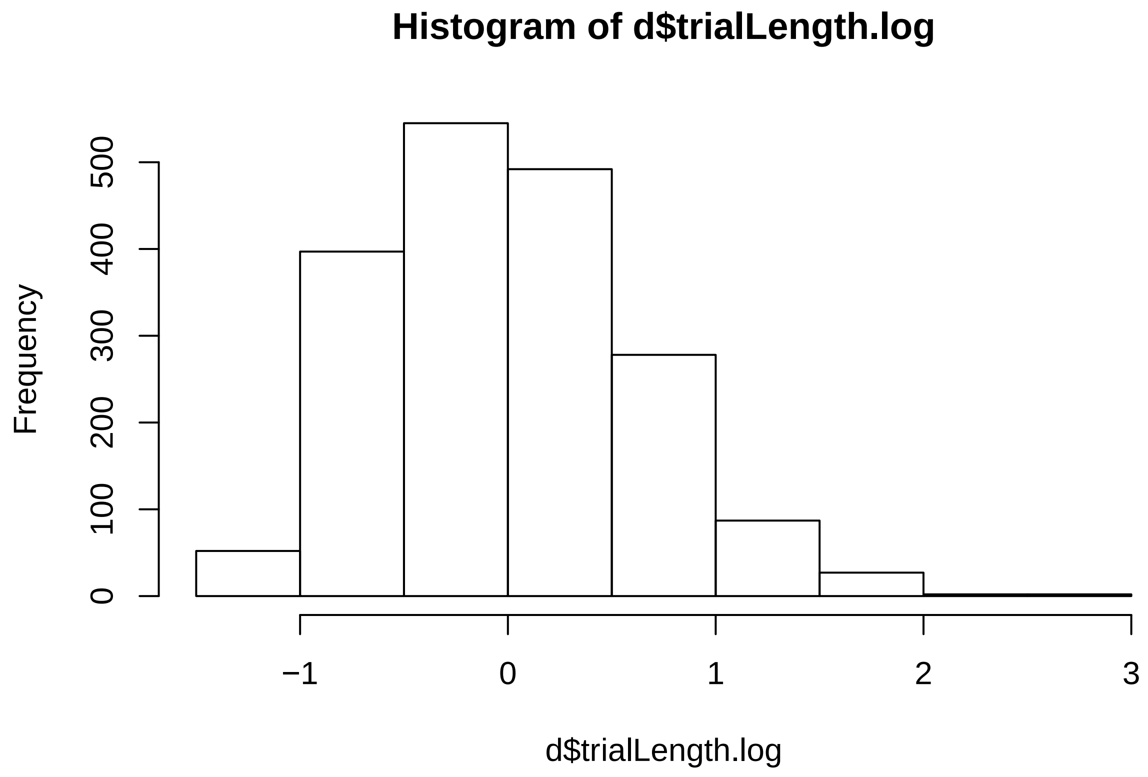


Figure 1: The efficiency of trials in different conditions



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

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



Get the length of the first T1

Make a variable to represent proportion of games played:

```r
# 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.

```r
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.

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

Variable for whether T1 was a multimodal signal.

```r
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)
```

```
## fixed-effect model matrix is rank deficient so dropping 1 column / coefficient
```

```
# 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)
```

```
## fixed-effect model matrix is rank deficient so dropping 1 column / coefficient
```

```
# 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)
```

```
## fixed-effect model matrix is rank deficient so dropping 1 column / coefficient
```

```
# 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)
```

```
## fixed-effect model matrix is rank deficient so dropping 1 column / coefficient
```

```
# 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)
```

```
## fixed-effect model matrix is rank deficient so dropping 1 column / coefficient
```

```
# 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)
```

```
## fixed-effect model matrix is rank deficient so dropping 1 column / coefficient
```

```
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)
```

```
## fixed-effect model matrix is rank deficient so dropping 1 column / coefficient

## Warning in checkConv(attr(opt, "derivs"), opt$par, ctrl = control
## $checkConv, : unable to evaluate scaled gradient

## Warning in checkConv(attr(opt, "derivs"), opt$par, ctrl = control
## $checkConv, : Model failed to converge: degenerate Hessian with 1 negative
## eigenvalues
```

```
# 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)
```

```
## fixed-effect model matrix is rank deficient so dropping 1 column / coefficient
```

```
# 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)
```

```
## fixed-effect model matrix is rank deficient so dropping 1 column / coefficient
```

```
# 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)
```

```
## fixed-effect model matrix is rank deficient so dropping 1 column / coefficient
```

```
# 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
```

```
## fixed-effect model matrix is rank deficient so dropping 1 column / coefficient
```

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
```

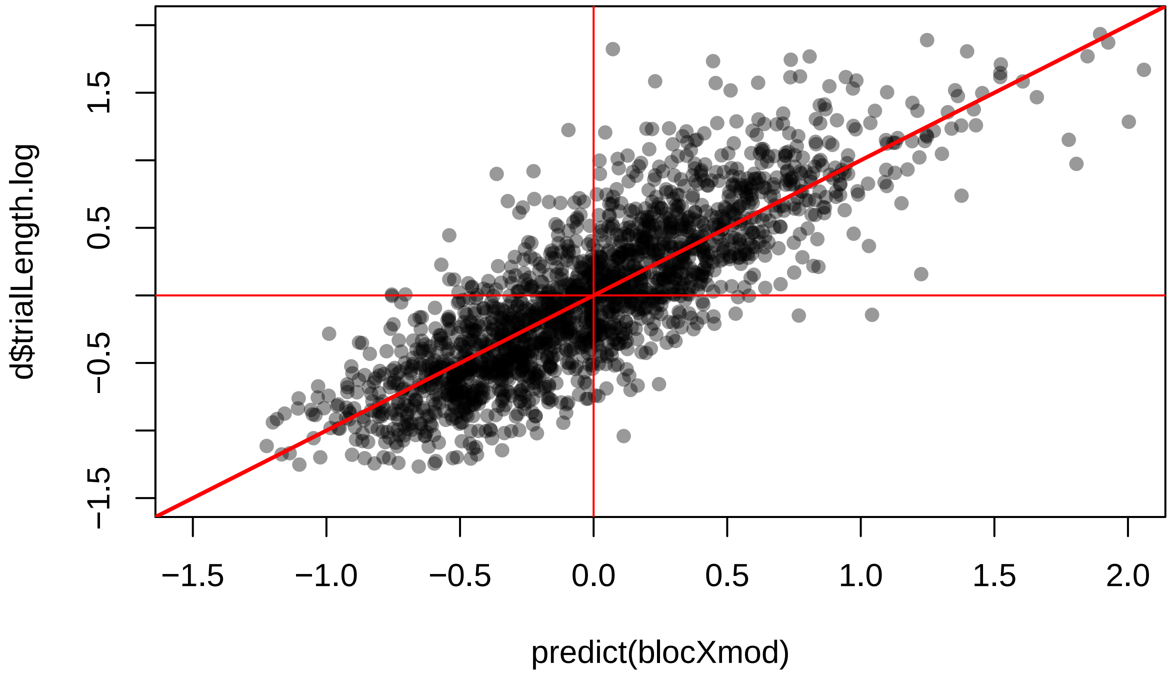
```
## Data: d
## Models:
## m0: trialLength.log ~ 1 + (1 + condition + incorrect | dyadNumber/playerId) +
## m0:     (1 + modalityCondition | itemId)
## modality: trialLength.log ~ 1 + modalityCondition + (1 + condition + incorrect |
## modality:     dyadNumber/playerId) + (1 + modalityCondition | itemId)
## 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 2686.0 2796.8 -1323.01   2646.0
## modality 22 2687.6 2809.5 -1321.80   2643.6   2.4208      2   0.298075
## cond     23 2688.9 2816.3 -1321.44   2642.9   0.7133      1   0.398367
## game     24 2291.5 2424.4 -1121.73   2243.5 399.4113      1  < 2.2e-16 ***
## modXcond 26 2283.8 2427.8 -1115.89   2231.8  11.6871      2   0.002899 **
## conXgame 27 2285.3 2434.9 -1115.66   2231.3   0.4693      1   0.493320
## modXgame 30 2284.8 2451.0 -1112.39   2224.8   6.5318      3   0.088417 .
## moXcoXga 31 2282.9 2454.6 -1110.44   2220.9   3.9093      1   0.048020 *
## nTurns   32 1741.4 1918.7  -838.69   1677.4 543.4855      1  < 2.2e-16 ***
## nTurnXmo 34 1744.1 1932.5  -838.06   1676.1   1.2596      2   0.532703
## nTurnXco 35 1745.9 1939.8  -837.96   1675.9   0.2052      1   0.650553
## tuXmoXco 36 1743.0 1942.4  -835.48   1671.0   4.9633      1   0.025891 *
## incor    37 1727.4 1932.3  -826.68   1653.4  17.5995      1  2.727e-05 ***
## moXincor 39 1725.1 1941.2  -823.57   1647.1   6.2214      2   0.044571 *
## coXincor 40 1726.9 1948.5  -823.45   1646.9   0.2443      1   0.621091
## coXmoXin 42 1729.7 1962.4  -822.87   1645.7   1.1529      2   0.561901
## multim   43 1731.4 1969.6  -822.69   1645.4   0.3612      1   0.547832
## multiXco 44 1733.5 1977.3  -822.76   1645.5   0.0000      1   1.000000
## gamQuad  45 1684.4 1933.7  -797.22   1594.4  51.0806      1  8.865e-13 ***
## modXgamQ 47 1682.2 1942.6  -794.10   1588.2   6.2397      2   0.044164 *
## block    48 1684.0 1949.9  -793.98   1588.0   0.2433      1   0.621843
## blocXmod 50 1686.4 1963.4  -793.20   1586.4   1.5501      2   0.460678
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

Pick final model for estimates:

```
finalModel = blocXmod
```

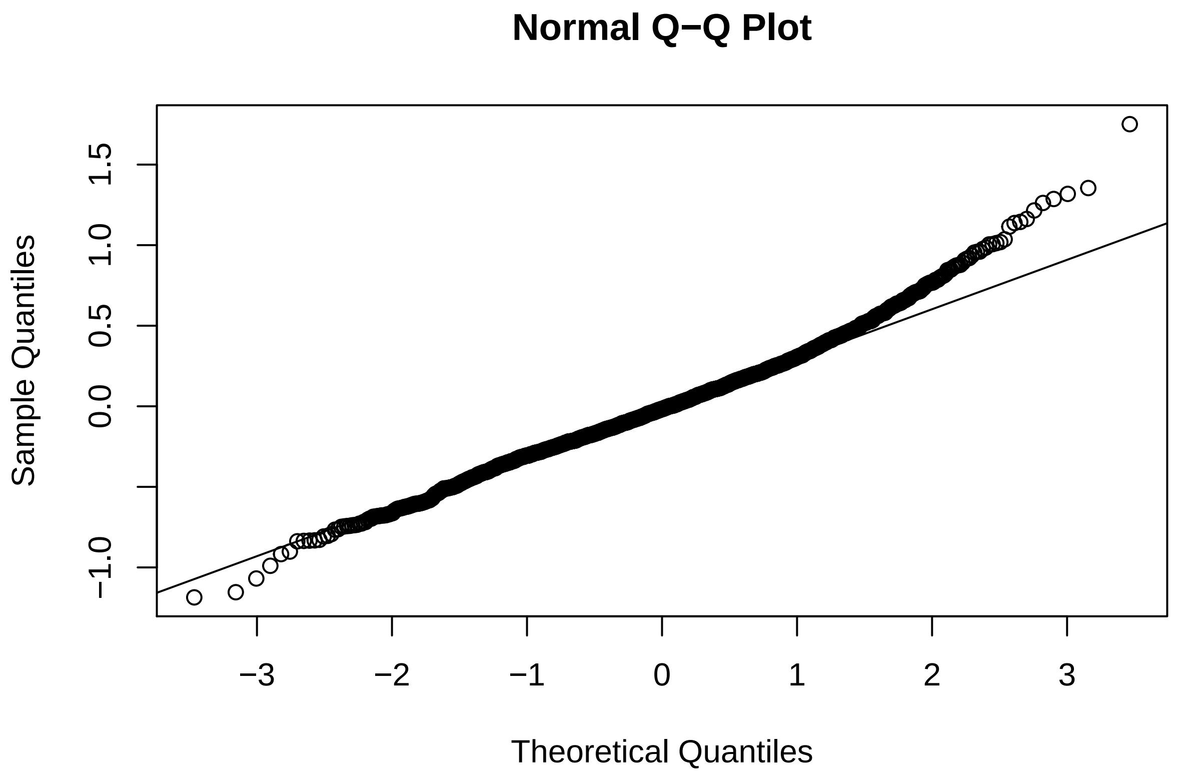
Check model predictions. The model predictions are in the right range and direction, fitting linear quite well:

```
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.

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



Plot the fixed effects

Relabel the effects:

```r
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","Inorrect","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","coXm
"modalityConditionvocal:conditionVisual:incorrectTRUE","Acoustic modality:Visual stimuli:incorrect","co

"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
```

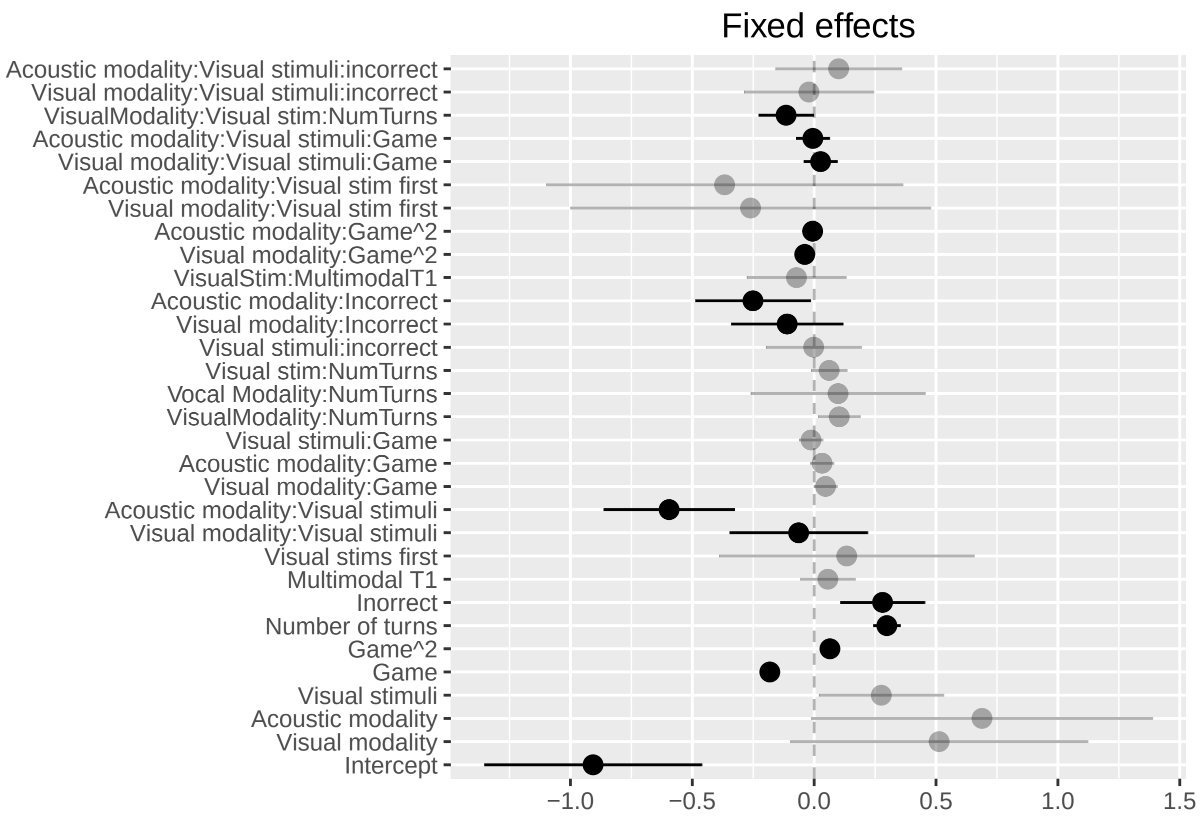
Plot the strength of the fixed effects:

```
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.
```

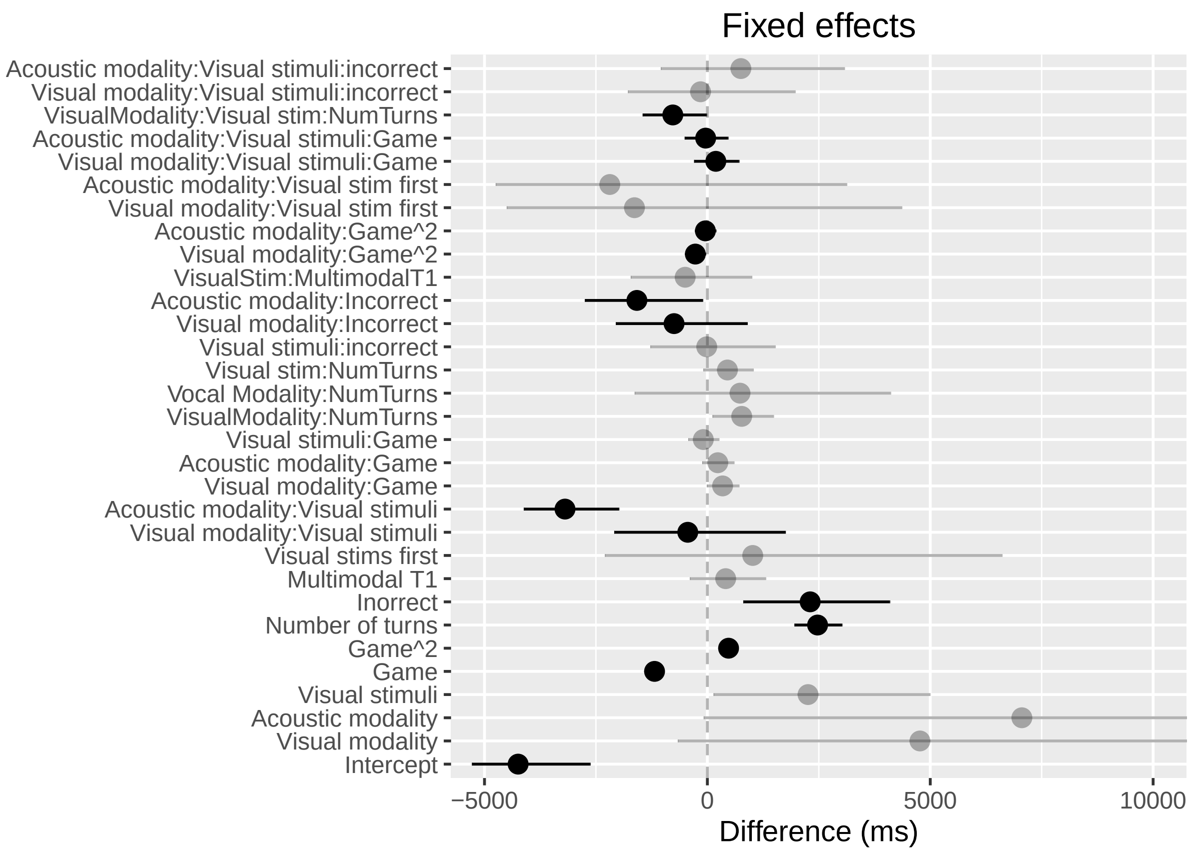
```
x$plot.list[[1]]$data$fade = sig.data$fade

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.
```

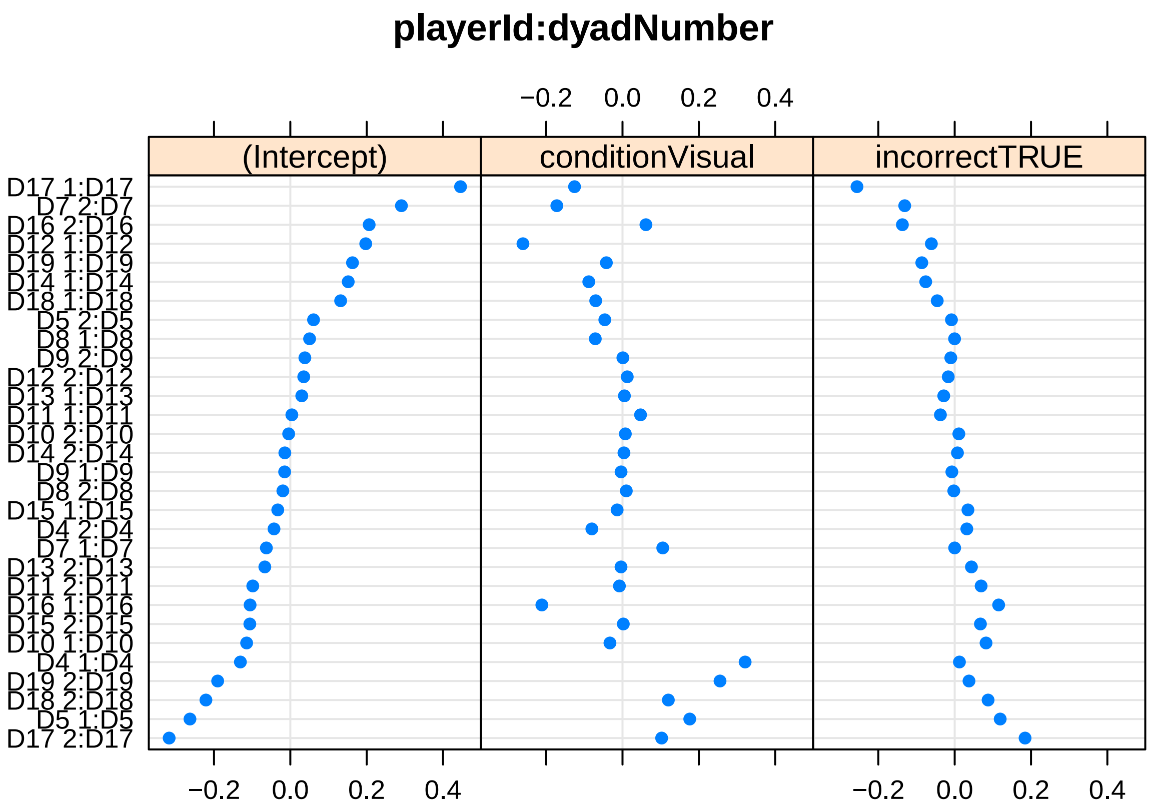


Random effects

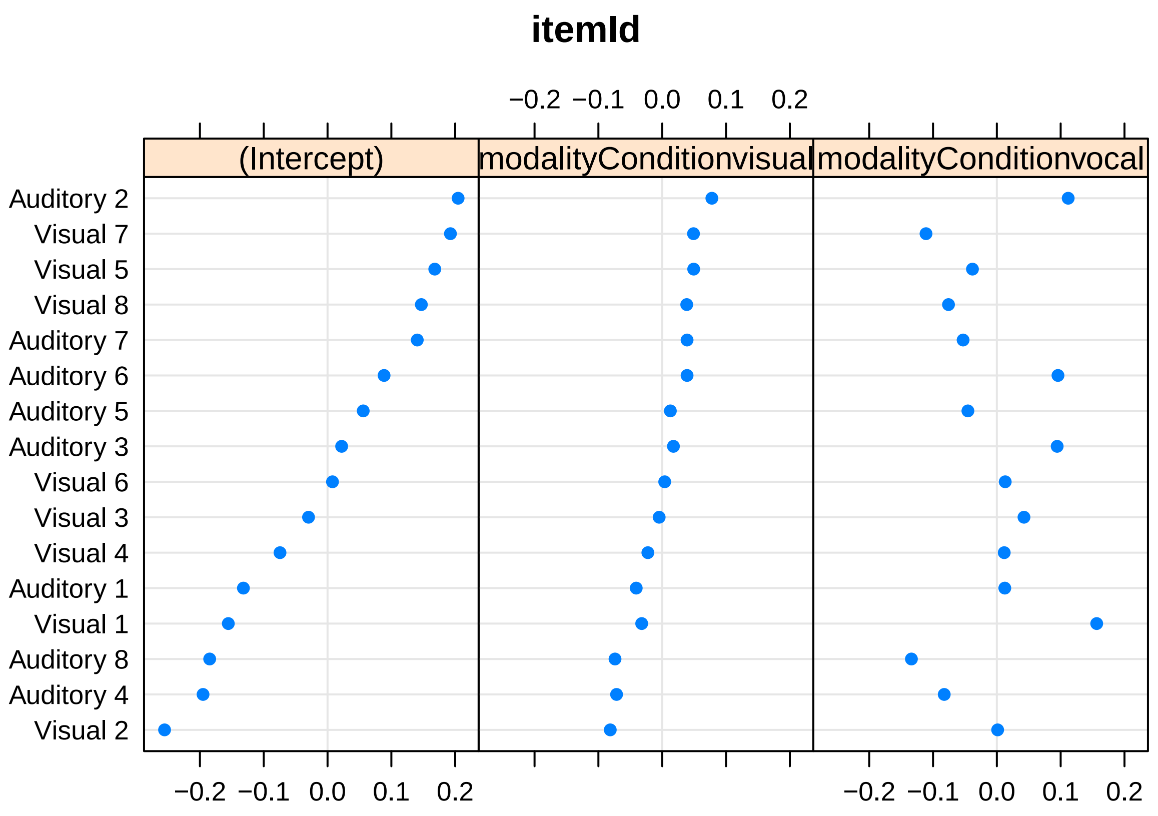
There is a reasonable amount of variaition in the random effects, suggesting that dyads and players differ. This justifies the use of mixed effects modelling.

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

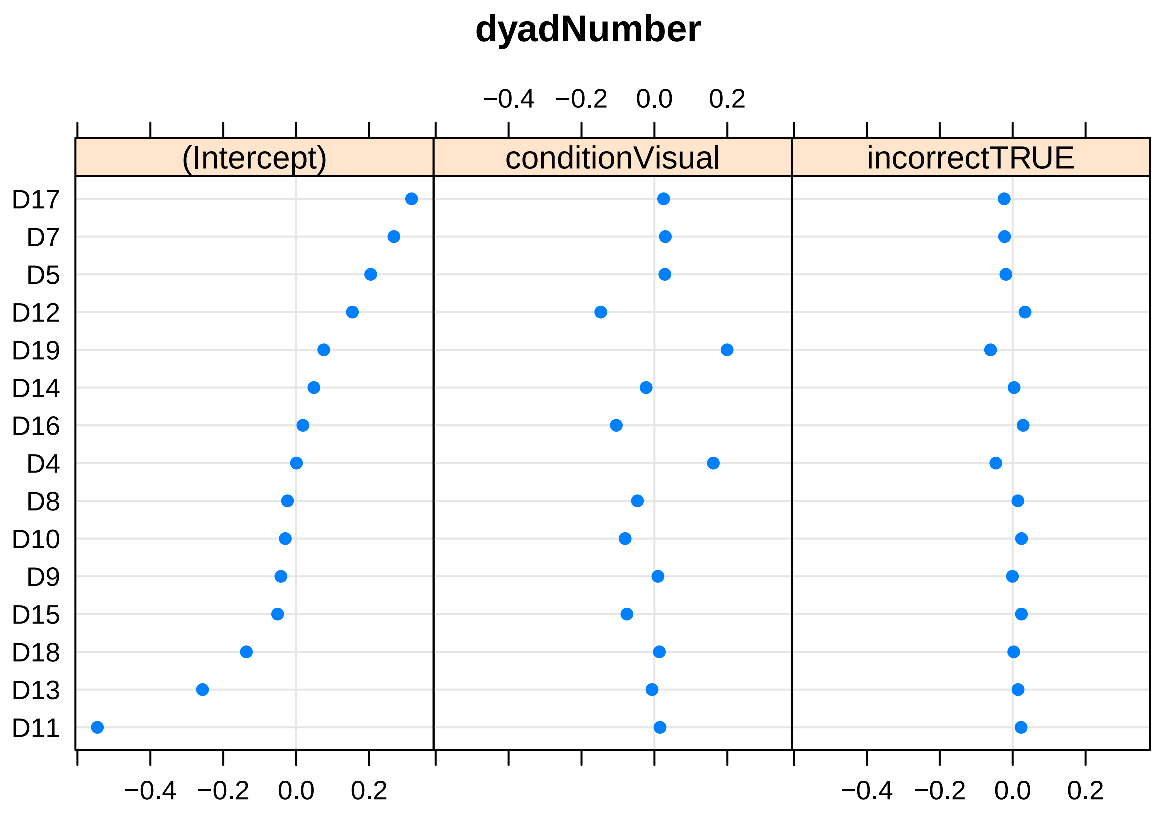
```
## $`playerId:dyadNumber`
```



```
##
## $itemId
```


itemId
(Intercept)
modalityConditionvisual
modalityConditionvocal
Auditory 2
Visual 7
Visual 5
Visual 8
Auditory 7
Auditory 6
Auditory 5
Auditory 3
Visual 6
Visual 3
Visual 4
Auditory 1
Visual 1
Auditory 8
Auditory 4
Visual 2
−0.2 −0.1 0.0 0.1 0.2

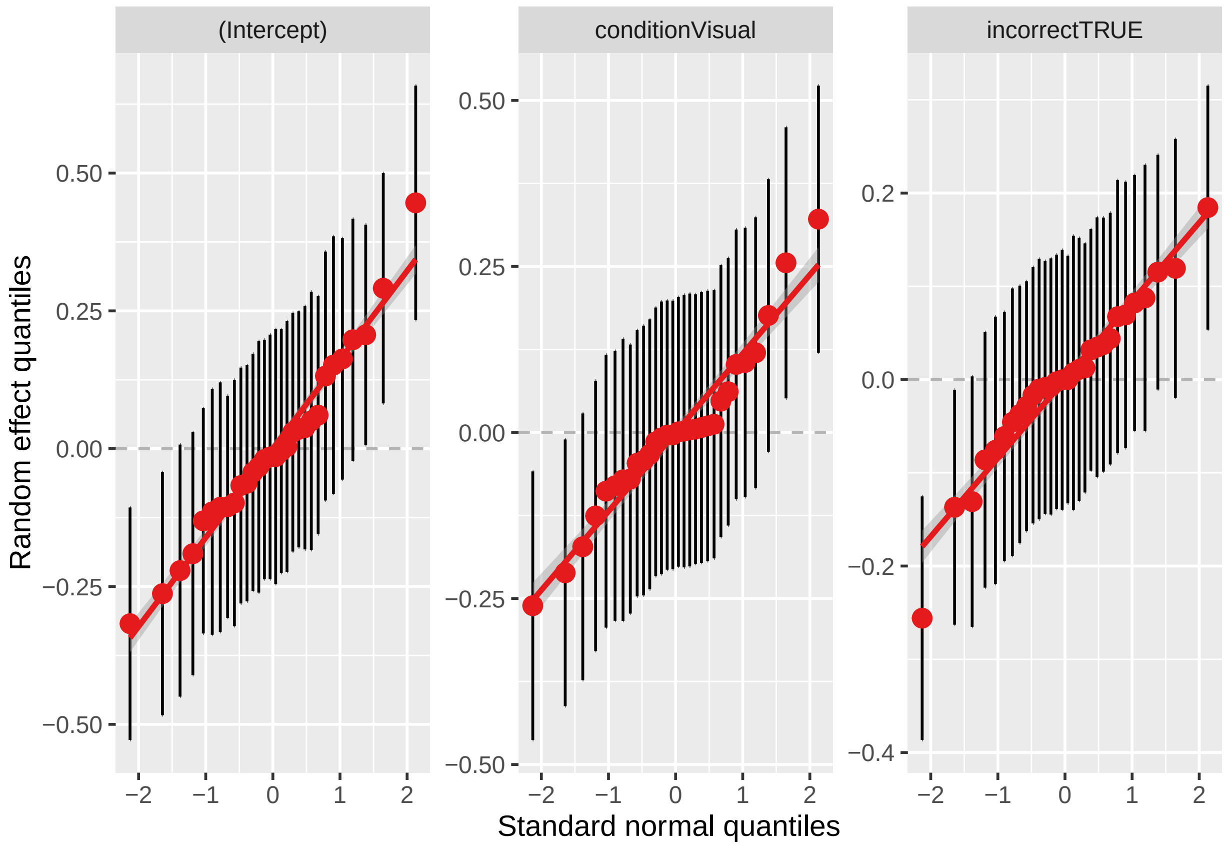
```
##
## $dyadNumber
```


dyadNumber
(Intercept)
conditionVisual
incorrectTRUE
D17
D7
D5
D12
D19
D14
D16
D4
D8
D10
D9
D15
D18
D13
D11
−0.4 −0.2 0.0 0.2

qq-plots of random effects

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

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


(Intercept)
conditionVisual
incorrectTRUE
Random effect quantiles
Standard normal quantiles