ModelReportBaseline3

Fiona Zhu

21/03/2020

Load the packages

customize theme

```
 theme_new <- theme_bw() +
  theme(panel.border = element_blank(),
        panel.grid.major = element_blank(),
        panel.grid.minor = element_blank(),
        axis.line = element_line(colour = "black"),
        strip.background = element_rect(color = "white", fill = "white"),
        panel.grid = element_blank())
```

load all experiment data

```
options(mc.cores = parallel::detectCores())
rstan_options (auto_write=TRUE)
# flag for saving figures
saveFigure = TRUE
# flag for generating CSV
generateSCV = TRUE
# flag for running rstan model and saving the results
runModels = FALSE
# path of model result
rstanmodelPath = 'RSTANMODELS'
modelResultPath = paste0(rstanmodelPath, '/Baseline3')
```

Define the Rstan models and functions to plot

Baseline: Model for short and long groups

```
stancodeBaseline <- 'data {
int<lower=0> n_s;  //number of the short group baseline data points
int<lower=0> n_l;  //number of the long group baseline data points
int<lower=0> n_mix;  //number of the mix group baseline data points
real<lower=0> Y_s[n_s];   //measured reproductive duration (short group)
real<lower=0> X_s[n_s];   //stimulus duration (short group)
real<lower=0> Y_l[n_l];   //measured reproductive duration (long group)
real<lower=0> X_l[n_l];   //stimulus duration (long group)
real<lower=0> X_mix[n_mix];   //stimulus duration (mix group)
real xmean[3];  // mean of the target duration in each group
}

parameters {
//hyperparameters
real<lower=0, upper = 1> p_wf_s;   //Weber Fraction of local prior
real<lower=0, upper = 1> wf_s;     //Weber Fraction of sensory noise
real<lower=0, upper = 1> p_wf_l;   //Weber Fraction of local prior
```

```
real<lower=0, upper = 1> wf_l;     //Weber Fraction of sensory noise
vector[n_s] mu_s;   // mean of internal prior of short group
vector[n_l] mu_l;   // mean of internal prior of long group
real<lower=0> sig_m_square;   //square of sigma of distribution of motor noise
}

model {
real  w_s[n_s];   //  weight of stimuli in short group
real  w_l[n_l];   //  weight of stimuli in short group

//hyperpriors
mu_s ~ normal(xmean[1], p_wf_s^2 * xmean[1]^2);  // mean prior of short group
mu_l ~ normal(xmean[2], p_wf_l^2 * xmean[2]^2);   // mean prior of long group

//short groups
for (i in 1:n_s)
{
    w_s[i] = (mu_s[i]^2 * p_wf_s^2)/(mu_s[i]^2 * p_wf_s^2+ X_s[i]^2*wf_s^2);    // weight of current sti
    Y_s[i] ~ normal(mu_s[i] *  w_s[i]+ (1- w_s[i])* X_s[i], sig_m_square + (mu_s[i]^2 * p_wf_s^2 * X_s[i
}

//long groups
for (i in 1:n_l)
{
    w_l[i] = (mu_l[i]^2 * p_wf_l^2)/(mu_l[i]^2 * p_wf_l^2+ X_l[i]^2*wf_l^2);  // weight of current stimu
    Y_l[i] ~ normal(mu_l[i] *  w_l[i]+ (1- w_l[i])* X_l[i],
    sig_m_square + (mu_l[i]^2 * p_wf_l^2 * X_l[i]^2*wf_l^2) / mu_l[i]^2 * p_wf_l^2 + X_l[i]^2*wf_l^2);

}
}


generated quantities {
  vector[n_s] ynew_s;
  vector[n_l] ynew_l;
  vector[n_mix] ynew_mix;
  vector[n_s] mu_s_new;   // mean of internal prior of short group
  vector[n_l] mu_l_new;   // mean of internal prior of long group
  vector[n_mix] mu_mix_new;   // mean of internal prior of mix group

real  w_new_s[n_s];   //  weight of stimuli in short group
real  w_new_l[n_l];   //  weight of stimuli in long group
real  w_new_mix[n_mix];   //  weight of stimuli in mix group


  for (i in 1:n_s)  //prediction of short group
  {
    mu_s_new[i] = normal_rng(xmean[1], p_wf_s^2 * xmean[1]^2);  // mean prior of short group
    w_new_s[i] = (mu_s_new[i]^2 * p_wf_s^2)/(mu_s_new[i]^2 * p_wf_s^2+ X_s[i]^2*wf_s^2);    // weight o
    ynew_s[i] = normal_rng(mu_s_new[i] *  w_new_s[i]+ (1- w_new_s[i])* X_s[i], sig_m_square + (mu_s_new
  }

  for (i in 1:n_l)   //prediction of long group
  {
     mu_l_new[i] = normal_rng(xmean[2], p_wf_l^2 * xmean[2]^2);   // mean prior of long group
     w_new_l[i] = (mu_l_new[i]^2 * p_wf_l^2)/(mu_l_new[i]^2 * p_wf_l^2+ X_l[i]^2*wf_l^2);  // weight of
    ynew_l[i] = normal_rng(mu_l_new[i] *  w_new_l[i]+ (1- w_new_l[i])* X_l[i],
    sig_m_square + (mu_l_new[i]^2 * p_wf_l^2 * X_l[i]^2*wf_l^2) / mu_l_new[i]^2 * p_wf_l^2 + X_l[i]^2*w
  }

  for (i in 1:n_mix)   //prediction of mix group
  {
    if(X_mix[i] >= 1) {

    mu_mix_new[i] = normal_rng(xmean[2], p_wf_l^2 * xmean[2]^2);   // mean prior of long group
    w_new_mix[i] = (mu_mix_new[i]^2 * p_wf_l^2)/(mu_mix_new[i]^2 * p_wf_l^2+ X_mix[i]^2*wf_l^2);  // we
    ynew_mix[i] = normal_rng(mu_mix_new[i] *  w_new_mix[i]+ (1- w_new_mix[i])* X_mix[i],
    sig_m_square + (mu_mix_new[i]^2 * p_wf_l^2 * X_mix[i]^2*wf_l^2) / mu_mix_new[i]^2 * p_wf_l^2 + X_mi

    }
   else{
    mu_mix_new[i] = normal_rng(xmean[1], p_wf_s^2 * xmean[1]^2);  // mean prior of short group
    w_new_mix[i] = (mu_mix_new[i]^2 * p_wf_s^2)/(mu_mix_new[i]^2 * p_wf_s^2+ X_mix[i]^2*wf_s^2);    //
    ynew_mix[i] = normal_rng(mu_mix_new[i] *  w_new_mix[i]+ (1- w_new_mix[i])* X_mix[i], sig_m_square +
    }

  }

}
'

# compile models
stanmodeBaseline <- stan_model(model_code = stancodeBaseline, model_name="Baseline")
```

Definisiton of the function to predicte the parameters of Bayesian by runing Rstan model

```
funFitBaseLineStan <- function(data, rstanModel, filename){
  Bayfit = {}
  Bayparlist = {}
  subList <- unique(data$NSub)
  fitparList = {}
  PredYlist_l = {}
  PredYlist_s = {}
  PredYlist_mix = {}
  expList <- unique(data$Exp)

  for (expName in expList) {
    subdata <- data %>% filter(valid > 0 & Exp == expName)
    subList <- unique(data$NSub)
    for (subNo in subList) {
      print(paste0('Start working on Subject No.',subNo, ' in ', expName))

      xmean <- data %>% filter(valid > 0 & Exp == expName & NSub == subNo )  %>% dplyr::group_by(group)

      subdata <- data %>% filter(valid > 0  & NSub == subNo & Exp == expName)
      data_s<- subdata %>% filter(group == 1)  # short groups only
```

```
data_l <- subdata %>% filter(group == 2)  # long groups only
data_mix <- subdata %>% filter(group == 3)  # mixed groups
PredY_s_list <- data_s[c('NSub','targetDur', 'RP','Exp','group')]
PredY_l_list <- data_l[c('NSub','targetDur', 'RP','Exp','group')]
PredY_mix_list <- data_mix[c('NSub','targetDur', 'RP','Exp','group')]
n_s <- length(data_s$RP)
n_l <- length(data_l$RP)
n_mix <- length(data_mix$RP)

stan_data = list(Y_s=data_s$RP, n_s=n_s, X_s = data_s$targetDur,
                 Y_l=data_l$RP, n_l=n_l, X_l = data_l$targetDur,
                 X_mix = data_mix$targetDur, n_mix = n_mix, "xmean" =xmean$targetMean)  #data pas

# fit models
subfit <- sampling(rstanModel, stan_data, chains = 4, iter = 2000)

#parameters <- c("a_s", "b_s", "a_l", "b_l", "p_wf_s","p_wf_l","ynew_s","ynew_l", "ynew_mix")
parameters <- c("p_wf_s","wf_s", "p_wf_l","wf_l","sig_m_square", "w_new_l", "w_new_s", "w_new_mix
fitpar <- summary(subfit, pars = parameters)$summary



list_of_draws <- rstan::extract(subfit, pars = parameters)
p_wf_s =  mean(list_of_draws$p_wf_s)
wf_s =  mean(list_of_draws$wf_s)
p_wf_l =  mean(list_of_draws$p_wf_l)
wf_l =  mean(list_of_draws$wf_l)
sig_m_square =  mean(list_of_draws$sig_m_square)

ynew_s_list <- list_of_draws$ynew_s
w_new_s_list <- list_of_draws$w_new_s
pred_y_s <- {}
w_new_s <- {}
for (n in 1:n_s){
  pred_y_s[n] <-  mean(ynew_s_list[,n] )
  w_new_s[n] <-  mean(w_new_s_list[,n] )
}
PredY_s_list$w = w_new_s
PredY_s_list$predY = pred_y_s
PredYlist_s <- rbind2(PredYlist_s, PredY_s_list)

pred_y_l <- {}
w_new_l <- {}
ynew_l_list <- list_of_draws$ynew_l
w_new_l_list <- list_of_draws$w_new_l
for (n in 1:n_l){
  pred_y_l[n] <-  mean(ynew_l_list[,n] )
   w_new_l[n] <-  mean(w_new_l_list[,n] )
}
PredY_l_list$predY = pred_y_l
PredY_l_list$w = w_new_l
PredYlist_l <- rbind2(PredYlist_l, PredY_l_list)
```

```r
      pred_y_mix <- {}
      w_new_mix <- {}
      ynew_mix_list <- list_of_draws$ynew_mix
      w_new_mix_list <- list_of_draws$w_new_mix
      for (n in 1:n_mix){
        pred_y_mix[n] <-  mean(ynew_mix_list[,n] )
        w_new_mix[n] <-  mean(w_new_mix_list[,n] )
      }
      PredY_mix_list$predY = pred_y_mix
      PredY_mix_list$w = w_new_mix
      PredYlist_mix <- rbind2(PredYlist_mix, PredY_mix_list)

      Baypar = data.frame(
        Nsub = subNo,
        Exp = expName,
        p_wf_s = p_wf_s,
        wf_s = wf_s,
        p_wf_l = p_wf_l,
        wf_l = wf_l,
        sig_m_square = sig_m_square
      )
      Bayparlist <- rbind2(Bayparlist, Baypar)
    }
  }
  write.csv(Bayparlist, file = paste0(modelResultPath, "/BaseLine_", filename,".csv"))
  write.csv(PredYlist_s, file = paste0(modelResultPath, "/PredY_s_", filename,".csv"))
  write.csv(PredYlist_l, file = paste0(modelResultPath, "/PredY_l_", filename,".csv"))
  write.csv(PredYlist_mix, file = paste0(modelResultPath, "/PredY_mix_", filename,".csv"))

  return(list("Bayparlist" = Bayparlist))
}
```

run Baseline RStan Models

display the model restults

load the model result data

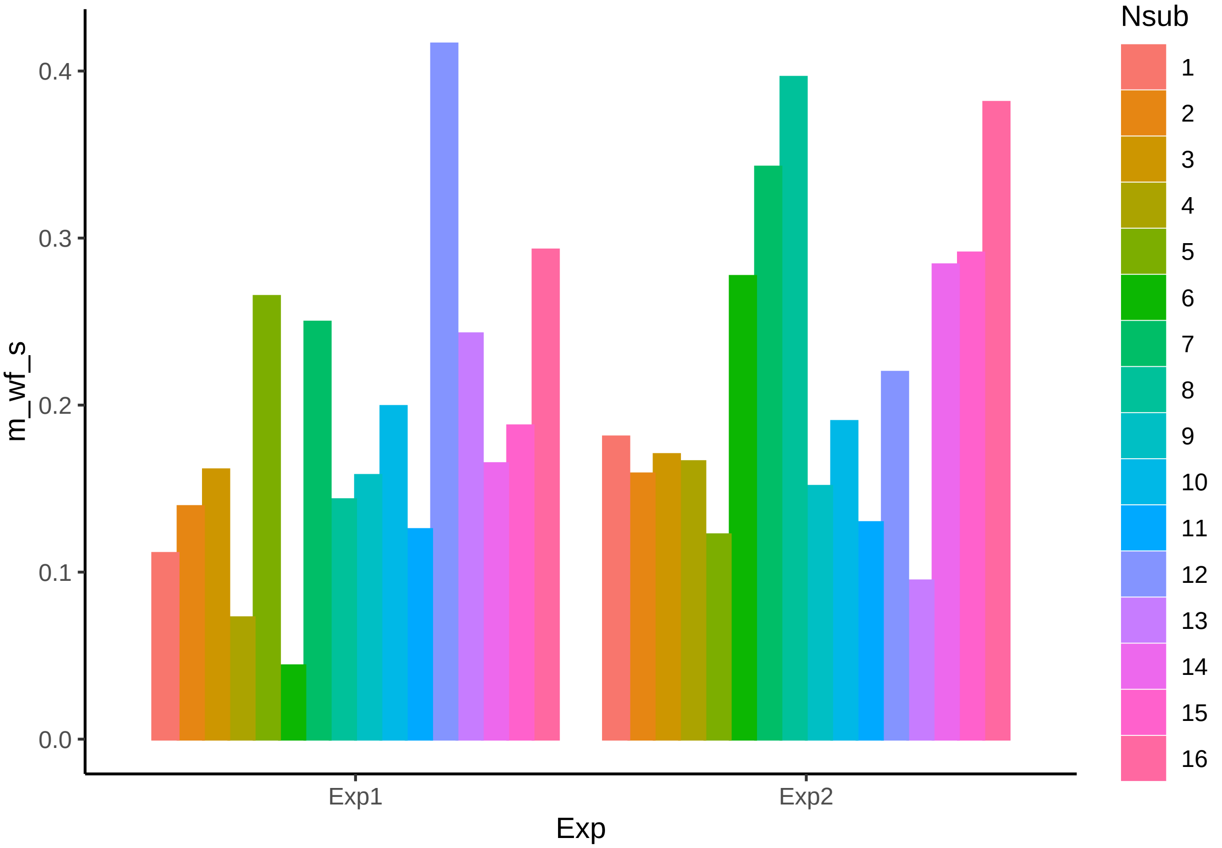
Analysis on the Rstan model parameters

```r
m_Baypar <- dplyr::group_by(AllDat_Bayparlist, Exp, Nsub) %>%
  dplyr::summarize( m_sig_m_square = mean(sig_m_square), m_wf_s = mean(wf_s),m_wf_l = mean(wf_l),
            m_p_wf_s = mean(p_wf_s), m_p_wf_l = mean(p_wf_l))
m_Baypar$Nsub <- as.factor(m_Baypar$Nsub)

m_Baypar
```

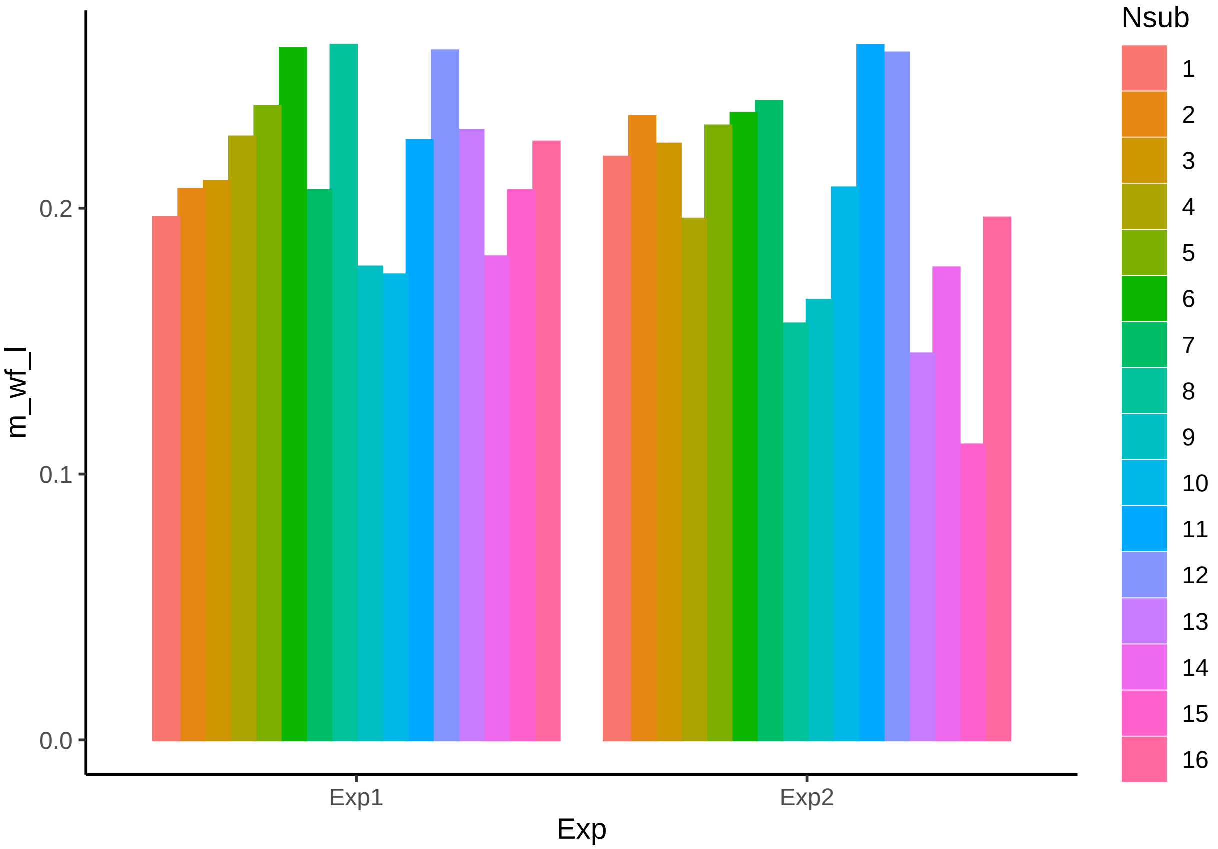
```
## # A tibble: 32 x 7
## # Groups:   Exp [2]
##    Exp   Nsub  m_sig_m_square m_wf_s m_wf_l m_p_wf_s m_p_wf_l
##    <chr> <fct>          <dbl>  <dbl>  <dbl>    <dbl>    <dbl>
##  1 Exp1  1             0.120  0.111   0.196    0.225   0.132
##  2 Exp1  2             0.0873 0.139   0.207    0.240   0.0828
##  3 Exp1  3             0.107  0.161   0.210    0.214   0.253
##  4 Exp1  4             0.0410 0.0727  0.227    0.556   0.294
##  5 Exp1  5             0.0323 0.265   0.238    0.650   0.426
##  6 Exp1  6             0.0739 0.0439  0.260    0.245   0.130
##  7 Exp1  7             0.0685 0.250   0.207    0.156   0.0724
##  8 Exp1  8             0.0861 0.143   0.261    0.268   0.117
##  9 Exp1  9             0.104  0.158   0.178    0.109   0.122
## 10 Exp1  10            0.128  0.199   0.175    0.198   0.0891
## # ... with 22 more rows
```

p_wf in models

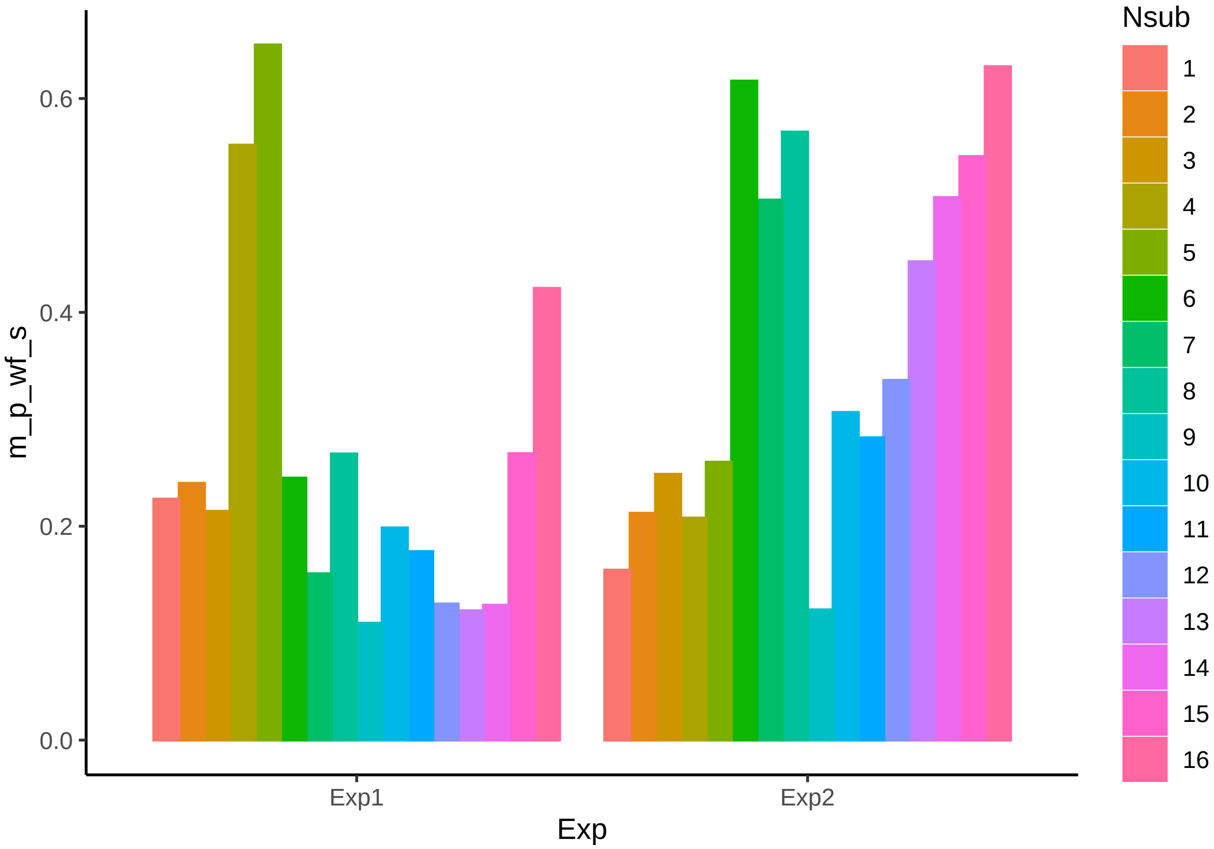
```
ggplot(m_Baypar, aes(x = Exp, y = m_wf_s, color = Nsub, fill = Nsub, group = Nsub)) +
    geom_bar(stat = "identity",
             position = position_dodge()) +
  theme_new
```



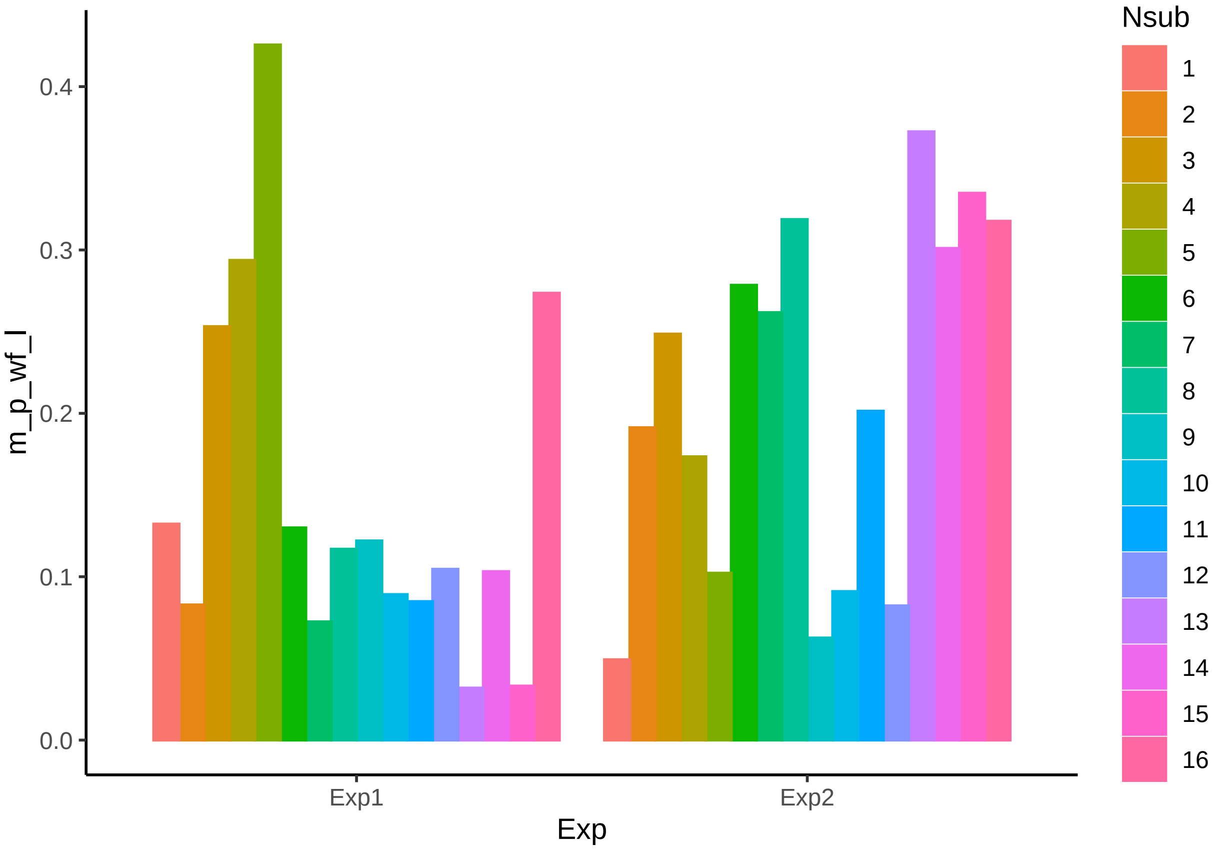
```
ggplot(m_Baypar, aes(x = Exp, y = m_wf_l, color = Nsub, fill = Nsub, group = Nsub)) +
    geom_bar(stat = "identity",
             position = position_dodge()) +
  theme_new
```



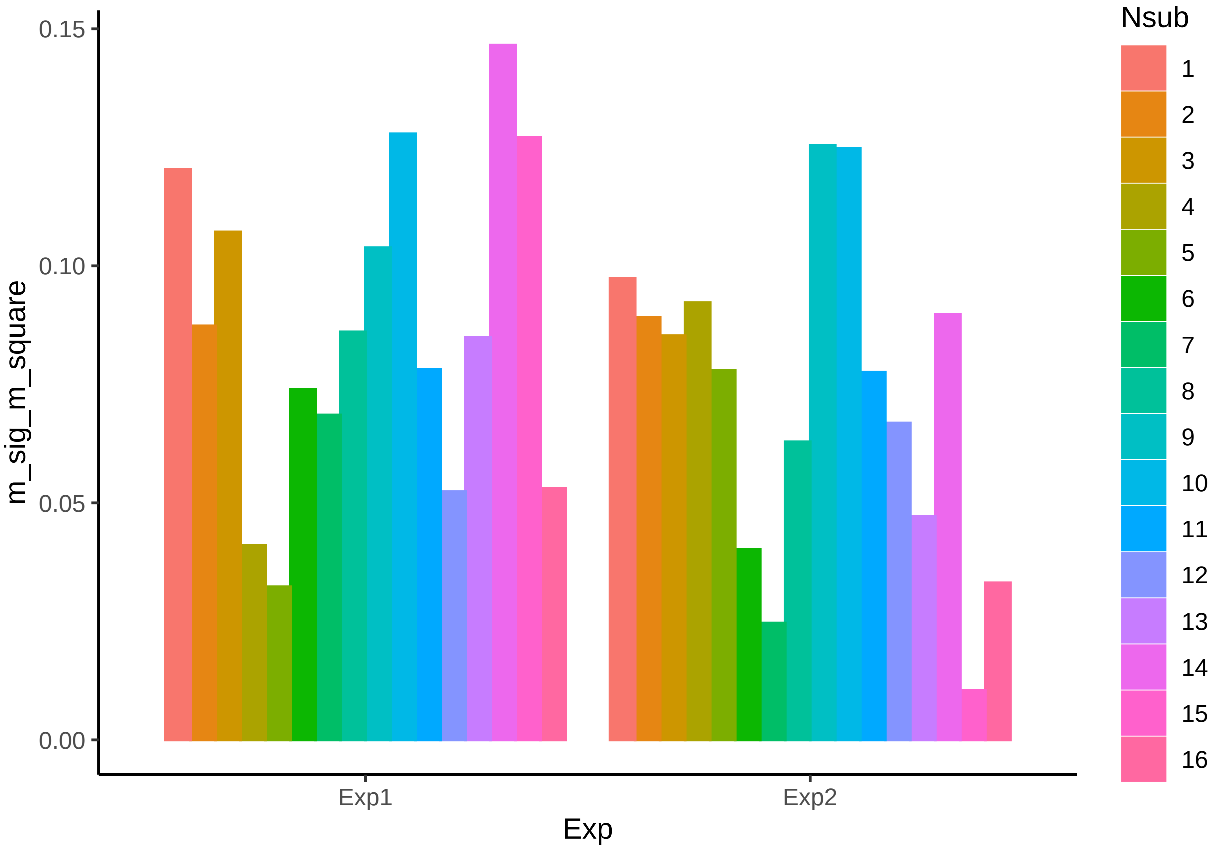
```
ggplot(m_Baypar, aes(x = Exp, y = m_p_wf_s, color = Nsub, fill = Nsub, group = Nsub)) +
    geom_bar(stat = "identity",
             position = position_dodge()) +
  theme_new
```



```
ggplot(m_Baypar, aes(x = Exp, y = m_p_wf_l, color = Nsub, fill = Nsub, group = Nsub)) +
    geom_bar(stat = "identity",
             position = position_dodge()) +
  theme_new
```



```
ggplot(m_Baypar, aes(x = Exp, y = m_sig_m_square, color = Nsub, fill = Nsub, group = Nsub)) +
    geom_bar(stat = "identity",
             position = position_dodge()) +
  theme_new
```



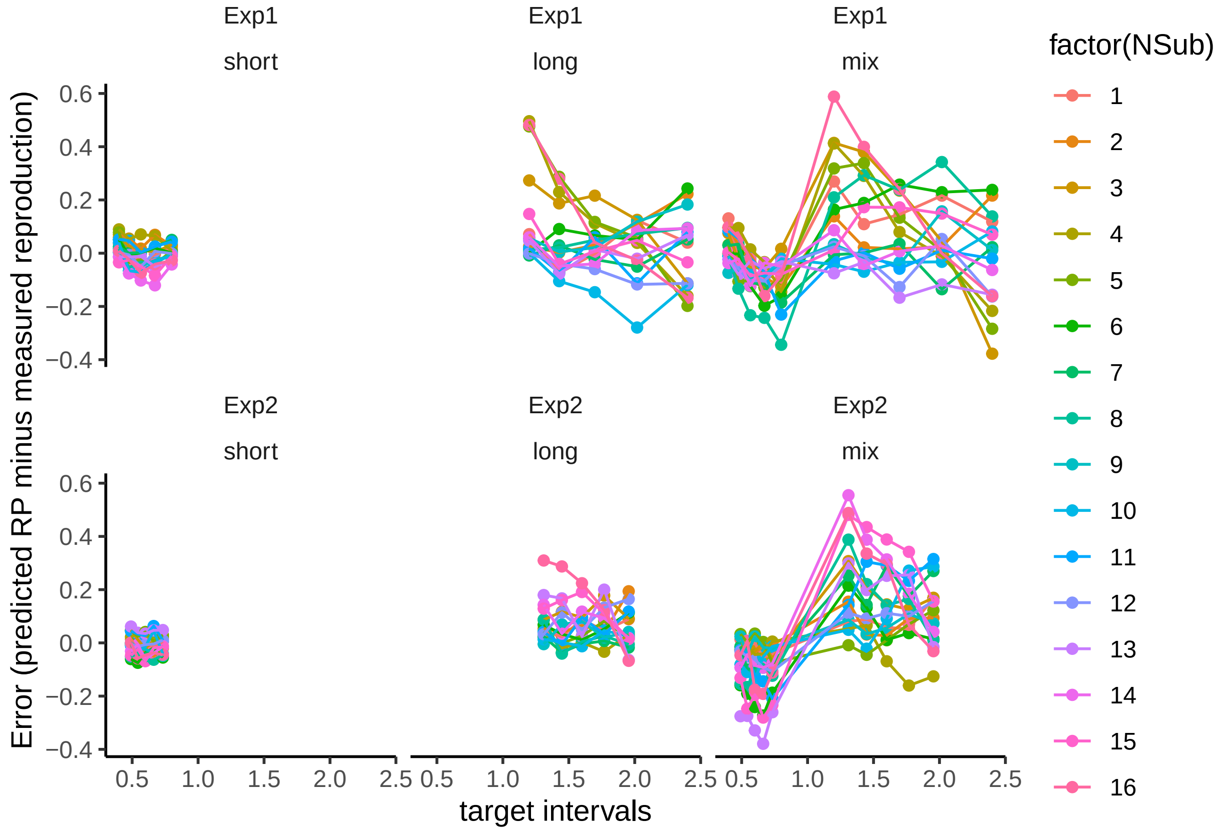
Prediction results (short blocks and long blocks)

```
predY <- dplyr::group_by(PredY_Baseline, targetDur, Exp, NSub, group) %>%
  dplyr::summarize(m_RP = mean(RP), n = n(), m_predY = mean(predY))
predY$m_rpErr = predY$m_predY - predY$m_RP
predY$m_relativeErr = predY$m_rpErr / predY$targetDur
predY
```

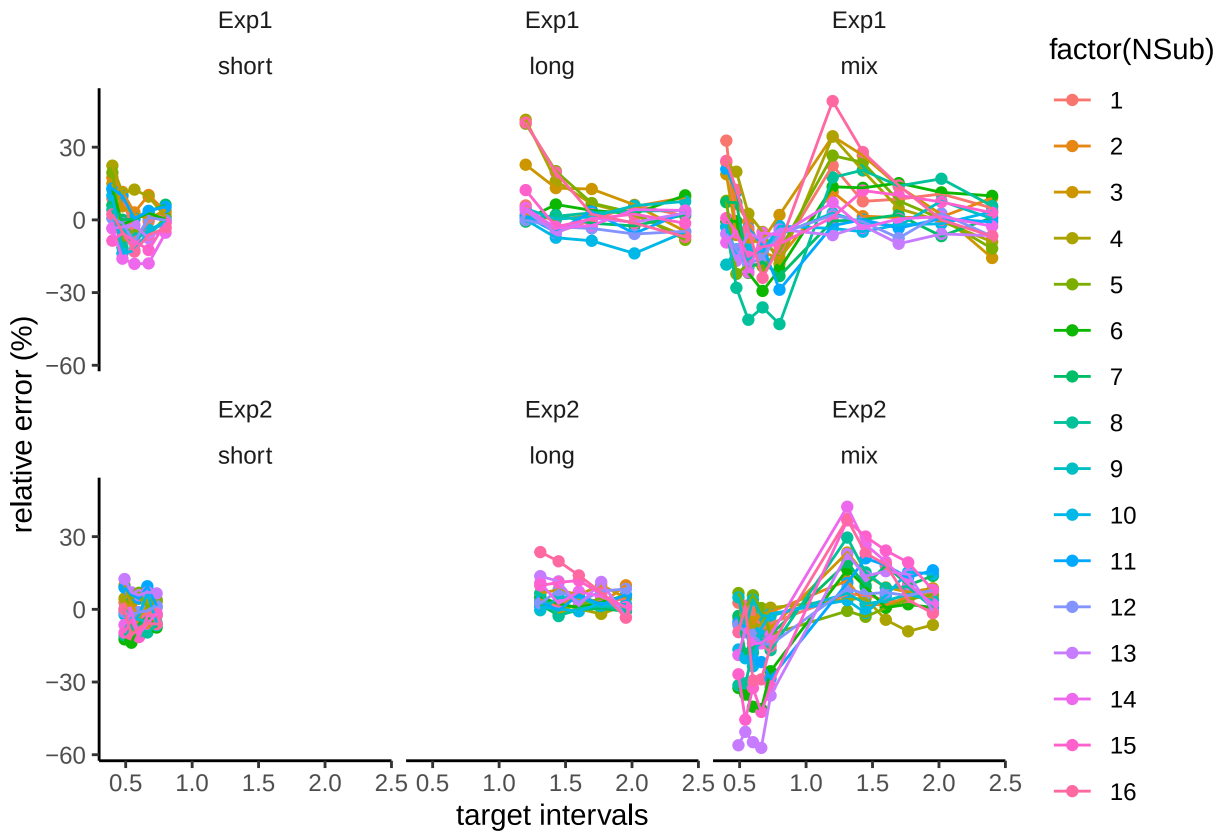
```
## # A tibble: 640 x 9
## # Groups:   targetDur, Exp, NSub [320]
##    targetDur Exp    NSub group  m_RP     n m_predY m_rpErr m_relativeErr
##        <dbl> <chr> <dbl> <fct> <dbl> <int>   <dbl>   <dbl>         <dbl>
##  1       0.4 Exp1      1 short 0.531    28   0.566  0.0353        0.0884
##  2       0.4 Exp1      1 mix   0.434    14   0.565  0.131         0.327
##  3       0.4 Exp1      2 short 0.486    28   0.556  0.0699        0.175
##  4       0.4 Exp1      2 mix   0.459    14   0.555  0.0964        0.241
##  5       0.4 Exp1      3 short 0.489    29   0.549  0.0598        0.150
##  6       0.4 Exp1      3 mix   0.474    14   0.550  0.0753        0.188
##  7       0.4 Exp1      4 short 0.496    28   0.585  0.0895        0.224
##  8       0.4 Exp1      4 mix   0.490    15   0.586  0.0955        0.239
##  9       0.4 Exp1      5 short 0.497    29   0.575  0.0779        0.195
## 10       0.4 Exp1      5 mix   0.544    14   0.575  0.0315        0.0787
## # ... with 630 more rows
```

The predication of short and long blocks

```
#plot Error in predication
  ggplot(data=predY, aes(x= targetDur, y=m_rpErr, group = factor(NSub), color= factor(NSub))) +
    geom_point()+geom_line()+
    labs(x="target intervals", y="Error (predicted RP minus measured reproduction)")+
  facet_wrap(Exp~group) +
  theme_new
```

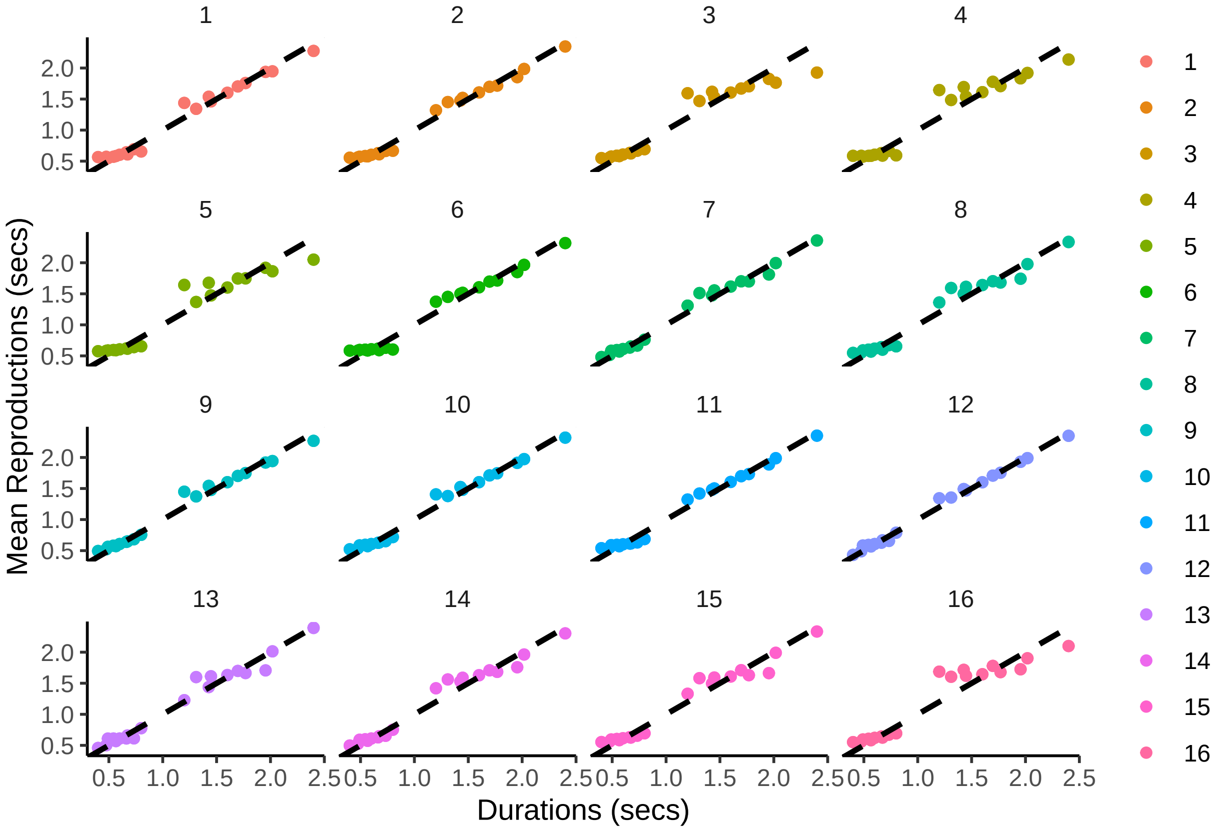


```
#plot relative Error for mixed blocks
 fig_rerr_model <-  ggplot(data=predY, aes(x= targetDur, y=m_relativeErr*100, group = factor(NSub), col
     geom_point()+ geom_line()+
    labs(x="target intervals", y="relative error (%)")+
  facet_wrap(Exp~group) +
  theme_new

fig_rerr_model
```



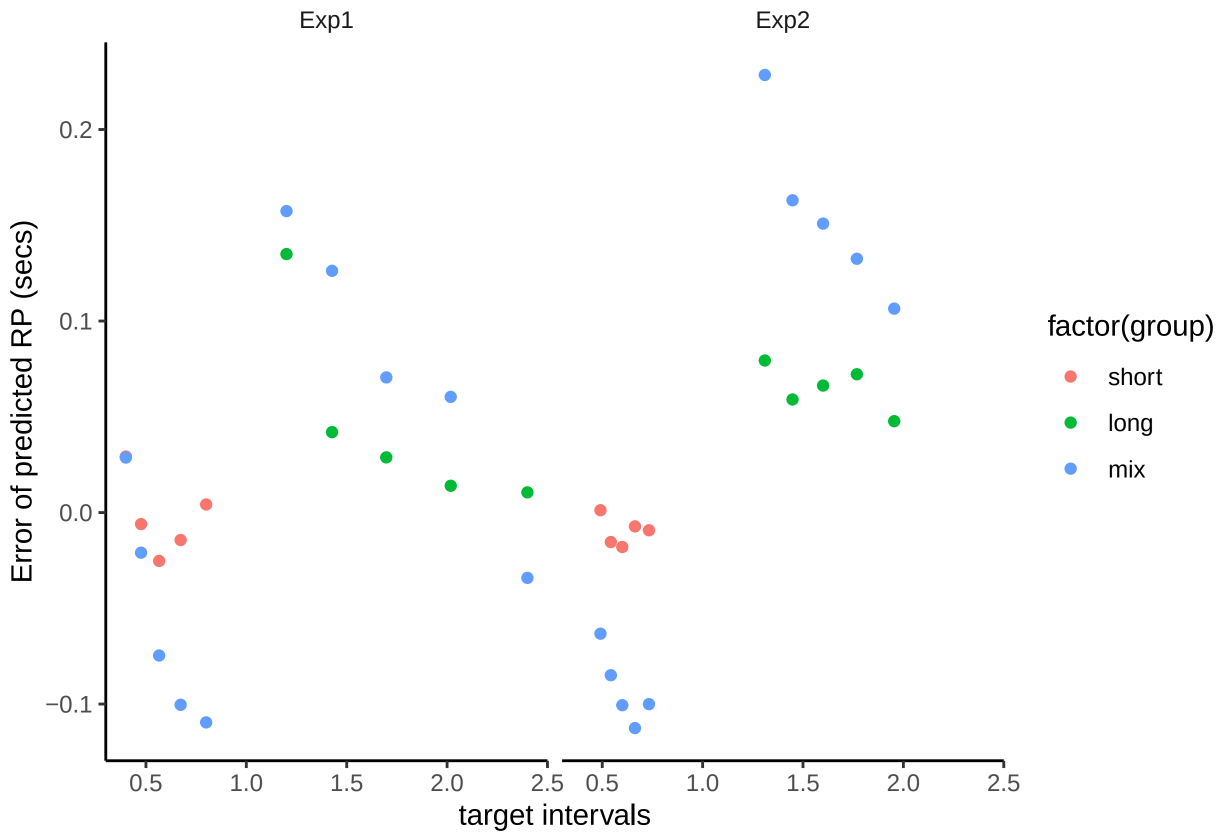
```
ggsave(file.path('figures','fig_rerr_model.png'), fig_rerr_model, width = 7, height = 5)
```

```
#plot the average of the predicted Y under the mixed condition
fig_mpredY = ggplot(predY) +
  geom_point(aes(targetDur, m_predY, group = factor(NSub), color = factor(NSub))) +
  #geom_line(aes(targetDur, m_RP, group = factor(NSub), color = factor(NSub)),  size = 1) +
  #geom_errorbar(aes(ymin = m_m_predY-se_m_predY, ymax = m_m_predY + se_m_predY), width = 0.05) +
  geom_abline(slope = 1, linetype = 2, size = 1) + # add diagonal line
  facet_wrap(~Exp) +
  guides(color = guide_legend(title = element_blank())) + # remove legend title
  theme_classic() +
  theme(strip.background = element_blank()) + # remove subtitle background
  labs(x = "Durations (secs)", y = "Mean Reproductions (secs)", size =15) + theme(legend.position="bott
  facet_wrap(NSub~.) +
  theme_new

fig_mpredY
```



```
ggsave(file.path('figures','fig_mpredY.png'), fig_mpredY, width = 7, height = 5)
```

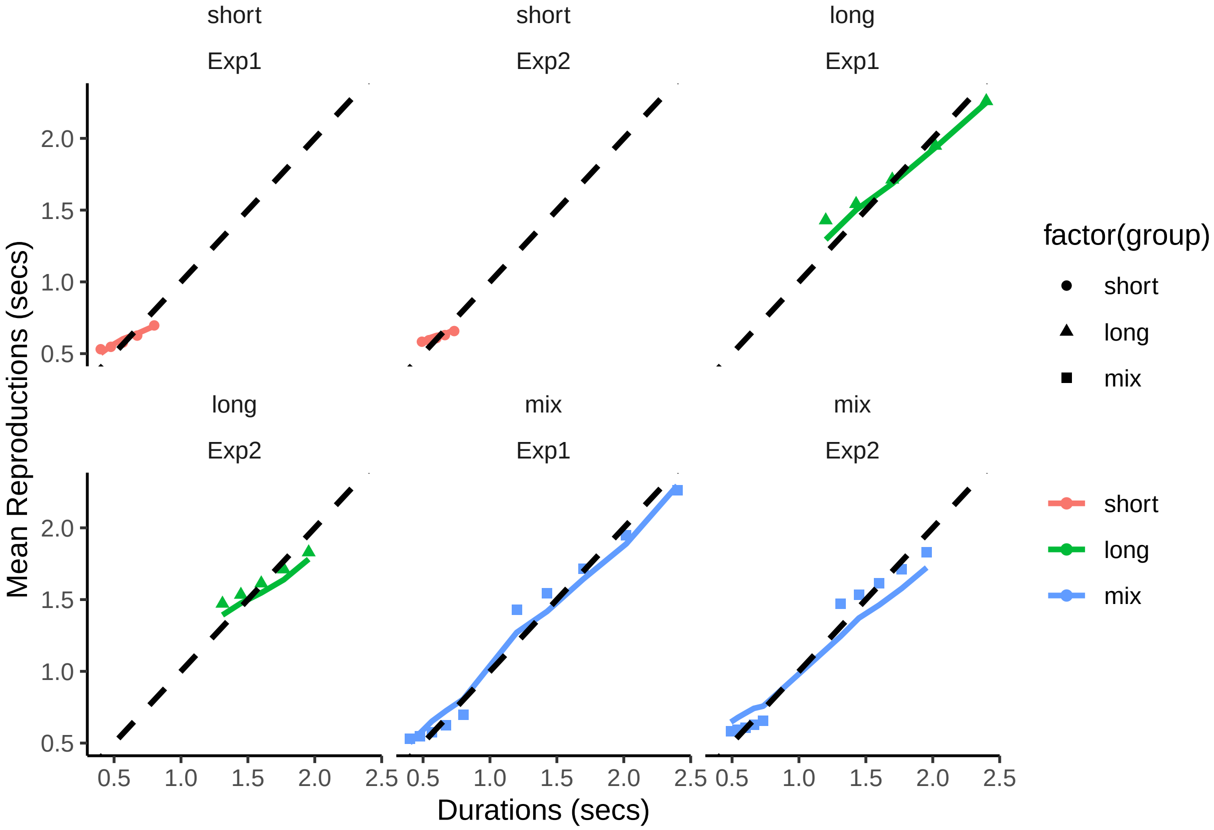
```
m_predY <- predY%>%
  dplyr::group_by(targetDur, Exp, group) %>%
  dplyr::summarize(
    n = n(),
    m_predY = mean(m_predY),
    m_RP = mean(m_RP)
  )
m_predY$m_rpErr =m_predY$m_predY-m_predY$m_RP

#plot Error in predication
  ggplot(data=m_predY, aes(x= targetDur, y=m_rpErr,
                           color = factor(group))) +
    geom_point()+  facet_wrap(~Exp) +
    labs(x="target intervals", y="Error of predicted RP (secs)") +
  theme_new
```



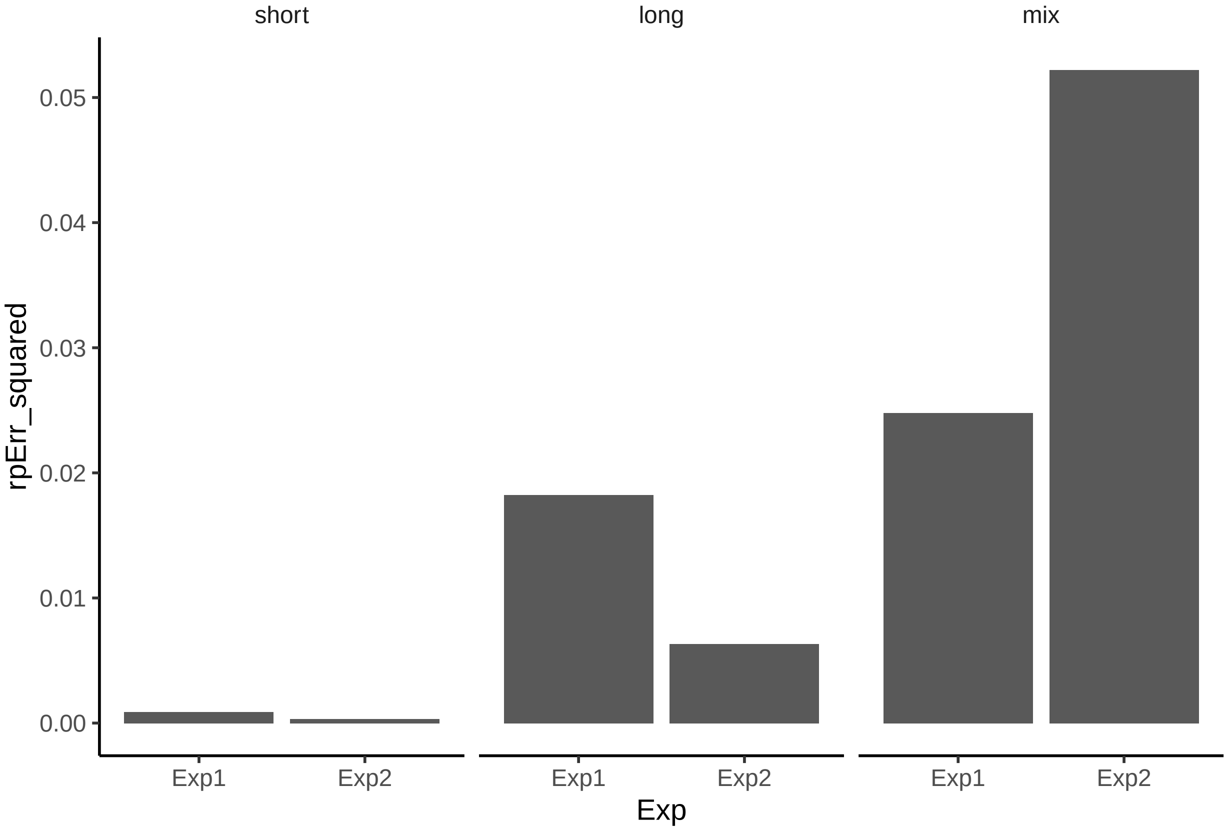
```
#plot the average of the predicted Y under the mixed condition
fig_m_predY = ggplot(m_predY) +
  geom_point(aes(targetDur, m_predY, group = factor(group), color = factor(group), shape = factor(group
  geom_line(aes(targetDur, m_RP, group = factor(group), shape = factor(group), color = factor(group)),
  #geom_errorbar(aes(ymin = m_m_predY-se_m_predY, ymax = m_m_predY + se_m_predY), width = 0.05) +
  geom_abline(slope = 1, linetype = 2, size = 1) + # add diagonal line
  facet_wrap(group~Exp) +
  guides(color = guide_legend(title = element_blank())) + # remove legend title
  theme_classic() +
  theme(strip.background = element_blank()) + # remove subtitle background
  labs(x = "Durations (secs)", y = "Mean Reproductions (secs)", size =15) + theme(legend.position="bott
  theme_new
```

```
## Warning: Ignoring unknown aesthetics: shape
```

```
fig_m_predY
```



```
m_predY$rpErr_squared <- m_predY$m_rpErr^2

fig_rpErr_model <- ggplot(m_predY, aes(x = Exp, y = rpErr_squared)) +
    geom_bar(stat = "identity",
             position = position_dodge()) +
    theme(legend.position="bottom")+
    facet_wrap(~group)  +
  theme_new

ggsave(file.path('figures','fig_rpErr_model.png'), fig_rpErr_model, width = 7, height = 5)

fig_rpErr_model
```


short
long
mix
rpErr_squared
0.05
0.04
0.03
0.02
0.01
0.00
Exp1
Exp2
Exp1
Exp2
Exp1
Exp2
Exp