Pilot data analysis

```
.libPaths('C:/Users/vbeliaev/Documents/r_packages')

knitr::opts_chunk$set(echo = TRUE)

rm(list = ls())

library(ggsignif)
library(ggplot2)
library(gridExtra)
library(lme4)
library(plyr)
library(dplyr)
library(boot)
library(data.table)

'%!in%' <- function(x,y)!('%in%'(x,y))
```

Preprocessing

```
tab1 = read.csv("Data_collected_together.csv")

# set bottom choice to 0 (instead of -1), when top picture is chosen = 1
tab1$Choice01 = tab1$Choice
tab1$Choice01[tab1$Choice01 == -1] = 0

# remove too slow answers
idx = which(tab1$RT_choice>0)
tab1 = tab1[idx,]

# create 8 tiles for size and taste trials
# this tiles will be used for plots
tab1$Size_diff.ntile = ntile(tab1$Size_diff,8)
tab1$Taste_diff.ntile = ntile(tab1$Taste_diff,8)

# take absolute value of differences in size and taste between top and bottom food items
tab1$Size_diff.abs = abs(tab1$Size_diff)
tab1$Taste_diff.abs = abs(tab1$Taste_diff)

# 1 subject is removed because they had 50% of correct trails - chance level
idx = which(tab1$Participant %!in% c(2))
tab1 = tab1[idx,]

tab1$Stim = 1
idx = which(tab1$Session_type==0)         #Stim variable: active/sham sessions
tab1$Stim[idx] = -1
```

```
tab1$Block = 1
idx = which(tab1$Trial_Nr>=113)            # Block variable: first 112 and last 64 trials
tab1$Block[idx] = -1

# leave only taste trials
idx = which(tab1$Cue_Taste1_Size2 == 1)
dataVal = tab1[idx,]

# leave only size trials
idx = which(tab1$Cue_Taste1_Size2 == 2)
dataPer = tab1[idx,]

## Get the correct response for taste table
dataVal$corr = 0
idx = which( (dataVal$Taste_diff>0 & dataVal$Choice01==1) | (dataVal$Taste_diff<0 & dataVal$Choice01==0)
dataVal$corr[idx] = 1
dataVal$Taste_diff.abs = scale(dataVal$Taste_diff.abs)

## Get the correct response for size table
dataPer$corr = 0
idx = which( (dataPer$Size_diff>0 & dataPer$Choice01==1) | (dataPer$Size_diff<0 & dataPer$Choice01==0))
dataPer$corr[idx] = 1
dataPer$Size_diff.abs = scale(dataPer$Size_diff.abs)

write.csv(rbind(dataVal, dataPer), 'Data_collected_together_preprocessed.csv')

ns = length(unique(tab1$Participant))
```

Data analysis

Here we test the effect of TI on amount of correct trials in the choice task.

Correct answers correspond to trials, in which participant has chosen a picture, which was earlier rated higher during the rating task. For example, participant during the rating task estimated taste of banana for 0.8 and Twix for 0.9. Then in the choice task, when twix and banana are presented in the same trial, if participant chooses Twix, answer is correct, if they choose banana the answer is considered incorrect.

TI stimulation was delivered durint the 1st part (112 trials) of the choice task (immidiate effects) and switched off during the second task (after effects, last 64 trials).

While the vmPFC that was stimulated with the TI is more involved in value-based decisions like taste, we expect to find effect of stimulation on taste trilas and not on size trials in the choice task.

For the model: dependent variable - vector, which contains correct (1) or incorrect (0) trials.
Regressors: (1) active stimulation = 1, sham stimulation = 0;
(2) difference in size or taste between two food items (the smaller the difference - the harder is the choice)

First, we will compare results across sessions, e.g., comparing results of 112 trials from active session and sham session. Then, we will compare results within session: 112 trilas with last 64 trials from active session.

Between session comparison (active vs sham)

Immidiate effects of TI on taste trials

There is no significant effect on correct taste trials during the 1st part of the choice task, when the TI is on.

```r
idx = which(dataVal$Trial_Nr<113)            #Table: first 112 trials, when TI is on
dataVal2 = dataVal[idx,]

m1.val.stim1.abs = glmer(corr ~ Stim*Taste_diff.abs + (1+Stim*Taste_diff.abs|Participant), data=dataVal

summary(m1.val.stim1.abs)
```

```
## Generalized linear mixed model fit by maximum likelihood (Laplace
##   Approximation) [glmerMod]
##  Family: binomial  ( logit )
## Formula:
## corr ~ Stim * Taste_diff.abs + (1 + Stim * Taste_diff.abs | Participant)
##    Data: dataVal2
##
##      AIC      BIC   logLik deviance df.resid
##   2769.0   2850.9  -1370.5   2741.0     2558
##
## Scaled residuals:
##     Min      1Q  Median      3Q     Max
## -4.9388 -0.9965  0.4125  0.6511  1.1876
##
## Random effects:
##  Groups      Name                Variance  Std.Dev. Corr
##  Participant (Intercept)         0.2515877 0.50159
##              Stim                0.0558012 0.23622   0.23
##              Taste_diff.abs      0.1069441 0.32702   0.99  0.09
##              Stim:Taste_diff.abs 0.0003588 0.01894  -0.94 -0.55 -0.88
## Number of obs: 2572, groups:  Participant, 23
##
## Fixed effects:
##                      Estimate Std. Error z value Pr(>|z|)
## (Intercept)          1.20354    0.11753  10.240  < 2e-16 ***
## Stim                -0.08395    0.07267  -1.155    0.248
## Taste_diff.abs       0.67057    0.08666   7.737 1.01e-14 ***
## Stim:Taste_diff.abs -0.07791    0.05348  -1.457    0.145
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Correlation of Fixed Effects:
##             (Intr) Stim   Tst_d.
## Stim         0.116
## Tast_dff.bs  0.802  0.018
## Stm:Tst_df. -0.093  0.254 -0.088
## convergence code: 0
## Model failed to converge with max|grad| = 0.0156558 (tol = 0.002, component 1)
```

After effects of TI on taste trials

After TI stimulation amount of correct choices in taste trials increases.

```r
idx = which(dataVal$Trial_Nr>=113)           #Table: last 64 trials, when TI is off
dataVal2 = dataVal[idx,]

m1.val.stim2.abs = glmer(corr ~ Stim*Taste_diff.abs + (1+Stim*Taste_diff.abs|Participant), data=dataVal
```

```r
summary(m1.val.stim2.abs)
```

```
## Generalized linear mixed model fit by maximum likelihood (Laplace
##   Approximation) [glmerMod]
##  Family: binomial  ( logit )
## Formula:
## corr ~ Stim * Taste_diff.abs + (1 + Stim * Taste_diff.abs | Participant)
##    Data: dataVal2
##
##      AIC      BIC   logLik deviance df.resid
##   1667.6   1741.7   -819.8   1639.6     1458
##
## Scaled residuals:
##     Min      1Q  Median      3Q     Max
## -3.9580 -1.0208  0.4639  0.6760  1.2235
##
## Random effects:
##  Groups      Name                Variance Std.Dev. Corr
##  Participant (Intercept)         0.178467 0.42245
##              Stim                0.002521 0.05021  0.50
##              Taste_diff.abs      0.098056 0.31314  0.91 0.18
##              Stim:Taste_diff.abs 0.050405 0.22451  0.68 0.97 0.41
## Number of obs: 1472, groups:  Participant, 23
##
## Fixed effects:
##                     Estimate Std. Error z value Pr(>|z|)
## (Intercept)          1.08944    0.11176   9.748  < 2e-16 ***
## Stim                 0.15321    0.06949   2.205   0.0275 *
## Taste_diff.abs       0.63216    0.09500   6.654 2.84e-11 ***
## Stim:Taste_diff.abs  0.06536    0.08332   0.784   0.4328
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Correlation of Fixed Effects:
##             (Intr) Stim  Tst_d.
## Stim        0.143
## Tast_dff.bs 0.656  0.106
## Stm:Tst_df. 0.362  0.380 0.228
## convergence code: 0
## Model failed to converge with max|grad| = 0.0249328 (tol = 0.002, component 1)
```

Immidiate effects of TI on size trials

No significant effect of TI on size trials.

```r
idx = which(dataPer$Trial_Nr<113)            #Table: first 112 trials, when TI is on
dataPer2 = dataPer[idx,]

m1.per.stim1.abs = glmer(corr ~ Stim*Size_diff.abs + (1+Stim*Size_diff.abs|Participant), data=dataPer2,

summary(m1.per.stim1.abs)
```

```
## Generalized linear mixed model fit by maximum likelihood (Laplace
##   Approximation) [glmerMod]
```

```
##  Family: binomial  ( logit )
## Formula: corr ~ Stim * Size_diff.abs + (1 + Stim * Size_diff.abs | Participant)
##    Data: dataPer2
##
##      AIC      BIC   logLik deviance df.resid
##   2779.8   2861.8  -1375.9   2751.8     2554
##
## Scaled residuals:
##     Min      1Q  Median      3Q     Max
## -4.6899 -0.9671  0.4191  0.6491  1.2212
##
## Random effects:
##  Groups      Name               Variance Std.Dev. Corr
##  Participant (Intercept)        0.211414 0.45980
##              Stim               0.015831 0.12582   0.00
##              Size_diff.abs      0.052754 0.22968   0.96  0.27
##              Stim:Size_diff.abs 0.004288 0.06548  -1.00  0.05 -0.95
## Number of obs: 2568, groups:  Participant, 23
##
## Fixed effects:
##                    Estimate Std. Error z value Pr(>|z|)
## (Intercept)         1.16694    0.10963  10.645   <2e-16 ***
## Stim               -0.09835    0.05914  -1.663   0.0963 .
## Size_diff.abs       0.72991    0.07170  10.180   <2e-16 ***
## Stim:Size_diff.abs -0.04727    0.05507  -0.858   0.3906
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Correlation of Fixed Effects:
##             (Intr) Stim   Sz_df.
## Stim        -0.036
## Size_dff.bs  0.705  0.030
## Stm:Sz_dff. -0.251  0.345 -0.206
## convergence code: 0
## Model failed to converge with max|grad| = 0.00764901 (tol = 0.002, component 1)
```

After effects of TI on size trials

No significant effect of TI on size trials.

```
idx = which(dataPer$Trial_Nr>=113)            #Table: last 64 trials, when TI is off
dataPer2 = dataPer[idx,]

m1.per.stim2.abs = glmer(corr ~ Stim*Size_diff.abs + (1+Stim*Size_diff.abs|Participant), data=dataPer2,

summary(m1.per.stim2.abs)
```

```
## Generalized linear mixed model fit by maximum likelihood (Laplace
##   Approximation) [glmerMod]
##  Family: binomial  ( logit )
## Formula: corr ~ Stim * Size_diff.abs + (1 + Stim * Size_diff.abs | Participant)
##    Data: dataPer2
##
##      AIC      BIC   logLik deviance df.resid
##   1603.1   1677.2   -787.6   1575.1     1454
```

```
##
## Scaled residuals:
##     Min      1Q  Median      3Q     Max
## -4.1324 -0.9568  0.4066  0.6420  1.1330
##
## Random effects:
##  Groups      Name               Variance Std.Dev. Corr
##  Participant (Intercept)        0.15036  0.3878
##              Stim               0.05587  0.2364   0.95
##              Size_diff.abs      0.05207  0.2282   0.92 0.80
##              Stim:Size_diff.abs 0.01508  0.1228   0.75 0.53 0.82
## Number of obs: 1468, groups:  Participant, 23
##
## Fixed effects:
##                     Estimate Std. Error z value Pr(>|z|)
## (Intercept)          1.15550    0.10709  10.790   <2e-16 ***
## Stim                 0.03059    0.08579   0.357    0.721
## Size_diff.abs        0.76952    0.08466   9.090   <2e-16 ***
## Stim:Size_diff.abs -0.01960    0.07452  -0.263    0.792
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Correlation of Fixed Effects:
##             (Intr) Stim  Sz_df.
## Stim        0.463
## Size_dff.bs 0.603  0.296
## Stm:Sz_dff. 0.231  0.407 0.197
## convergence code: 0
## boundary (singular) fit: see ?isSingular
```

```
save(m1.val.stim1.abs, file = 'TI_immidiate_taste.RData')
save(m1.val.stim2.abs, file = 'TI_after_taste.RData')
save(m1.per.stim1.abs, file = 'TI_immidiate_size.RData')
save(m1.per.stim2.abs, file = 'TI_after_size.RData')
```

Within session comparison (immidiate vs after effects)

Taste trials: immidiate and after effect in active stimulation condition

In the session when TI was applied there was no difference in accuracy during the first part of the choice task (immidiate effects) and the second part (after effects) for taste trials.

```
idx = which(dataVal$Session_type==1)          # Table: active sessions
dataVal2 = dataVal[idx,]

m2.val.stim1.abs = glmer(corr ~ Block*Taste_diff.abs + (1+Block*Taste_diff.abs|Participant), data=dataVa

summary(m2.val.stim1.abs)
```

```
## Generalized linear mixed model fit by maximum likelihood (Laplace
##   Approximation) [glmerMod]
##  Family: binomial  ( logit )
## Formula: corr ~ Block * Taste_diff.abs + (1 + Block * Taste_diff.abs |
##     Participant)
##    Data: dataVal2
##
```

```
##      AIC      BIC   logLik deviance df.resid
##   2219.5   2298.1  -1095.8   2191.5     2009
##
## Scaled residuals:
##     Min      1Q  Median      3Q     Max
## -5.1404 -1.0086  0.4328  0.6651  1.0750
##
## Random effects:
##  Groups      Name                 Variance Std.Dev. Corr
##  Participant (Intercept)          0.289995 0.5385
##              Block                0.009546 0.0977    0.75
##              Taste_diff.abs       0.118349 0.3440    0.93  0.57
##              Block:Taste_diff.abs 0.034139 0.1848   -0.31  0.38 -0.52
## Number of obs: 2023, groups:  Participant, 23
##
## Fixed effects:
##                      Estimate Std. Error z value Pr(>|z|)
## (Intercept)           1.18664    0.12915   9.188  < 2e-16 ***
## Block                -0.06374    0.06671  -0.955    0.339
## Taste_diff.abs        0.64847    0.09585   6.765 1.33e-11 ***
## Block:Taste_diff.abs -0.05164    0.07412  -0.697    0.486
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Correlation of Fixed Effects:
##             (Intr) Block  Tst_d.
## Block        0.044
## Tast_dff.bs  0.738  0.025
## Blck:Tst_d. -0.212  0.386 -0.387
## convergence code: 0
## Model failed to converge with max|grad| = 0.00348866 (tol = 0.002, component 1)
```

Taste trials: immidiate and after effect in sham condition

In sham session participants performed better during the first part of the choice task, but then accuracy dropped for the taste trails, in particular.
This pattern was not present in condition when TI was applied.

```
idx = which(dataVal$Session_type==0)          # Table: sham sessions
dataVal2 = dataVal[idx,]

m2.val.stim2.abs = glmer(corr ~ Block*Taste_diff.abs + (1+Block*Taste_diff.abs|Participant), data=dataVa

summary(m2.val.stim2.abs)
```

```
## Generalized linear mixed model fit by maximum likelihood (Laplace
##   Approximation) [glmerMod]
##  Family: binomial  ( logit )
## Formula: corr ~ Block * Taste_diff.abs + (1 + Block * Taste_diff.abs |
##     Participant)
##    Data: dataVal2
##
##      AIC      BIC   logLik deviance df.resid
##   2216.2   2294.8  -1094.1   2188.2     2007
##
```

```
## Scaled residuals:
##     Min      1Q  Median      3Q     Max
## -4.8359 -1.0082  0.4289  0.6754  1.2560
##
## Random effects:
##  Groups      Name                 Variance Std.Dev. Corr
##  Participant (Intercept)          0.155162 0.39391
##              Block                0.043687 0.20901   0.36
##              Taste_diff.abs       0.103180 0.32122   0.93  0.67
##              Block:Taste_diff.abs 0.000597 0.02443   0.69 -0.43  0.37
## Number of obs: 2021, groups:  Participant, 23
##
## Fixed effects:
##                       Estimate Std. Error z value Pr(>|z|)
## (Intercept)           1.11199    0.10147  10.959  < 2e-16 ***
## Block                 0.17649    0.07384   2.390   0.0168 *
## Taste_diff.abs        0.65682    0.08992   7.305 2.78e-13 ***
## Block:Taste_diff.abs  0.09207    0.06019   1.529   0.1261
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Correlation of Fixed Effects:
##             (Intr) Block  Tst_d.
## Block        0.108
## Tast_dff.bs  0.695  0.312
## Blck:Tst_d.  0.063  0.253 -0.082
## convergence code: 0
## boundary (singular) fit: see ?isSingular
```

Size trials: immidiate and after effect in active stimulation condition

No significant effect of stimulation on the size trials.

```
idx = which(dataPer$Session_type==1)          # Table: active sessions
dataPer2 = dataPer[idx,]

m2.per.stim1.abs = glmer(corr ~ Block*Size_diff.abs + (1+Block*Size_diff.abs|Participant), data=dataPer

summary(m2.per.stim1.abs)
```

```
## Generalized linear mixed model fit by maximum likelihood (Laplace
##   Approximation) [glmerMod]
##  Family: binomial  ( logit )
## Formula:
## corr ~ Block * Size_diff.abs + (1 + Block * Size_diff.abs | Participant)
##    Data: dataPer2
##
##      AIC      BIC   logLik deviance df.resid
##   2221.1   2299.6  -1096.6   2193.1     2004
##
## Scaled residuals:
##     Min      1Q  Median      3Q     Max
## -4.0695 -0.9779  0.4139  0.6643  1.2048
##
## Random effects:
```

```
##  Groups      Name                Variance Std.Dev. Corr
##  Participant (Intercept)         0.33833  0.5817
##              Block               0.01567  0.1252   -0.68
##              Size_diff.abs       0.09491  0.3081    0.91 -0.32
##              Block:Size_diff.abs 0.01100  0.1049   -0.87  0.23 -0.99
## Number of obs: 2018, groups:  Participant, 23
##
## Fixed effects:
##                     Estimate Std. Error z value Pr(>|z|)
## (Intercept)          1.14842    0.13746   8.354  < 2e-16 ***
## Block               -0.06822    0.06867  -0.993    0.321
## Size_diff.abs        0.73725    0.09050   8.146 3.76e-16 ***
## Block:Size_diff.abs -0.04329    0.06652  -0.651    0.515
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Correlation of Fixed Effects:
##             (Intr) Block  Sz_df.
## Block       -0.387
## Size_dff.bs  0.711 -0.205
## Blck:Sz_df. -0.331  0.378 -0.451
## convergence code: 0
## Model failed to converge with max|grad| = 0.0204894 (tol = 0.002, component 1)
```

Size trials: immidiate and after effect in sham condition

No significant effect of stimulation on the size trials.

```
idx = which(dataPer$Session_type==0)          # Table: sham sessions
dataPer2 = dataPer[idx,]

m2.per.stim2.abs = glmer(corr ~ Block*Size_diff.abs + (1+Block*Size_diff.abs|Participant), data=dataPer

summary(m2.per.stim2.abs)
```

```
## Generalized linear mixed model fit by maximum likelihood (Laplace
##   Approximation) [glmerMod]
##  Family: binomial  ( logit )
## Formula:
## corr ~ Block * Size_diff.abs + (1 + Block * Size_diff.abs | Participant)
##    Data: dataPer2
##
##      AIC      BIC   logLik deviance df.resid
##   2148.6   2227.2  -1060.3   2120.6     2004
##
## Scaled residuals:
##     Min      1Q  Median      3Q     Max
## -4.5082 -0.9491  0.4017  0.6325  1.2548
##
## Random effects:
##  Groups      Name                Variance Std.Dev. Corr
##  Participant (Intercept)         0.086558 0.29421
##              Block               0.031933 0.17870   1.00
##              Size_diff.abs       0.066072 0.25705   1.00  1.00
##              Block:Size_diff.abs 0.001059 0.03254  -0.19 -0.20 -0.15
```

```
## Number of obs: 2018, groups:  Participant, 23
##
## Fixed effects:
##                      Estimate Std. Error z value Pr(>|z|)
## (Intercept)           1.19631    0.08698  13.754   <2e-16 ***
## Block                 0.06322    0.07186   0.880    0.379
## Size_diff.abs         0.78505    0.08227   9.542   <2e-16 ***
## Block:Size_diff.abs -0.01380    0.06252  -0.221    0.825
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Correlation of Fixed Effects:
##             (Intr) Block  Sz_df.
## Block        0.249
## Size_dff.bs  0.671  0.308
## Blck:Sz_df. -0.046  0.320 -0.172
## convergence code: 0
## unable to evaluate scaled gradient
## Model failed to converge: degenerate  Hessian with 1 negative eigenvalues
```

Plot main result

```
# firs plot for taste trials

idx = which(dataVal$Trial_Nr<113)
dataVal_imm = as.data.table(dataVal[idx,])

idx = which(dataVal$Trial_Nr>=113)
dataVal_after = as.data.table(dataVal[idx,])

data1 = ddply(dataVal_imm, .(Participant, Session_type), summarise, acc = mean(corr))
data2 = ddply(data1, .(Session_type), summarise, acc2 = mean(acc), se=sd(acc)/sqrt(ns))
data2$cued = "Immidiate"
colnames(data2)[1] = "Stim"

data1 = ddply(dataVal_after, .(Participant, Session_type), summarise, acc = mean(corr))
data3 = ddply(data1, .(Session_type), summarise, acc2 = mean(acc), se=sd(acc)/sqrt(ns))
data3$cued = "After effects"
colnames(data3)[1] = "Stim"

dataVal_plot = rbind(data3,data2)
dataVal_plot$Stim = factor(dataVal_plot$Stim, levels = c(1,0), labels = c('Active','Sham'))
dataVal_plot$cued = as.factor(dataVal_plot$cued)
dataVal_plot$cued = ordered(dataVal_plot$cued, levels = c('Immidiate', 'After effects'))

limits = aes(ymax = acc2+se, ymin=acc2-se, colour=cued, group=cued)

plot_val = ggplot(dataVal_plot, aes(x=cued, y=acc2, fill = Stim)) +
   geom_bar(stat="identity", position=position_dodge(), alpha = 0.5) +
  geom_errorbar(aes(ymin=acc2-se, ymax=acc2+se), width=.1,
                position=position_dodge(.9)) +
  geom_point(position=position_dodge(.9), show_guide = FALSE) +
    theme_bw() +
```

```
    ylab('Accuracy') +
  xlab(' ') +
  scale_fill_manual(values=c('black', 'lightgray')) +
  #ylim(c(0, 1)) +
  ggtitle('Value-based trials') +
  theme(legend.title = element_blank()) +
  #scale_y_continuous(limits = c(0.5,1), ) +
  coord_cartesian(ylim= c(0.5,1)) +
  #geom_signif(comparisons = list(c("Immidiate effects", "After effects")), annotation = c('*'))
  geom_signif(y_position = c(0.82, 0.82, 0.9), xmin = c(0.8, 1.8, 1.2), xmax = c(1.2, 2.2, 2.3),
    annotation = c("NS", "*", '*'), tip_length = 0.2) +
  theme(legend.position = c(0.2, 0.87)) +
    theme(text = element_text(size=14), axis.text.x = element_text(size=14),
        axis.text.y = element_text(size=14))
```

```
# then plot for size trials

idx = which(dataPer$Trial_Nr<113)
dataPer_imm = as.data.table(dataPer[idx,])

idx = which(dataPer$Trial_Nr>=113)
dataPer_after = as.data.table(dataPer[idx,])

data1 = ddply(dataPer_imm, .(Participant, Session_type), summarise, acc = mean(corr))
data2 = ddply(data1, .(Session_type), summarise, acc2 = mean(acc), se=sd(acc)/sqrt(ns))
data2$cued = "Immidiate"
colnames(data2)[1] = "Stim"

data1 = ddply(dataPer_after, .(Participant, Session_type), summarise, acc = mean(corr))
data3 = ddply(data1, .(Session_type), summarise, acc2 = mean(acc), se=sd(acc)/sqrt(ns))
data3$cued = "After effects"
colnames(data3)[1] = "Stim"

dataPer_plot = rbind(data3,data2)
dataPer_plot$Stim = factor(dataPer_plot$Stim, levels = c(1,0), labels = c('Active','Sham'))
dataPer_plot$cued = as.factor(dataPer_plot$cued)
dataPer_plot$cued = ordered(dataPer_plot$cued, levels = c('Immidiate', 'After effects'))

limits = aes(ymax = acc2+se, ymin=acc2-se, colour=cued, group=cued)

plot_per = ggplot(dataPer_plot, aes(x=cued, y=acc2, fill = Stim)) +
   geom_bar(stat="identity", position=position_dodge(), alpha = 0.5) +
  geom_errorbar(aes(ymin=acc2-se, ymax=acc2+se), width=.1,
                position=position_dodge(.9)) +
  geom_point(position=position_dodge(.9), show_guide = FALSE) +
    theme_bw() +
    ylab('') +
  xlab(' ') +
  scale_fill_manual(values=c('black', 'lightgray')) +
  #ylim(c(0, 1)) +
  ggtitle('Perceptual trials') +
  theme(legend.title = element_blank()) +
  #scale_y_continuous(limits = c(0.5,1), ) +
  coord_cartesian(ylim= c(0.5,1)) +
```

```
  #geom_signif(comparisons = list(c("Immidiate effects", "After effects")), annotation = c('*'))
  geom_signif(y_position = c(0.82, 0.82, 0.9), xmin = c(0.8, 1.8, 1.2), xmax = c(1.2, 2.2, 2.3),
    annotation = c("NS", "NS", 'NS'), tip_length = 0.2) +
  theme(legend.position = 'none') +
    theme(text = element_text(size=14), axis.text.x = element_text(size=14),
        axis.text.y = element_text(size=14))
```

```
grid.arrange(plot_val, plot_per, ncol=2, widths=c(1,1))
```