Marta Pecina's initial neurofeedback/placebo experiment

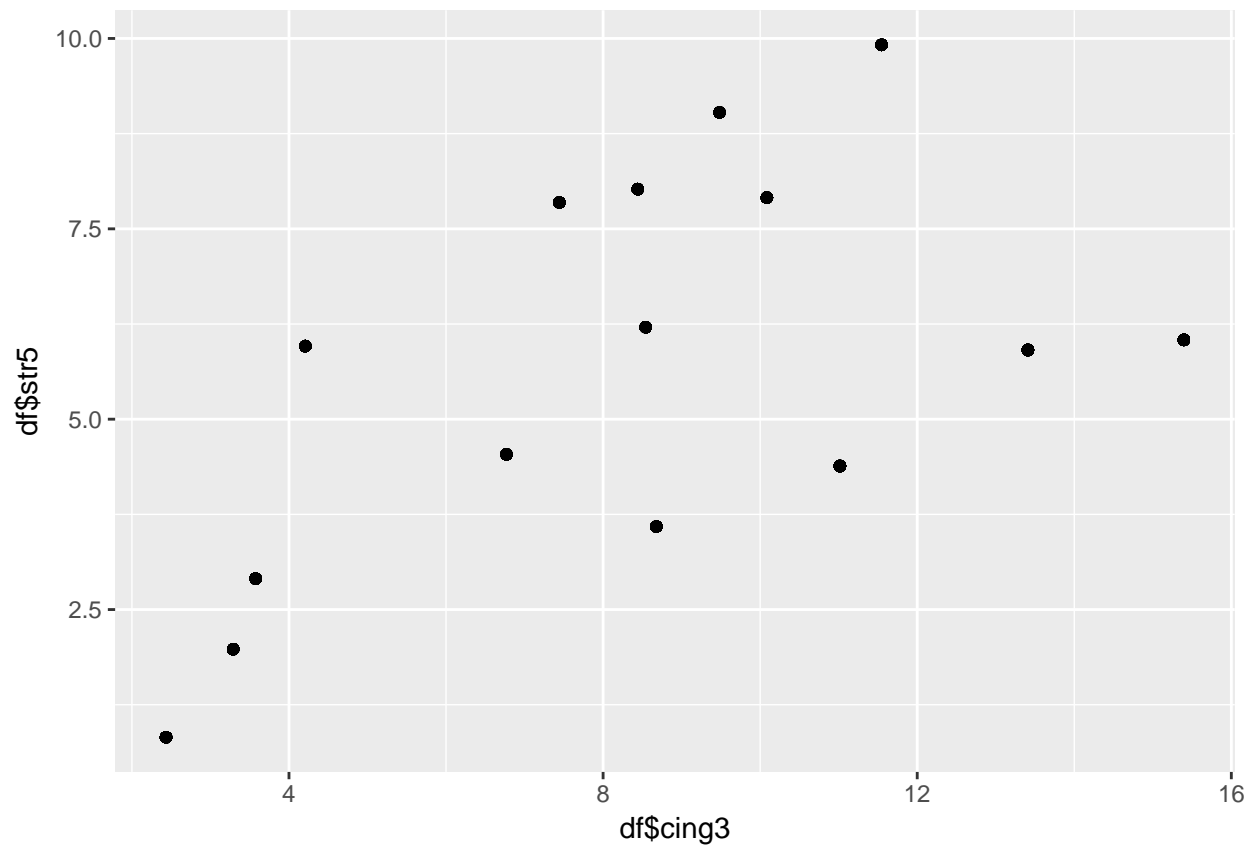*Alex Dombrovski*

1/20/2017

```
knitr::opts_chunk$set(echo = FALSE, cache = TRUE)
```

analysize and plot estimated marginal means in Marta's placebo/NF data

```
## Loading required package: Matrix
```

```
##
## Attaching package: 'lme4'
```

```
## The following object is masked from 'package:nlme':
##
##     lmList
```

```
## Loading required package: estimability
```

import behavior, individual differences and betas data, check betas
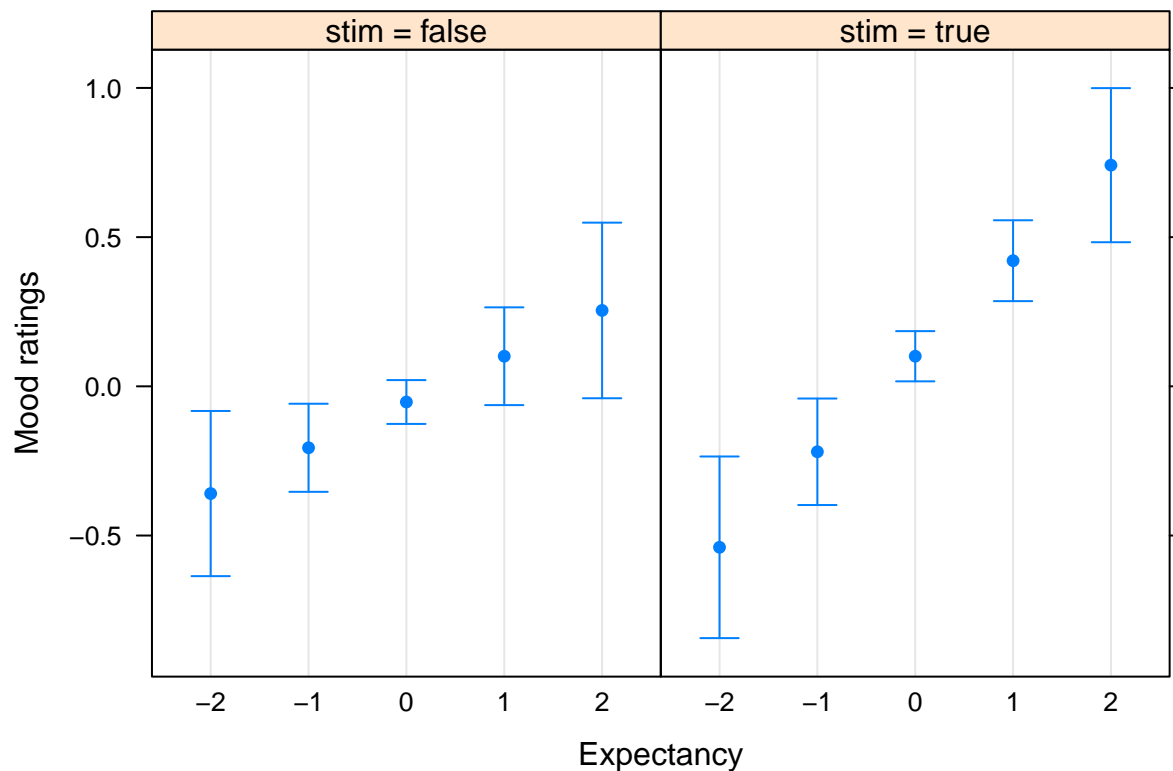
```
## Parsed with column specification:
## cols(
##     .default = col_integer(),
##     `ID` = col_character(),
##     stim = col_character(),
##     stimlag = col_double(),
##     feedbacklag = col_double(),
##     stim_rating = col_double(),
##     feedback_rating = col_double(),
##     feedback_ratinglag = col_double(),
##     feedback_maglag = col_double(),
##     feedback_valencelag = col_double(),
##     feedback_rating_sigm = col_double(),
##     stim_rating_sigm = col_double(),
##     ASQ_Avoidance = col_double(),
##     ASQ_Anxiety = col_double(),
##     endorf1 = col_double(),
##     cort1 = col_double(),
##     cort2 = col_double(),
##     endorf2 = col_double(),
##     endorf2_1 = col_double(),
##     cort1_2 = col_double(),
##     CuneusVisual = col_double()
##     # ... with 7 more columns
## )
```

```
## See spec(...) for full column specifications.
```

```
## Warning: Removed 504 rows containing missing values (geom_point).
```

Predict feedback ratings.

```
## Linear mixed model fit by REML ['lmerMod']
## Formula:
## feedback_rating ~ stim_rating * stim + feedback + feedback_ratinglag +
##     (1 + feedback + stim_rating | subject)
##    Data: df
##
## REML criterion at convergence: 2823
##
## Scaled residuals:
##     Min      1Q  Median      3Q     Max
## -4.2157 -0.4170 -0.0015  0.4469  4.3383
##
## Random effects:
##  Groups   Name        Variance Std.Dev. Corr
##  subject  (Intercept) 0.005861 0.07656
##           feedback    0.094715 0.30776   0.12
##           stim_rating 0.038707 0.19674   0.08 -0.65
##  Residual             0.554586 0.74471
## Number of obs: 1205, groups:  subject, 22
##
## Fixed effects:
##                 Estimate Std. Error t value
## (Intercept)     -0.05337    0.03680  -1.450
## stim_rating      0.15342    0.06725   2.281
## stimtrue         0.15339    0.05178   2.962
## feedback         0.30541    0.06780   4.505
```

```
## feedback_ratinglag     0.02105     0.02063    1.021
## stim_rating:stimtrue  0.16673     0.06440    2.589
##
## Correlation of Fixed Effects:
##             (Intr) stm_rt stimtr fedbck fdbck_
## stim_rating  0.142
## stimtrue    -0.593 -0.101
## feedback     0.095 -0.408 -0.053
## fdbck_rtngl -0.105 -0.021  0.110 -0.019
## stm_rtng:st -0.127 -0.507 -0.200 -0.010 -0.031

## Analysis of Deviance Table (Type II Wald chisquare tests)
##
## Response: feedback_rating
##                    Chisq Df Pr(>Chisq)
## stim_rating      17.4036  1  3.023e-05 ***
## stim             12.6207  1  0.0003815 ***
## feedback         20.2929  1  6.645e-06 ***
## feedback_ratinglag  1.0415  1  0.3074652
## stim_rating:stim   6.7030  1  0.0096248 **
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

## Loading required namespace: lmerTest
```



```
## Linear mixed model fit by REML ['lmerMod']
## Formula:
## feedback_rating ~ stim_rating * stim + feedback + feedback_ratinglag +
##     visual1 * stim + (1 + feedback + stim_rating | subject)
##    Data: df
##
```

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```
## REML criterion at convergence: 2116.1
##
## Scaled residuals:
##     Min      1Q  Median      3Q     Max
## -3.9182 -0.4414 -0.0409  0.4647  4.2064
##
## Random effects:
##  Groups   Name         Variance Std.Dev. Corr
##  subject  (Intercept)  0.006309 0.07943
##           feedback     0.109292 0.33059   0.36
##           stim_rating  0.019707 0.14038  -0.43 -0.83
##  Residual              0.612982 0.78293
## Number of obs: 862, groups:  subject, 15
##
## Fixed effects:
##                      Estimate Std. Error t value
## (Intercept)        -0.0947058  0.1162884  -0.814
## stim_rating         0.1085709  0.0641845   1.692
## stimtrue            0.4541812  0.1552853   2.925
## feedback            0.3879902  0.0872967   4.445
## feedback_ratinglag -0.0086605  0.0231879  -0.373
## visual1             0.0007072  0.0096314   0.073
## stim_rating:stimtrue 0.1966278 0.0727723   2.702
## stimtrue:visual1   -0.0273673  0.0126070  -2.171
##
## Correlation of Fixed Effects:
##             (Intr) stm_rt stimtr fedbck fdbck_ visul1 stm_r:
## stim_rating  0.146
## stimtrue    -0.662 -0.142
## feedback     0.081 -0.452 -0.025
## fdbck_rtngl -0.090 -0.017  0.090 -0.019
## visual1     -0.921 -0.153  0.610 -0.002  0.053
## stm_rtng:st -0.171 -0.581 -0.023 -0.010 -0.029  0.141
## stimtr:vsl1  0.626  0.115 -0.905  0.002 -0.038 -0.674 -0.097
## Analysis of Deviance Table (Type II Wald chisquare tests)
##
## Response: feedback_rating
##                    Chisq Df Pr(>Chisq)
## stim_rating      16.0500  1  6.169e-05 ***
## stim              9.0856  1   0.002576 **
## feedback         19.7536  1  8.810e-06 ***
## feedback_ratinglag 0.1395 1   0.708783
## visual1           3.5386  1   0.059957 .
## stim_rating:stim  7.3006  1   0.006893 **
## stim:visual1      4.7124  1   0.029946 *
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

## Linear mixed model fit by REML ['lmerMod']
## Formula:
## feedback_rating ~ stim_rating * stim + feedback + feedback_ratinglag +
##     motor2 * stim + (1 + feedback + stim_rating | subject)
##    Data: df
##
```

```
## REML criterion at convergence: 2113.8
##
## Scaled residuals:
##     Min      1Q  Median      3Q     Max
## -3.8259 -0.4344 -0.0464  0.4555  4.1876
##
## Random effects:
##  Groups   Name        Variance Std.Dev. Corr
##  subject  (Intercept) 0.009859 0.09929
##           feedback    0.112918 0.33603   0.25
##           stim_rating 0.013049 0.11423  -0.15 -0.91
##  Residual             0.612023 0.78232
## Number of obs: 862, groups:  subject, 15
##
## Fixed effects:
##                     Estimate Std. Error t value
## (Intercept)         -0.29786    0.13920  -2.140
## stim_rating          0.08725    0.06021   1.449
## stimtrue             0.66283    0.17635   3.759
## feedback             0.38705    0.08867   4.365
## feedback_ratinglag  -0.01070    0.02312  -0.463
## motor2               0.02628    0.01657   1.586
## stim_rating:stimtrue 0.22742    0.07354   3.092
## stimtrue:motor2     -0.06494    0.02062  -3.150
##
## Correlation of Fixed Effects:
##             (Intr) stm_rt stimtr fedbck fdbck_ motor2 stm_r:
## stim_rating  0.216
## stimtrue    -0.601 -0.184
## feedback     0.063 -0.432 -0.025
## fdbck_rtngl -0.062 -0.011  0.079 -0.019
## motor2      -0.940 -0.196  0.560 -0.005  0.027
## stm_rtng:st -0.191 -0.624  0.028 -0.010 -0.040  0.163
## stimtr:mtr2  0.573  0.160 -0.929  0.006 -0.029 -0.602 -0.130

## Analysis of Deviance Table (Type II Wald chisquare tests)
##
## Response: feedback_rating
##                    Chisq Df Pr(>Chisq)
## stim_rating      18.7165  1  1.517e-05 ***
## stim              9.2272  1   0.002385 **
## feedback         19.0541  1  1.271e-05 ***
## feedback_ratinglag 0.2142 1   0.643523
## motor2            0.1496  1   0.698870
## stim_rating:stim  9.5620  1   0.001986 **
## stim:motor2       9.9199  1   0.001635 **
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

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

## Data: df
## Models:
## nm3: feedback_rating ~ stim_rating * stim + feedback + feedback_ratinglag +
## nm3:     visual1 * stim + (1 + feedback + stim_rating | subject)
## nm4: feedback_rating ~ stim_rating * stim + feedback + feedback_ratinglag +
```

```
## nm4:      motor2 * stim + (1 + feedback + stim_rating | subject)
##     Df    AIC    BIC  logLik deviance  Chisq Chi Df Pr(>Chisq)
## nm3 15 2105.3 2176.7 -1037.7   2075.3
## nm4 15 2105.2 2176.6 -1037.6   2075.2 0.1172      0  < 2.2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

## Linear mixed model fit by REML ['lmerMod']
## Formula:
## feedback_rating ~ stim_rating * stim + feedback + feedback_ratinglag +
##     striatum * stim + (1 + feedback + stim_rating | subject)
##    Data: df
##
## REML criterion at convergence: 2112.6
##
## Scaled residuals:
##     Min      1Q  Median      3Q     Max
## -3.7030 -0.4565 -0.0582  0.4634  4.1261
##
## Random effects:
##  Groups   Name        Variance Std.Dev. Corr
##  subject  (Intercept) 0.008667 0.0931
##           feedback    0.114069 0.3377    0.09
##           stim_rating 0.021634 0.1471    0.04 -0.72
##  Residual             0.607947 0.7797
## Number of obs: 862, groups:  subject, 15
##
## Fixed effects:
##                     Estimate Std. Error t value
## (Intercept)         -0.32402    0.11369  -2.850
## stim_rating          0.07781    0.06588   1.181
## stimtrue             0.54246    0.15302   3.545
## feedback             0.38675    0.08909   4.341
## feedback_ratinglag  -0.01313    0.02313  -0.568
## striatum             0.04056    0.01788   2.268
## stim_rating:stimtrue 0.22356    0.07299   3.063
## stimtrue:striatum   -0.06605    0.02329  -2.836
##
## Correlation of Fixed Effects:
##             (Intr) stm_rt stimtr fedbck fdbck_ stritm stm_r:
## stim_rating  0.182
## stimtrue    -0.602 -0.145
## feedback     0.040 -0.399 -0.028
## fdbck_rtngl -0.022 -0.003  0.029 -0.018
## striatum    -0.910 -0.139  0.538 -0.007 -0.020
## stm_rtng:st -0.161 -0.564 -0.041 -0.010 -0.043  0.128
## stmtr:strtm  0.564  0.114 -0.902  0.006  0.028 -0.604 -0.077

## Analysis of Deviance Table (Type II Wald chisquare tests)
##
## Response: feedback_rating
##                 Chisq Df Pr(>Chisq)
## stim_rating   12.4006  1  0.0004292 ***
## stim           9.7214  1  0.0018213 **
## feedback      18.8448  1  1.418e-05 ***
```
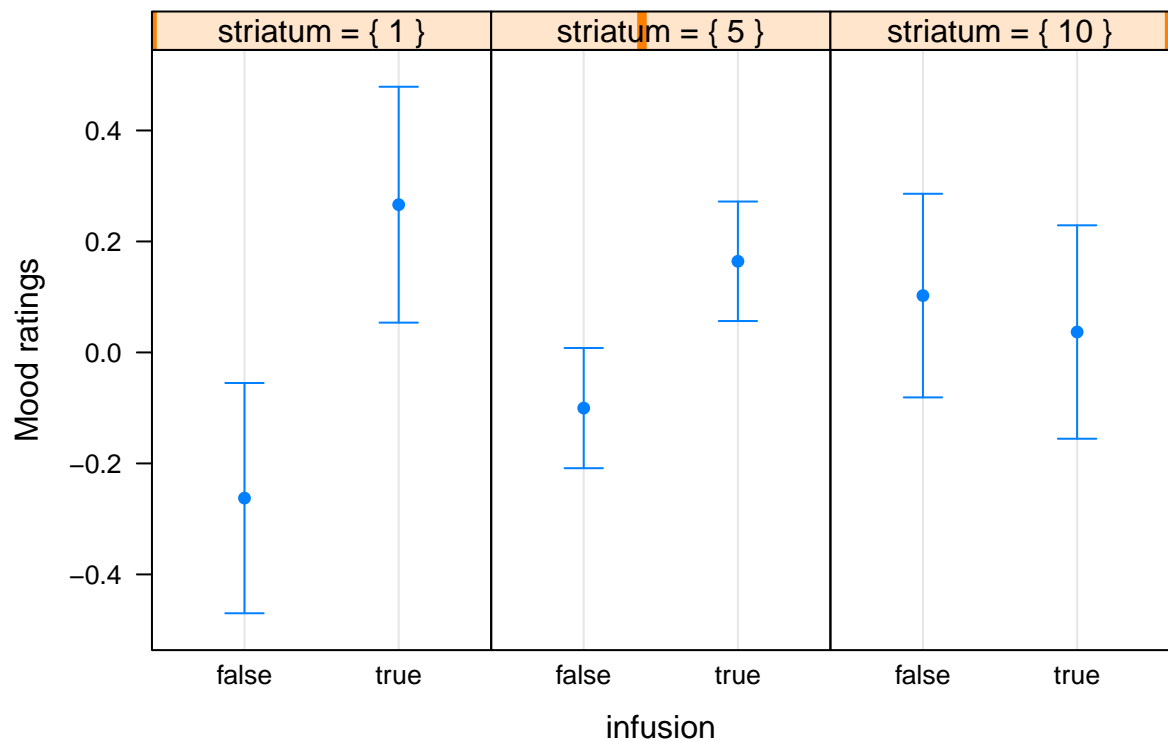
```
## feedback_ratinglag   0.3222   1   0.5702644
## striatum              0.4833   1   0.4869336
## stim_rating:stim      9.3818   1   0.0021915 **
## stim:striatum         8.0420   1   0.0045705 **
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

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

## Data: df
## Models:
## nm4: feedback_rating ~ stim_rating * stim + feedback + feedback_ratinglag +
## nm4:     motor2 * stim + (1 + feedback + stim_rating | subject)
## nm5: feedback_rating ~ stim_rating * stim + feedback + feedback_ratinglag +
## nm5:     striatum * stim + (1 + feedback + stim_rating | subject)
##     Df    AIC    BIC  logLik deviance  Chisq Chi Df Pr(>Chisq)
## nm4 15 2105.2 2176.6 -1037.6   2075.2
## nm5 15 2105.0 2176.4 -1037.5   2075.0 0.2282      0  < 2.2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```
Save results

Striatal activity modulates effect of infusion

Expectancy rating models

```
## Linear mixed model fit by REML ['lmerMod']
## Formula: stim_rating ~ stim + feedback_ratinglag * striatum + (1 + stim |
##     subject)
##     Data: df
##
## REML criterion at convergence: 1939.1
```

```
##
## Scaled residuals:
##     Min      1Q  Median      3Q     Max
## -4.1878 -0.3220 -0.0038  0.4897  4.1080
##
## Random effects:
##  Groups   Name        Variance Std.Dev. Corr
##  subject  (Intercept) 0.1607   0.4008
##           stimtrue    0.4307   0.6563   -0.86
##  Residual             0.4632   0.6806
## Number of obs: 895, groups:  subject, 15
##
## Fixed effects:
##                              Estimate Std. Error t value
## (Intercept)                 -0.249982   0.167531  -1.492
## stimtrue                     0.754688   0.175766   4.294
## feedback_ratinglag          -0.049109   0.047371  -1.037
## striatum                     0.021592   0.022488   0.960
## feedback_ratinglag:striatum  0.017575   0.007266   2.419
##
## Correlation of Fixed Effects:
##            (Intr) stimtr fdbck_ stritm
## stimtrue    -0.547
## fdbck_rtngl -0.016  0.012
## striatum    -0.762 -0.003  0.009
## fdbck_rtng:  0.010 -0.002 -0.909 -0.012
```

```
## Analysis of Deviance Table (Type II Wald chisquare tests)
##
## Response: stim_rating
##                              Chisq Df Pr(>Chisq)
## stim                        18.4360  1  1.757e-05 ***
## feedback_ratinglag           7.8115  1   0.005192 **
## striatum                     0.9793  1   0.322365
## feedback_ratinglag:striatum  5.8495  1   0.015581 *
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
## Linear mixed model fit by REML ['lmerMod']
## Formula: stim_rating ~ stim + feedback_ratinglag * striatum + stim_diff +
##     (1 + stim | subject)
##    Data: df
##
## REML criterion at convergence: 1936.6
##
## Scaled residuals:
##     Min      1Q  Median      3Q     Max
## -4.1220 -0.3857 -0.0155  0.4861  4.1928
##
## Random effects:
##  Groups   Name        Variance Std.Dev. Corr
##  subject  (Intercept) 0.1603   0.4004
##           stimtrue    0.4317   0.6570   -0.86
##  Residual             0.4602   0.6784
## Number of obs: 895, groups:  subject, 15
```

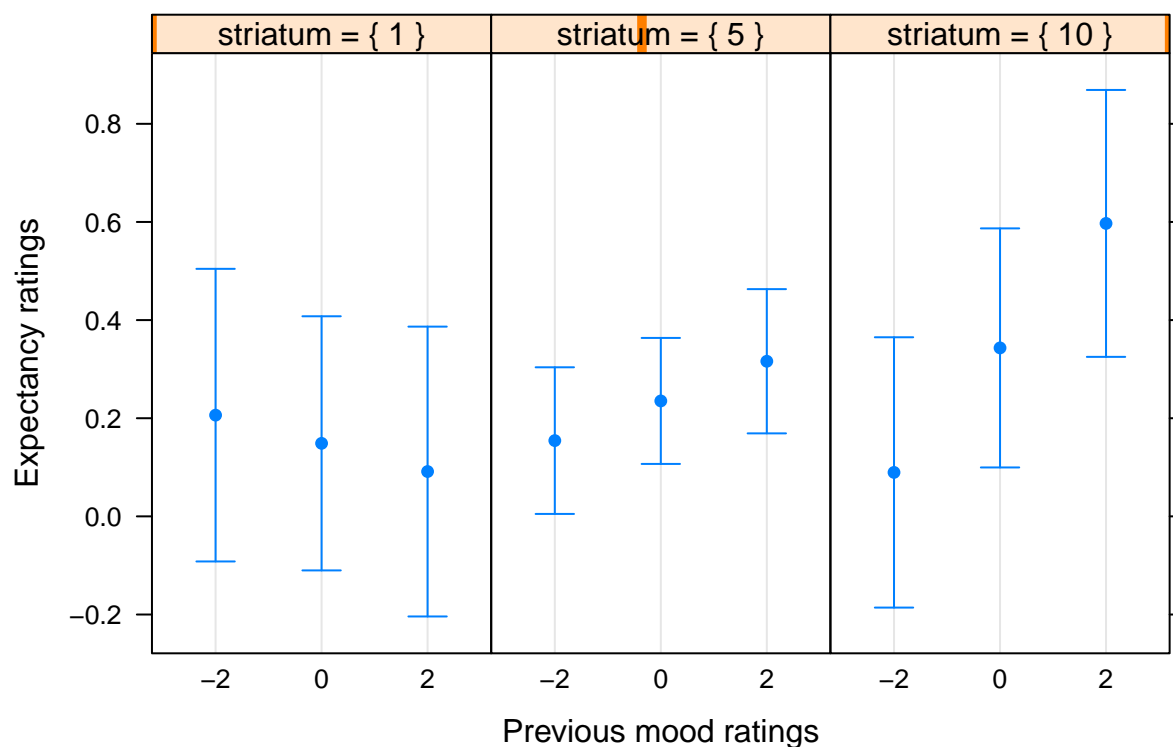```
##
Fixed effects:
Estimate Std. Error t value
(Intercept)   -0.298744   0.167945 -1.779
stimtrue   0.754898   0.175910   4.291
feedback_ratinglag   -0.046013   0.047232 -0.974
striatum   0.021609   0.022363   0.966
stim_diff   0.120584   0.046313   2.604
feedback_ratinglag:striatum 0.017288   0.007244   2.387
##
Correlation of Fixed Effects:
(Intr) stimtr fdbck_ stritm stm_df
stimtrue   -0.546
fdbck_rtngl -0.019 0.012
striatum   -0.756 -0.003 0.009
stim_diff   -0.111 0.000 0.025 0.000
fdbck_rtng: 0.011 -0.002 -0.909 -0.012 -0.015

Analysis of Deviance Table (Type II Wald chisquare tests)
##
Response: stim_rating
Chisq Df Pr(>Chisq)
stim   18.4160 1 1.776e-05 ***
feedback_ratinglag   8.2656 1   0.004040 **
striatum   0.9908 1   0.319536
stim_diff   6.7791 1   0.009223 **
feedback_ratinglag:striatum 5.6959 1   0.017004 *

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

**Striatal activity modulates effect of earlier mood**

```
Linear mixed model fit by REML ['lmerMod']
Formula:
feedback_rating ~ stim_rating * stim + feedback + feedback_ratinglag +
(1 + feedback + stim_rating | subject)
Data: df
##
REML criterion at convergence: 2823
##
Scaled residuals:
Min   1Q Median   3Q   Max
-4.2157 -0.4170 -0.0015 0.4469 4.3383
##
Random effects:
Groups   Name   Variance Std.Dev. Corr
subject (Intercept) 0.005861 0.07656
feedback   0.094715 0.30776   0.12
stim_rating 0.038707 0.19674   0.08 -0.65
Residual   0.554586 0.74471
Number of obs: 1205, groups: subject, 22
##
Fixed effects:
Estimate Std. Error t value
(Intercept)   -0.05337   0.03680 -1.450
stim_rating   0.15342   0.06725   2.281
stimtrue   0.15339   0.05178   2.962
feedback   0.30541   0.06780   4.505
feedback_ratinglag 0.02105   0.02063   1.021
```
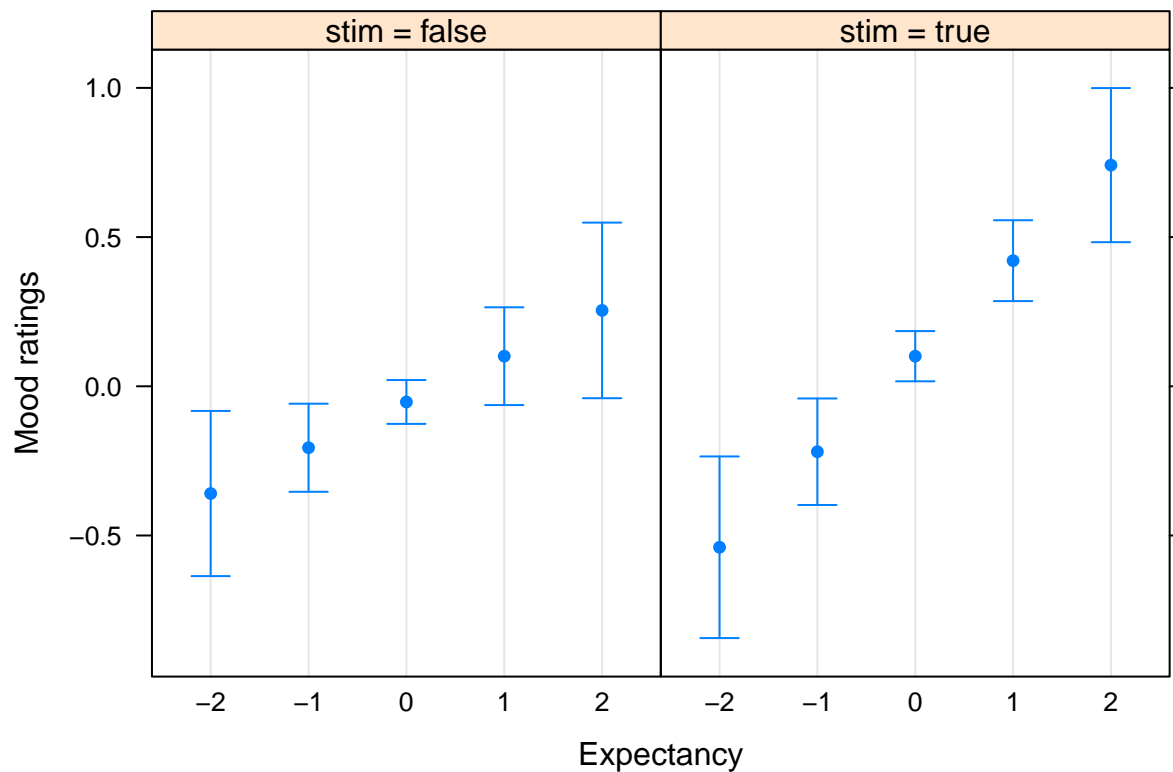
```
stim_rating:stimtrue 0.16673   0.06440   2.589
##
Correlation of Fixed Effects:
(Intr) stm_rt stimtr fedbck fdbck_
stim_rating 0.142
stimtrue   -0.593 -0.101
feedback   0.095 -0.408 -0.053
fdbck_rtngl -0.105 -0.021 0.110 -0.019
stm_rtng:st -0.127 -0.507 -0.200 -0.010 -0.031

Analysis of Deviance Table (Type II Wald chisquare tests)
##
Response: feedback_rating
Chisq Df Pr(>Chisq)
stim_rating   17.4036 1 3.023e-05 ***
stim   12.6207 1 0.0003815 ***
feedback   20.2929 1 6.645e-06 ***
feedback_ratinglag 1.0415 1 0.3074652
stim_rating:stim   6.7030 1 0.0096248 **

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Linear mixed model fit by REML ['lmerMod']
Formula:
feedback_rating ~ stim_rating * stim + feedback + feedback_ratinglag +
df$DAS7 * feedback + (1 + feedback + stim_rating | subject)
Data: df
##
REML criterion at convergence: 2211.6
##
Scaled residuals:
Min   1Q Median   3Q   Max
-4.1127 -0.4576 -0.0016 0.5176 3.6031
##
Random effects:
Groups   Name   Variance Std.Dev. Corr
subject (Intercept) 0.0008402 0.02899
feedback   0.0676876 0.26017 -0.80
stim_rating 0.0530637 0.23036   0.95 -0.56
Residual   0.5854049 0.76512
Number of obs: 919, groups: subject, 17
##
Fixed effects:
Estimate Std. Error t value
(Intercept)   0.187279   0.124788   1.501
stim_rating   0.191202   0.082034   2.331
stimtrue   0.203372   0.061393   3.313
feedback   0.759621   0.282752   2.687
feedback_ratinglag 0.019727   0.024458   0.807
df$DAS7   -0.013993   0.006132 -2.282
stim_rating:stimtrue 0.128510   0.072360   1.776
feedback:df$DAS7   -0.023859   0.013968 -1.708
##
Correlation of Fixed Effects:
(Intr) stm_rt stimtr fedbck fdbck_ d$DAS7 stm_r:
```

```
## stim_rating  0.050
## stimtrue    -0.200 -0.093
## feedback    -0.191 -0.074 -0.029
## fdbck_rtngl -0.083 -0.011  0.104 -0.002
## df$DAS7     -0.951  0.021 -0.001  0.193  0.054
## stm_rtng:st -0.003 -0.450 -0.230  0.005 -0.064 -0.034
## fdbck:$DAS7  0.190 -0.016  0.015 -0.972 -0.002 -0.199 -0.009

## Analysis of Deviance Table (Type II Wald chisquare tests)
##
## Response: feedback_rating
##                     Chisq Df Pr(>Chisq)
## stim_rating       12.2747  1  0.0004591 ***
## stim              14.6158  1  0.0001318 ***
## feedback          19.1271  1  1.223e-05 ***
## feedback_ratinglag 0.6505  1  0.4199193
## df$DAS7            7.1557  1  0.0074726 **
## stim_rating:stim   3.1541  1  0.0757367 .
## feedback:df$DAS7   2.9177  1  0.0876150 .
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

check Apathy ratings