Multi-level models of reinforcement predicting subject ratings on Marta's placebo/neurofeedback data

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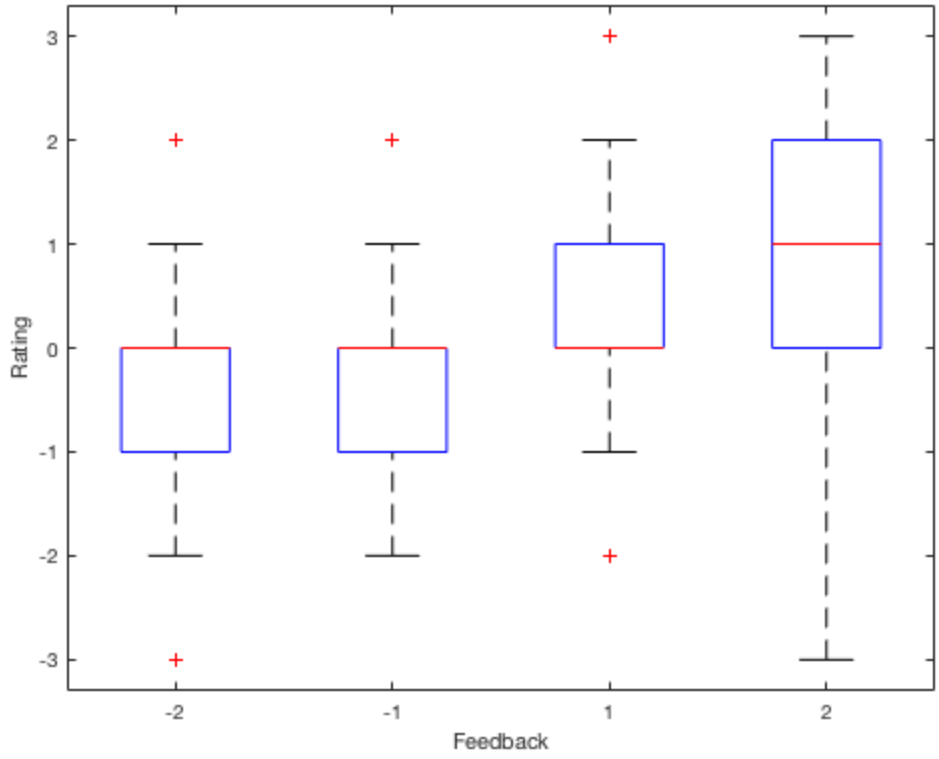
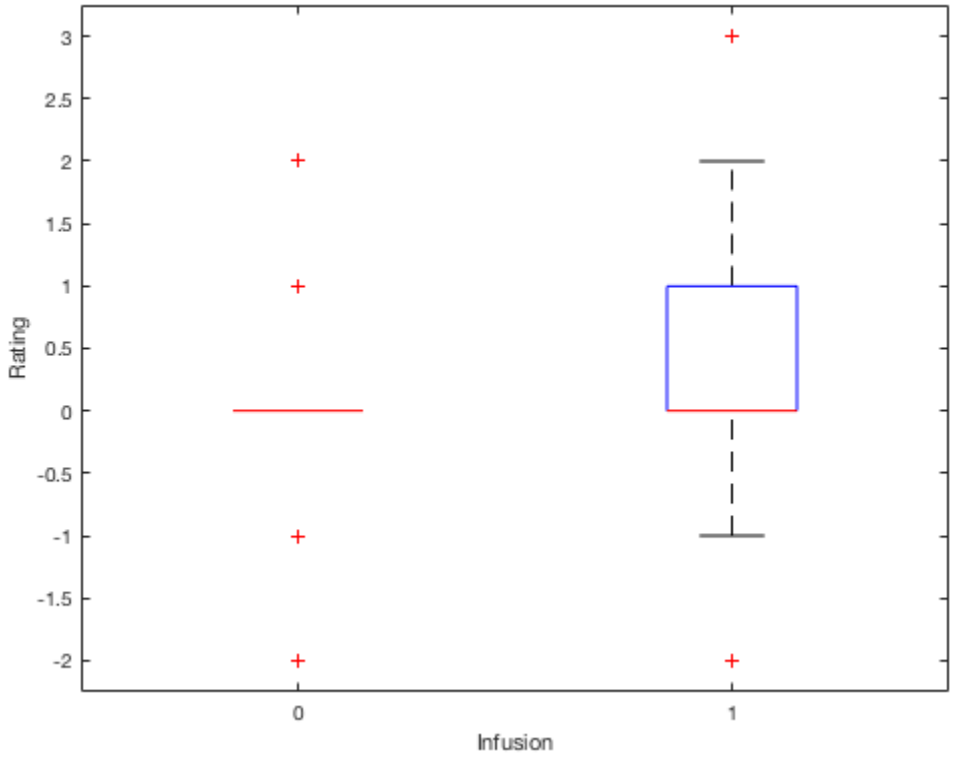
Read in data

```
cd('/Users/localadmin/Dropbox/data_projects/placebo_marta/');
load('p');
% read_nf_data
% cs = [];
% us = [];
% for i = 1:length(feedback)
% cs(i) = strcmpi(char(stim(i)),'Infusion');
% if strcmpi(char(feedback(i)),'100% Pos Feedback');
% us(i) = 2;
% elseif strcmpi(char(feedback(i)),'50% Pos Feedback');
% us(i) = 1;
% elseif strcmpi(char(feedback(i)),'50% Neg Feedback');
% us(i) = -1;
% elseif strcmpi(char(feedback(i)),'100% Neg Feedback');
% us(i) = -2;
% end
% end
% cs = logical(cs);
% % nf = table(us',cs',stim,feedback,feedback_ratings,stim_ratings);
%
% %% write to table for LME analysis
% clear p; p = table;
% trials = 72;
% start = 1;
% for sub = 1:size(feedback_ratings,2)
%     p.feedback_rating(start:start+trials-1,1) =
 feedback_ratings(:,sub);
%     p.subject(start:start+trials-1,1) = sub*ones(trials,1);
%     p.stim_rating(start:start+trials-1,1) = stim_ratings(:,sub);
%     p.trial(start:start+trials-1,1) = [1:72]';
%     p.stim(start:start+trials-1,1)  = cs';
%     p.feedback(start:start+trials-1,1) = us';
%     start = start + trials;
```

```
% end
% p.subject = nominal(p.subject);

% Sanity check
figure(1); boxplot(p.feedback_rating,p.feedback); xlabel('Feedback');
 ylabel('Rating');
figure(2); boxplot(p.stim_rating, p.stim); xlabel('Infusion');
 ylabel('Rating');

%
% % separate feedback magnitude and valence
% p.feedback_mag = abs(p.feedback);
% p.feedback_valence = p.feedback > 0;
%
%
% % calculate lagged feedback representing the reward rate
% p.feedbacklag = [NaN; p.feedback(1:end-1)];
% p.feedbacklag(p.trial==1) = NaN; % make sure there is no carryover
 from previous subject
%
% p.feedback_ratinglag = [NaN; p.feedback_rating(1:end-1)];
% p.feedback_ratinglag(p.trial==1) = NaN; % make sure there is no
 carryover from previous subject
%
% p.feedback_maglag = [NaN; p.feedback_mag(1:end-1)];
% p.feedback_maglag(p.trial==1) = NaN; % make sure there is no
 carryover from previous subject
%
% p.feedback_valencelag = [NaN; p.feedback_valence(1:end-1)];
% p.feedback_valencelag(p.trial==1) = NaN; % make sure there is no
 carryover from previous subject
%
% % sigmoid transform
% p.feedback_rating_sigm = sigm(p.feedback_rating)';
% p.stim_rating_sigm = sigm(p.stim_rating)';



% model1 = fitlme(p,'feedback_rating ~ 1 + feedback + trial +
 stim*trial + (feedback*trial + stim|subject)')
% anova(model1)
% model2 = fitlme(p,'feedback_rating ~ 1 + feedback + trial +
 stim*trial + (feedback + stim|subject)')
% anova(model2)
```


Rating
Feedback
3
2
1
0
-1
-2
-3
-2
-1
1
2


Rating
Infusion
3
2.5
2
1.5
1
0.5
0
-0.5
-1
-1.5
-2
0
1

Feedback ratings 1: the best model to date shows that their feedback ratings are influenced by both neurofeedback and infusion

```
% stim_1 - infusion

feed_model = fitlme(p,'feedback_rating ~ 1 + feedback + trial + stim +
 (feedback + stim|subject)')
% anova(feed_model)

% % try with sigmoid transform -- same results
% feed_model_sigm = fitlme(p,'feedback_rating_sigm ~ 1 + feedback +
 trial + stim + (feedback + stim|subject)')
% anova(feed_model_sigm)


feed_model =


Linear mixed-effects model fit by ML

Model information:
    Number of observations             1354
    Fixed effects coefficients            4
    Random effects coefficients          66
    Covariance parameters                 7

Formula:
    Linear Mixed Formula with 4 predictors.

Model fit statistics:
    AIC     BIC       LogLikelihood    Deviance
    3156    3213.4    -1567             3134

Fixed effects coefficients (95% CIs):
    Name                 Estimate     SE            tStat      DF
    '(Intercept)'         -0.12121      0.064458    -1.8804    1350
    'trial'              0.0017538    0.00097375     1.8011    1350
    'stim_1'                0.2791       0.09429     2.9601    1350
    'feedback'             0.31194      0.065628     4.7532    1350


    pValue        Lower          Upper
      0.060265       -0.24766    0.0052402
       0.07191    -0.00015641    0.0036641
     0.0031294       0.094134      0.46407
    2.2165e-06          0.1832      0.44069

Random effects covariance parameters (95% CIs):
Group: subject (22 Levels)
    Name1                Name2                Type          Estimate
```

```
    '(Intercept)'        '(Intercept)'        'std'            0.20982
    'stim_1'             '(Intercept)'        'corr'          -0.94689
    'feedback'           '(Intercept)'        'corr'           0.11699
    'stim_1'             'stim_1'             'std'            0.39101
    'feedback'           'stim_1'             'corr'         -0.041733
    'feedback'           'feedback'           'std'             0.3004


    Lower       Upper
     0.13704    0.32127
    -0.99128    -0.7096
    -0.37212    0.55524
     0.26812    0.57022
    -0.47825    0.41132
     0.22051    0.40922

Group: Error
    Name             Estimate    Lower      Upper
    'Res Std'        0.73807     0.71013    0.7671
```

Feedback ratings 2: slight suggestion that people track their reward rate

indicated by a NS effect of lagged feedback rating

```
feed_model_back = fitlme(p,'feedback_rating ~ 1 + feedback +
 feedback_ratinglag + trial + stim + (feedback + feedback_ratinglag +
 stim|subject)')
% anova(feed_model_back)


%
% % try separating valence and magnitude
% feed_model_val_mag = fitlme(p,'feedback_rating ~
 1 + feedback_mag*feedback_valence + trial + stim +
 (feedback_mag*feedback_valence + stim|subject)')
% anova(feed_model_val_mag)

% compare(feed_model,feed_model_val_mag)


feed_model_back =


Linear mixed-effects model fit by ML

Model information:
    Number of observations            1277
    Fixed effects coefficients           5
    Random effects coefficients         88
    Covariance parameters               11
```

```
Formula:
    Linear Mixed Formula with 5 predictors.

Model fit statistics:
    AIC       BIC       LogLikelihood    Deviance
    2951.4    3033.9    -1459.7          2919.4

Fixed effects coefficients (95% CIs):
    Name                        Estimate      SE           tStat
 DF
    '(Intercept)'                 -0.10621     0.060032    -1.7693
 1272
    'trial'                     0.00095865    0.0010001    0.95853
 1272
    'stim_1'                       0.29778     0.085137     3.4976
 1272
    'feedback'                     0.30683     0.065407     4.6911
 1272
    'feedback_ratinglag'          0.079313     0.049481     1.6029
 1272


    pValue        Lower         Upper
      0.077083      -0.22399     0.011558
       0.33798    -0.0010034    0.0029207
    0.00048562       0.13075       0.4648
    3.0108e-06       0.17851      0.43515
       0.10921     -0.017761      0.17639

Random effects covariance parameters (95% CIs):
Group: subject (22 Levels)
    Name1                       Name2                       Type
    '(Intercept)'               '(Intercept)'               'std'
    'stim_1'                    '(Intercept)'               'corr'
    'feedback'                  '(Intercept)'               'corr'
    'feedback_ratinglag'        '(Intercept)'               'corr'
    'stim_1'                    'stim_1'                    'std'
    'feedback'                  'stim_1'                    'corr'
    'feedback_ratinglag'        'stim_1'                    'corr'
    'feedback'                  'feedback'                  'std'
    'feedback_ratinglag'        'feedback'                  'corr'
    'feedback_ratinglag'        'feedback_ratinglag'        'std'


    Estimate    Lower       Upper
     0.17191     0.10427      0.28342
      -0.949    -0.99549     -0.53506
      0.1326      -0.391      0.59135
     0.70989    0.026663      0.94106
      0.3409     0.22663       0.5128
    0.037283    -0.43079      0.48955
    -0.60991     -0.8801    -0.041316
     0.29905     0.21941       0.4076
```

```
    -0.2475    -0.63236      0.23534
    0.19392     0.12884      0.29186

Group: Error
    Name             Estimate    Lower      Upper
    'Res Std'        0.7213      0.69293    0.75083
```

Expectancy ratings

```
% they prefer infusion, but there is no evidence of learning as
 indicated by NS trial*stim_1 interaction
exp_model = fitlme(p,'stim_rating ~ 1 + trial*stim +
 feedback_ratinglag + (stim + feedback_ratinglag|subject)')
anova(exp_model)

% check sigmoid transform -- same results
% exp_model = fitlme(p,'stim_rating_sigm ~ 1 + trial*stim +
 feedback_ratinglag + (stim + feedback_ratinglag|subject)')
% anova(exp_model)



% [B,Bnames,stats] = randomEffects(model1);


exp_model =


Linear mixed-effects model fit by ML

Model information:
    Number of observations            1246
    Fixed effects coefficients           5
    Random effects coefficients         66
    Covariance parameters                7

Formula:
    Linear Mixed Formula with 4 predictors.

Model fit statistics:
    AIC       BIC       LogLikelihood    Deviance
    2390.3    2451.8    -1183.1          2366.3

Fixed effects coefficients (95% CIs):
    Name                        Estimate       SE           tStat
   DF
    '(Intercept)'                 -0.092067     0.090743     -1.0146
   1241
    'trial'                      -0.0012766    0.0011988     -1.0649
   1241
    'stim_1'                        0.68263      0.15146      4.5069
   1241
```

```
    'feedback_ratinglag'          0.080513     0.027347      2.9441
   1241
    'trial:stim_1'              -0.00042062    0.0017072    -0.24638
   1241


    pValue       Lower         Upper
       0.3105      -0.27009     0.085959
      0.28712    -0.0036284    0.0010753
    7.199e-06       0.38548      0.97978
    0.0032995      0.026861      0.13416
      0.80543      -0.00377    0.0029287

Random effects covariance parameters (95% CIs):
Group: subject (22 Levels)
    Name1                       Name2                       Type
    '(Intercept)'               '(Intercept)'               'std'
    'stim_1'                    '(Intercept)'               'corr'
    'feedback_ratinglag'        '(Intercept)'               'corr'
    'stim_1'                    'stim_1'                    'std'
    'feedback_ratinglag'        'stim_1'                    'corr'
    'feedback_ratinglag'        'feedback_ratinglag'        'std'


    Estimate    Lower       Upper
     0.35108     0.25259     0.48797
    -0.83543    -0.93295    -0.62369
     0.66204    0.073304      0.9086
     0.62233     0.45276      0.8554
     -0.7812    -0.97066    0.006683
    0.092214    0.054209     0.15687

Group: Error
    Name            Estimate    Lower      Upper
    'Res Std'       0.59805     0.57442    0.62266


ans =


    ANOVA MARGINAL TESTS: DFMETHOD = 'RESIDUAL'

    Term                        FStat       DF1    DF2     pValue
    '(Intercept)'                 1.0294    1      1241       0.3105
    'trial'                       1.134     1      1241      0.28712
    'stim'                       20.312     1      1241    7.199e-06
    'feedback_ratinglag'          8.6676    1      1241    0.0032995
    'trial:stim'                0.060701    1      1241      0.80543
```

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