stabilityFeedbackICB

Overview

This MATLAB Live Script is associated with the paper "Idiosyncratic choice bias and feedback-induced bias differ in their long-term dynamics".

All data files required to reproduce our results available in https://github.com/Lior-Lebovich/stabilityFeedbackICB.

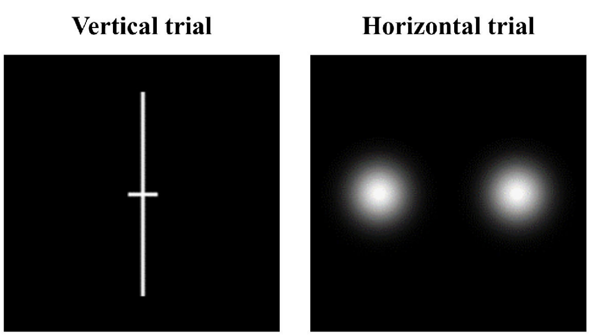
Contributor

This code was authored by Lior Lebovich, 2024.

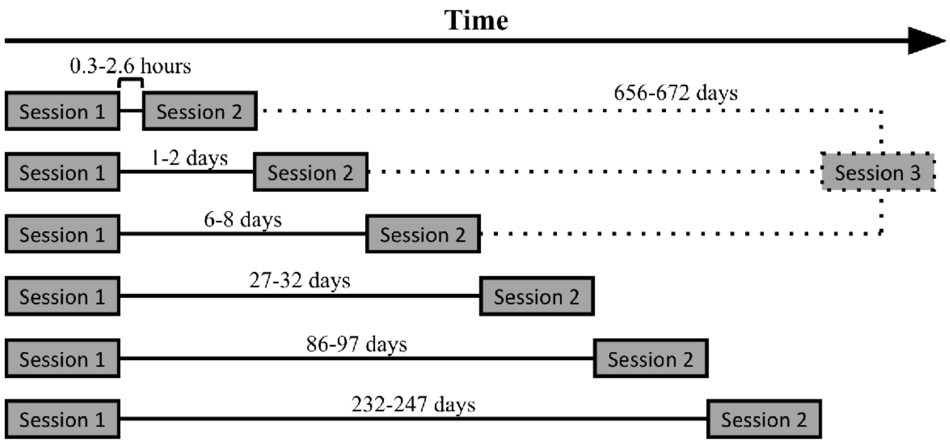
Datasets

This research includes two studies of Idiosyncratic Choice Biases (ICBs) in human participants.

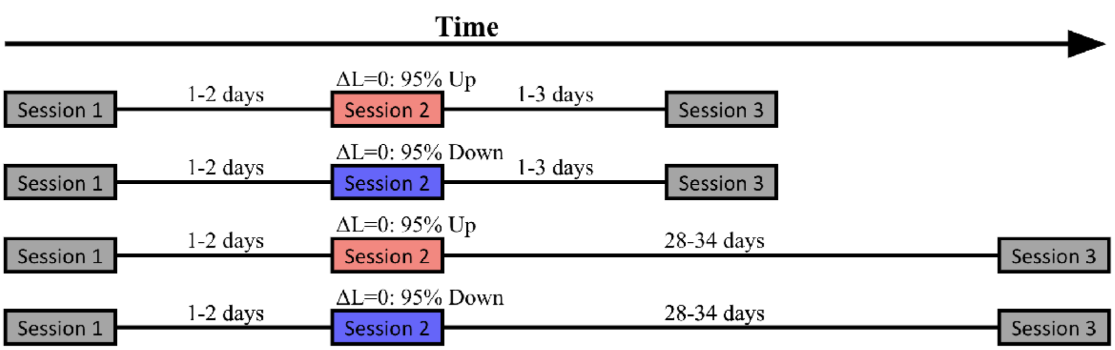
Each session consisted of 480 trials, 240 vertical and 240 horizontal. In a vertical trial, a vertical line, transected by a horizontal shorter line, was presented on a screen and participants were instructed to indicate which vertical segment out of two is longer. In a horizontal trial, two white Gaussian blur circles were presented on a black screen and participants were instructed to indicate which circle out of two is bigger. Trials in each session were ordered in 160 alternating blocks of 3 horizontal and 3 vertical transected lines. Unbeknown to the participants, there were 40 impossible vertical and 40 impossible horizontal trials in each session, appearing exclusively as first in a block of three trials. Stimuli in the possible trials were uniformly distributed, with an equal number of offsets in each direction.



Stability dataset: In the first study, participants' ICBs were measured in two repeated experimental sessions that were either 1 hour, 1 day, 1 week, 1 month, 3 months or 8 months apart. A subset of the participants also participated in a third session, 22 months after the second session. No trial-to-trial feedback was provided to participants. There were approx. 30 participants in each delay group.



Feedback dataset: In the second study, participants' ICBs were measured in three repeated experimental sessions. The first and second sessions were 1 day apart whereas the second and last sessions were either 1 day or 1 month apart. The first and last sessions were as in the sessions in the stability experiment, absent of trial-to-trial feedback, whereas the second session included trial-to-trial feedback. The trial-to-trial feedback was congruent with the stimuli in all possible trials (400/480 of the trials) and biased in the impossible trials (80/480 of the trials). The biased feedback considered one alternative as the correct response in 95% of the impossible trials and the other alternative as the correct response in 5% of the impossible trials. Participants were matched according to their ICBs in the first session and divided 8 groups: 2 second-last sessions delay times X 2 vertical feedback manipulation X 2 horizontal feedback manipulation.



Main data files:

Main data files are stored by dataset folders.

Response data of each delay group is stored under *[STUDY]/sortedTables/ sortedTable_[STUDY]_[DELAY_GROUP].csv*.

Between-sessions hour differences for each delay group are stored under *[STUDY]/assignTables/ assignTable_[STUDY]_[DELAY_GROUP].csv*.

Response data of the 8 months delay group in the stability study:

```
dataName = 'stability';
timeName = 'months8';
dataTable = readtable([dataName '/sortedTables/sortedTable_' ...
    dataName '_' timeName '.csv']);
```

```
head(dataTable, 8)
```

ID	endDate	startDate	didSess3	hourDif
{'0349843571f5184e8feb7995bc'}	27-Oct-2019 12:16:00	23-Jun-2020 21:26:00	0	5769.1
{'0349843571f5184e8feb7995bc'}	27-Oct-2019 12:16:00	23-Jun-2020 21:26:00	0	5769.1
{'0349843571f5184e8feb7995bc'}	27-Oct-2019 12:16:00	23-Jun-2020 21:26:00	0	5769.1
{'0349843571f5184e8feb7995bc'}	27-Oct-2019 12:16:00	23-Jun-2020 21:26:00	0	5769.1
{'0349843571f5184e8feb7995bc'}	27-Oct-2019 12:16:00	23-Jun-2020 21:26:00	0	5769.1
{'0349843571f5184e8feb7995bc'}	27-Oct-2019 12:16:00	23-Jun-2020 21:26:00	0	5769.1
{'0349843571f5184e8feb7995bc'}	27-Oct-2019 12:16:00	23-Jun-2020 21:26:00	0	5769.1
{'0349843571f5184e8feb7995bc'}	27-Oct-2019 12:16:00	23-Jun-2020 21:26:00	0	5769.1

Between-sessions hour differences for the 8 months delay group in the stability study:

```
dataName = 'stability';
timeName = 'months8';
assignTable = readtable([dataName '/assignTables/assignTable_' ...
    dataName '_' timeName '.csv']);
head(assignTable, 8)
```

timeCondition	subj_idx	ID	hourDiff21
{'months8'}	0	{'0349843571f5184e8feb7995bc'}	5769.1
{'months8'}	1	{'04bf771a158527a584696693ee'}	5791.2
{'months8'}	2	{'1e0bedfd7427aa3189a4de3c0c'}	5763.6
{'months8'}	3	{'2076262700981aeb117c0457e9'}	5680.4
{'months8'}	4	{'21fc1d85a3e4264449ef7f15a9'}	5730.6
{'months8'}	5	{'3707663e543822b1143b7f7366'}	5760.1
{'months8'}	6	{'3f8ec61536b41cbab72d3b1178'}	5761.2
{'months8'}	7	{'47e318f3e1fc694fb0af8efffb'}	5783

Read and process experimental data:

Define study (data), task, delay-group names and stimuli deviations:

```
dataNames = {'stability', 'feedback'};
taskNames = {'Vertical','Horizontal'};
dataTimeGroupNames.feedback = {'day','month'};
dataTimeGroupNames.stability = {'hour','day','week','month','months3',...
    'months8','years'};
dataTimeGroupNames2.stability = {'hour','day','week','month','3 months',...
    '8 months','22 months'};
dataTimeGroupNames2.feedback = dataTimeGroupNames.feedback;
timeStartName.stability = '';
timeStartName.feedback = 'time1';
relFields.stability = {'response'};
relFields.feedback = {'oldResponse','responseCongruent'};
nTrialsDevSessImp = 40;
nTrialsDevSessPos = 20;
devs.stability.Vertical = -10:2:10;
devs.feedback.Vertical = -10:2:10;
devs.stability.Horizontal = -10:2:10;
devs.feedback.Horizontal = -5:1:5;
```

```
toNormDev.Vertical = 100;
toNormDev.Horizontal = 75;
nTrialsVect = [20*ones(1,5), 40, 20*ones(1,5)];
xLab.Vertical = '\DeltaL/L';
xLab.Horizontal = '\DeltaR/R';
yLab.Vertical = 'p_{up}';
yLab.Horizontal = 'p_{right}';
save('behavioralDefs.mat');
```

Note that for the feedback data, the field 'oldResponse' denotes the actual respose (1=up/right and 0=down/left) whereas the field responseCongruent denotes whether the response is congruent(=1) or incungruent(=0) with the feedback manipulation.

Read, compute and store responses, response times and P for each study, delay group, session, task, participant, deviation and manipulation (for feedback data) and read 1st session's demographic data:

```
for dat = 1:length(dataNames)
    dataName = dataNames{dat};
    timeNames = dataTimeGroupNames.(dataName);
    % read demographic data (provided: 1st session onset):
    demogTable = readtable([dataName '/demogTable/demog_table_' ...
        dataName '.csv']);
    for ti = 1:length(timeNames)
        timeName = timeNames{ti};
        % read resposne data:
        assignTable = readtable([dataName '/assignTables/assignTable_' ...
            dataName '_' timeStartName.(dataName) timeName '.csv']);
        uniIDs = assignTable.ID;
        nSubs = length(uniIDs);
        dataTable = readtable([dataName '/sortedTables/sortedTable_' ...
            dataName '_' timeStartName.(dataName) timeName '.csv']);
        nSessS = max(unique(dataTable.session));

        for task = 1:length(taskNames)
            taskName = taskNames{task};
            % if feedback, then also read the manipulations:
            if strcmp(dataName,'feedback')
                behav.(dataName).(taskName).(timeName).manip = ...
                    assignTable.(['manip' taskName(1:3)]);
            end

            % save demographic data:
            age_cell = cell(nSubs, 1);
            gender_cell = cell(nSubs, 1);
            hand_cell = cell(nSubs, 1);
            for sub = 1:length(uniIDs)
                subID = uniIDs{sub};
                demogSub = demogTable( strcmp( demogTable.ID, subID ) , : );
                age_cell{sub} = demogSub.AgeYears;
                gender_cell{sub} = demogSub.Sex{1};
```

```
                hand_cell{sub} = demogSub.Hand{1};
            end
            behav.(dataName).(taskName).(timeName).demog.age = age_cell;
            behav.(dataName).(taskName).(timeName).demog.gender =
gender_cell;
            behav.(dataName).(taskName).(timeName).demog.hand = hand_cell;
            behav.(dataName).(taskName).(timeName).demog.ID = uniIDs;

            %
            for dev = devs.(dataName).(taskName)
                if dev == 0
                    nTrialsDev = nTrialsDevSessImp;
                else
                    nTrialsDev = nTrialsDevSessPos;
                end
                if dev < 0
                    devName = ['m' num2str(abs(dev))];
                else
                    devName = num2str(dev);
                end
                for sess = 1:nSessS
                    tableTaskDevSess = dataTable( strcmp( ...
                        dataTable.task,taskName) & ...
                        (dataTable.dev == dev) & ...
                        (dataTable.session == sess), : );

                    % save RTs:
                    rtMat = nan(nSubs, nTrialsDev);
                    tempMissChs = nan(nSubs, nTrialsDev);
                    for sub = 1:length(uniIDs)
                        subID = uniIDs{sub};
                        rtMat(sub,:) = tableTaskDevSess( strcmp( ...
                            tableTaskDevSess.ID, subID ) , : ).rt';
                        tempMissChs(sub,:) = tableTaskDevSess( strcmp( ...
                            tableTaskDevSess.ID, subID ) , : ...
                            ).(relFields.(dataName){1})';
                    end
                    % omit missing decisions:
                    rtMat( tempMissChs == 999 ) = NaN;

                    behav.(dataName).(taskName).(timeName).(['sess' ...
                        num2str(sess)]).(['dev' devName]...
                        ).rt.mat = rtMat;
                    behav.(dataName).(taskName).(timeName).(['sess' ...
                        num2str(sess)]).(['dev' devName]...
                        ).rt.mean = mean(rtMat,2,'omitnan');

                    % save responses:
                    for f = 1:length(relFields.(dataName))
                        fieldName = relFields.(dataName){f};
```

```
                        relMat = nan(nSubs, nTrialsDev);
                        for sub = 1:length(uniIDs)
                            subID = uniIDs{sub};
                            relMat(sub,:) = tableTaskDevSess( strcmp( ...
                                tableTaskDevSess.ID, subID ) , : ).( ...
                                fieldName)';
                        end
                        relMat( isnan(rtMat) ) = NaN; % omit irrelevant/
missing RTs
                        relMat( relMat == 999 ) = NaN; % omit missing
decisions
                        behav.(dataName).(taskName).(timeName).(['sess' ...
                            num2str(sess)]).(['dev' devName]...
                            ).(fieldName).mat = relMat;
                        behav.(dataName).(taskName).(timeName).(['sess' ...
                            num2str(sess)]).(['dev' devName]...
                            ).(fieldName).mean = mean(relMat,2,'omitnan');
                    end

                end
            end
        end
    end
end

save('behavioralData.mat','behav');
```

Fig. 1 - stability - ICB in the first session:

Load processed data and definitions:

```
%load('behavioralDefs.mat');
%load('behavioralData.mat');
```

Compute performance in stability study:

Read stability data:

```
dat = 1;
dataName = dataNames{dat};
timeNames = dataTimeGroupNames.(dataName);
timeNames2 = dataTimeGroupNames2.(dataName);
for task = 1:length(taskNames)
    taskName = taskNames{task};
    lastPar = 0;
    pMat.(taskName) = nan(183,11);
    timeCell = cell(183,1);
    for ti = 1:length(timeNames)-1
        timeName = timeNames{ti};
        timeName2 = timeNames2{ti};
        nSubsTime = length( behav.(dataName).Vertical.(timeName ...
```

```
            ).sess1.dev0.response.mean );
        timeCell(lastPar+1:lastPar+nSubsTime) = {timeName2};
        DEV = devs.(dataName).(taskName);
        for d = 1:length(DEV)
            dev = DEV(d);
            if dev < 0
                devName = ['m' num2str(abs(dev))];
            else
                devName = num2str(dev);
            end
            pMat.(taskName)( lastPar+1:lastPar+nSubsTime, d ) = ...
                behav.(dataName).(taskName).(timeName).sess1.(...
                ['dev' devName]).response.mean;
        end
        lastPar = lastPar + nSubsTime;
    end
end
```

Compute performance in vertical task:

Note that performance is measured from possible trials (dev~=0) of the first session.

```
performanceVertical = 0.5 * ( 1 - mean( pMat.Vertical(:,1:5), 2 ) + ...
    mean( pMat.Vertical(:,7:11), 2 ) );
performanceVertical_avg = mean(100 * performanceVertical)
```

```
performanceVertical_avg = 92.0601
```

```
performanceVertical_std = std(100 * performanceVertical)
```

```
performanceVertical_std = 5.3114
```

```
performanceVertical_minmax = 100 * [min(performanceVertical), ...
    max(performanceVertical)]
```

```
performanceVertical_minmax = 1×2
   62.0000   99.5000
```

Compute performance in horizontal task:

```
performanceHorizontal = 0.5 * ( 1 - mean( pMat.Horizontal(:,1:5), 2 ) + ...
    mean( pMat.Horizontal(:,7:11), 2 ) );
performanceHorizontal_avg = mean(100 * performanceHorizontal)
```

```
performanceHorizontal_avg = 98.5738
```

```
performanceHorizontal_std = std(100 * performanceHorizontal)
```

```
performanceHorizontal_std = 1.7894
```

```
performanceHorizontal_minmax = 100 * [min(performanceHorizontal), ...
    max(performanceHorizontal)]
```

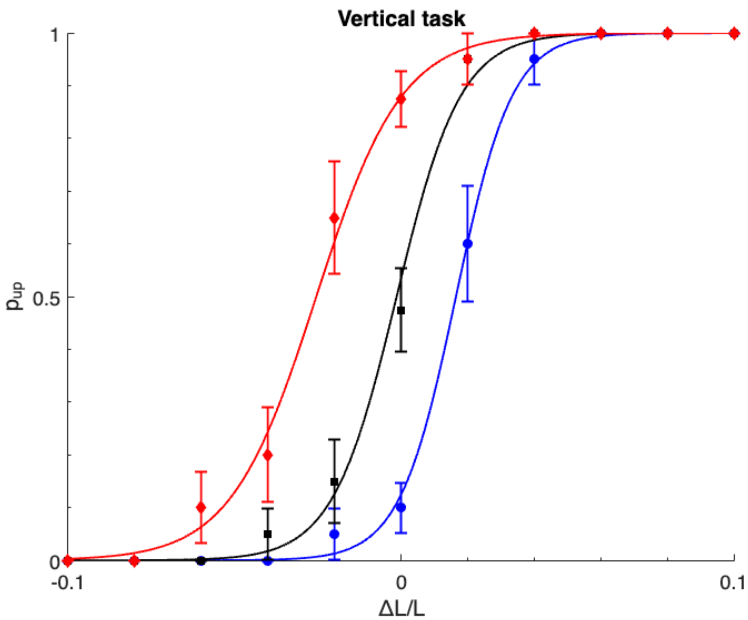
```
performanceHorizontal_minmax = 1×2
   89.5000  100.0000
```

Fig. 1A (&S4A): Psychometric curves of 3 example participants:

Note that different example participants were selected for the vertical and horizontal tasks.

```
% Define example participants for each task:
subPsycho.Vertical.group = {'months3','month','week'};
subPsycho.Vertical.locInGroup = [9,28,22];
subPsycho.Vertical.prop_up = nan(1,3);
subPsycho.Horizontal.group = {'week','hour','months8'};
subPsycho.Horizontal.locInGroup  = [8,11,16];
subPsycho.Horizontal.prop_up = nan(1,3);
cols = {'blue', 'black', 'red'};
marks = {'o', 's', 'd'};

% Read raw data of example participants and ML fit logistic curve:
for task = 1:length(taskNames)
    taskName = taskNames{task};
    devVect = devs.(dataName).(taskName) / toNormDev.(taskName);
    if task==1
        figName = 'Figure1A';
    elseif task==2
        figName = 'FigureS4A';
    end
    fig = figure;
    for k = 1:3
        col = cols{k};
        mark = marks{k};
        subGroup = subPsycho.(taskName).group{k};
        subLocInGroup = subPsycho.(taskName).locInGroup(k);
        subID = behav.stability.Vertical.
(subGroup).demog.ID{subLocInGroup};
        % Read group's raw response data:
        dataTable = readtable([dataName '/sortedTables/sortedTable_' ...
            dataName '_' timeStartName.(dataName) subGroup '.csv']);
        % Read participant's data in session 1 and specific task:
        subTable = dataTable( strcmp(dataTable.ID,subID) & ...
            (dataTable.session==1) & strcmp(dataTable.task,taskName), ...
            {'dev', 'response'} );
        stim = subTable.dev / toNormDev.(taskName); % normalized dev
        response = subTable.response;
        T_sub = table(stim(:), response(:), 'VariableNames', ...
            {'Stim', 'Response'});
        % Fit logistic regression model:
        mdl = fitglm(T_sub, 'Response ~ Stim', 'Distribution', 'binomial');
        % Extract parameters:
        intercept = mdl.Coefficients.Estimate(1);  % b0
        slope = mdl.Coefficients.Estimate(2);
        % Plot fitted logistic curve:
        x_vals = linspace(min(stim), max(stim), 100);
        y_vals = 1 ./ (1 + exp(-(intercept + slope * x_vals)));
```

```
        plot(x_vals, y_vals, col, 'LineWidth', 1); hold on;
        % Plot empirical data:
        stim_levels = unique(stim);
        prop_up = arrayfun(@(s) mean(response(stim == s)), stim_levels);
        subPsycho.(taskName).prop_up(k) = prop_up(6);
        se_prop = arrayfun(@(s) sqrt(mean(response(stim == s)) * ...
            (1 - mean(response(stim == s))) / sum(stim == s)), stim_levels);
        errorbar( stim_levels, prop_up, se_prop, ...
            'MarkerEdgeColor', 'none', 'MarkerSize', 5, 'Marker', mark, ...
            'LineStyle', 'none', 'lineWidth', 1, 'color', col, ...
            'MarkerFaceColor', col ); hold on;
    end
    xlim([min(stim_levels),max(stim_levels)]);
    ylim([0,1]); box off; legend off;
    xlabel(xLab.(taskName));
    ylabel(yLab.(taskName));
    ggg = gca;
    ggg.XMinorTick = 'on';
    ggg.YMinorTick = 'on';
    xticks(-0.1:0.1:0.1); yticks(0:0.5:1);
    title([taskName ' task']);
    savefig(fig, ['figures/' figName '.fig'])
end
```



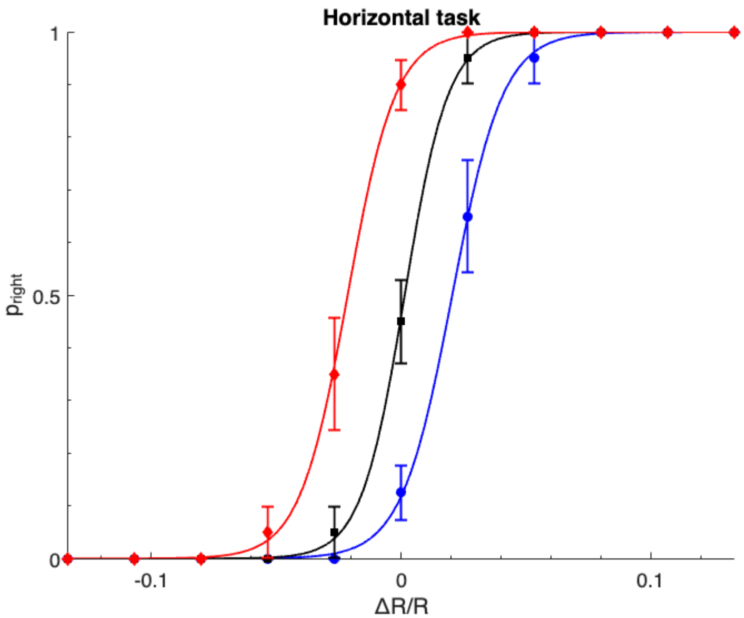
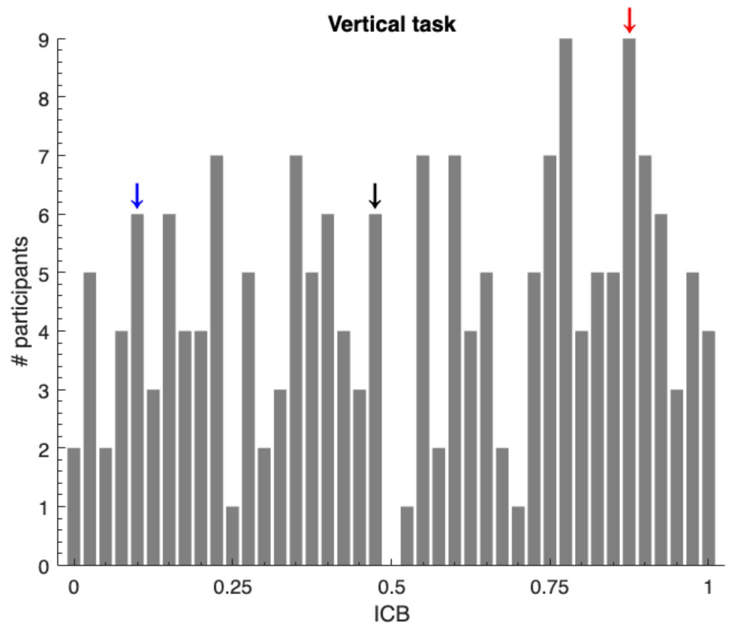


Fig. 1B (&S4B): ICB (Idiosyncratic Choice Bias) distribution:

The ICB is measured from each participant's reponses in the impossible trials (dev=0).

```
for task = 1:length(taskNames)
    taskName = taskNames{task};
    edges = linspace(0,1,42);
    ICB_BL_pdf = histcounts( pMat.(taskName)(:,6), 'binEdges', edges );
    if task==1
        figName = 'Figure2A';
    elseif task==2
        figName = 'FigureS4B';
    end
    fig = figure;
    bar( 0:(1/40):1, ICB_BL_pdf, 'FaceColor', [.5 .5 .5], 'edgeColor', ...
        'none' );
    xlim([-0.025,1.025]);
    box off;
    xlabel('ICB');
    ylabel('# participants');
    ggg = gca; ggg.XMinorTick = 'on'; ggg.YMinorTick = 'on';
    xticks(0:.25:1); hold on;
    % plot ICBs that correspond to the 3 psychometric curves:
    for k = 1:3
        col = cols{k};
        ICB_subPsy = subPsycho.(taskName).prop_up(k);
        relatedPDF = ICB_BL_pdf( find( 0:40 == round(40*ICB_subPsy) ) );
        text( ICB_subPsy, relatedPDF, '\downarrow', 'color', col, ...
            'FontSize',15, 'HorizontalAlignment', 'center', ...
            'VerticalAlignment', 'bottom', 'FontWeight', 'bold');
        hold on;
```

```
    end
    title([taskName ' task']);
    savefig(fig, ['figures/' figName '.fig'])
end
```



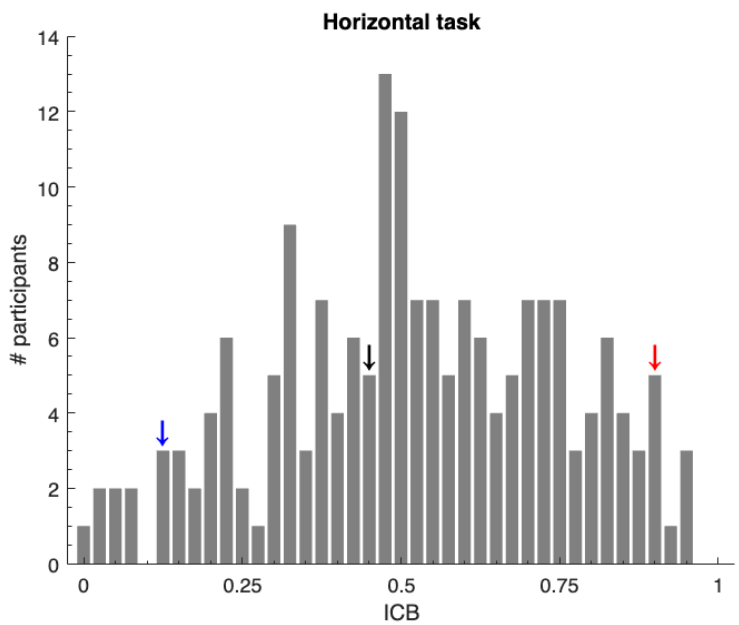


Fig. 1C (&S4D): raw vs psychometric fit ICB:

Fit psychometric curve of individual participants:

```
dataNames = {'stability', 'feedback'};
dataTimeGroupNames.feedback = {'day','month'};
dataTimeGroupNames.stability = {'hour','day','week','month','months3',...
    'months8','years'};
dataTimeGroupNames2.stability = {'hour','day','week','month','3 months',...
```

```
    '8 months','22 months'};
dataTimeGroupNames2.feedback = dataTimeGroupNames.feedback;
respName.stability = 'response';
respName.feedback = 'oldResponse';
taskNames = {'Vertical','Horizontal'};
toNormDev.Vertical = 100;
toNormDev.Horizontal = 75;
devs.stability.Vertical = -10:2:10;
devs.feedback.Vertical = -10:2:10;
devs.stability.Horizontal = -10:2:10;
devs.feedback.Horizontal = -5:1:5;
numSessions.stability = 2;
numSessions.feedback = 3;

sess = 1;

for dat = 1:numel(dataNames)
    dataName = dataNames{dat};
    timeNames = dataTimeGroupNames.(dataName);
    responseName = respName.(dataName);
    for ti = 1:numel(timeNames)
        timeName = timeNames{ti};
        subIDs = behav.(dataName).Vertical.(timeName).demog.ID;
        numSubsTimeName = size( subIDs, 1 );
        % Read delay group's raw response data:
        dataTable = readtable([dataName '/sortedTables/sortedTable_' ...
            dataName '_' timeStartName.(dataName) timeName '.csv']);
        for task = 1:numel(taskNames)
            taskName = taskNames{task};
            slope_subs = nan(numSubsTimeName,1);
            bias_subs = nan(numSubsTimeName,1);
            p_subDev = nan(numSubsTimeName,11);
            for sub = 1:numSubsTimeName
                subID = subIDs{sub};
                % Read participant's data in session 1 and specific task:
                colNames = {'dev', respName.(dataName)};
                subTable = dataTable( strcmp(dataTable.ID,subID) & ...
                    (dataTable.session==1) &
strcmp(dataTable.task,taskName), ...
                    colNames );
                stim = subTable.dev / toNormDev.(taskName); % normalized dev
                response = subTable.(colNames{2});
                T_sub = table(stim(:), response(:), 'VariableNames', ...
                    {'Stim', 'Response'});

                % Fit logistic regression model:
                mdl = fitglm(T_sub, 'Response ~ Stim', 'Distribution',
'binomial');
                % Extract parameters:
```

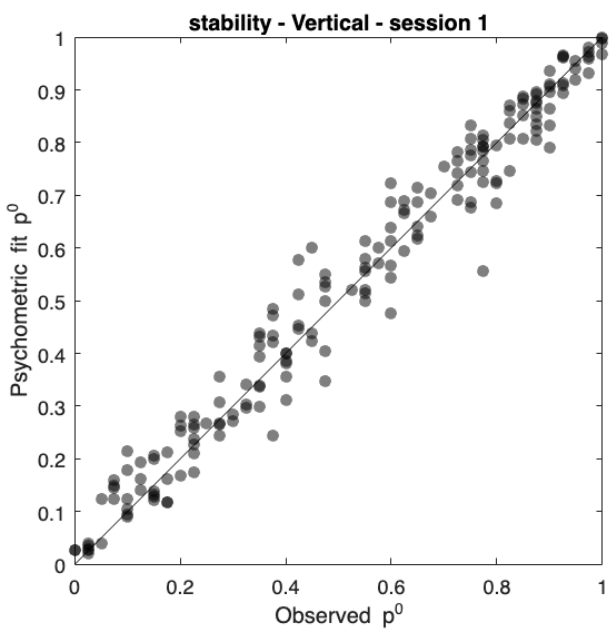
```
                bias_subs(sub) = mdl.Coefficients.Estimate(1);  % b0,
intercept
                slope_subs(sub) = mdl.Coefficients.Estimate(2);
                % Also store observed and fit p:
                stim_levels = unique(stim);
                prop = arrayfun(@(s) mean(response(stim == s)),
stim_levels);
                p_subDev(sub,:) = prop';
            end
            pStrct.(dataName).(taskName).(timeName).(['sess' ...
                num2str(sess)]) = p_subDev;
            slpStrct.(dataName).(taskName).(timeName).(['sess' ...
                num2str(sess)]) = slope_subs;
            biasStrct.(dataName).(taskName).(timeName).( ...
                ['sess' num2str(sess)]) = bias_subs;
            clear p_subDev slope_subs bias_subs;
        end
    end
end
```

Plot ICB I raw vs ICB I psychometric fit:

```
dTimeGroupNames.feedback = {'day','month'};
dTimeGroupNames.stability = {'hour','day','week','month','months3',...
    'months8'};

for task = 1:numel(taskNames)
    taskName = taskNames{task};
    obs_P0_task_cell = cell( numel(dataNames), 1 );
    psyc_P0_task_cell = cell( numel(dataNames), 1 );
    for dat = 1:numel(dataNames)
        dataName = dataNames{dat};
        timeNames = dTimeGroupNames.(dataName);
        responseName = respName.(dataName);
        obs_P0_dat_cell = cell( numel(timeNames), 1 );
        psyc_P0_dat_cell = cell( numel(timeNames), 1 );
        for ti = 1:numel(timeNames)
            timeName = timeNames{ti};
            obs_P0 = pStrct.(dataName).(taskName).(timeName).sess1(:,6);
            slope_subs = slpStrct.(dataName).(taskName).(timeName).sess1;
            bias_subs = biasStrct.(dataName).(taskName).(timeName).sess1;
            psyc_P0 = 1 ./ (1 + exp(-bias_subs));
            obs_P0_dat_cell{ti} = obs_P0;
            psyc_P0_dat_cell{ti} = psyc_P0;
        end
        obs_P0_dat = cell2mat(obs_P0_dat_cell);
        psyc_P0_dat = cell2mat(psyc_P0_dat_cell);

        % Display 1st session ICB raw.psych corr. - by dataset x task:
        disp([dataName ' - ' taskName ...
            ': obs/psychometric fit p0 correlation (1st session):'])
```

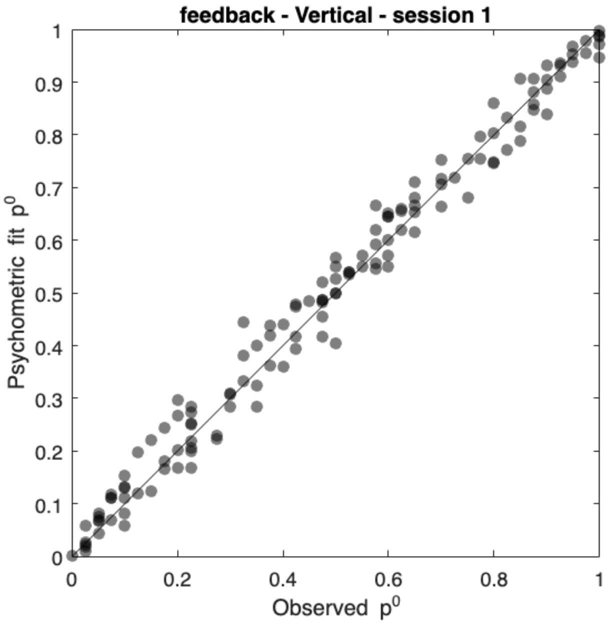
```
        [rho,pval] = corr( obs_P0_dat, psyc_P0_dat )

        % Plot raw vs psych. ICB:
        fig = figure;
        plot( [0,1], [0,1], 'k-' );
        hold on;
        scatter( obs_P0_dat, psyc_P0_dat, [], 'k', ...
            'filled', 'MarkerFaceAlpha', .5);
        xlabel('Observed p^0');
        ylabel('Psychometric fit p^0');
        title([dataName ' - ' taskName ' - session 1']);
        axis square;
        if strcmp(dataName,'stability')
            if task==1
                figName = 'Figure1C';
            elseif task==2
                figName = 'FigureS4D';
            end
            savefig(fig, ['figures/' figName '.fig']);
        end
        obs_P0_task_cell{dat} = obs_P0_dat;
        psyc_P0_task_cell{dat} = psyc_P0_dat;
    end
    obs_P0_task = cell2mat( obs_P0_task_cell );
    psyc_P0_task = cell2mat( psyc_P0_task_cell );
    obs_P0_sess1.(taskName) = obs_P0_task;
    psyc_P0_sess1.(taskName) = psyc_P0_task;
end
```

```
stability - Vertical: obs/psychometric fit p0 correlation (1st session):
rho = 0.9846
pval = 5.8464e-139
```

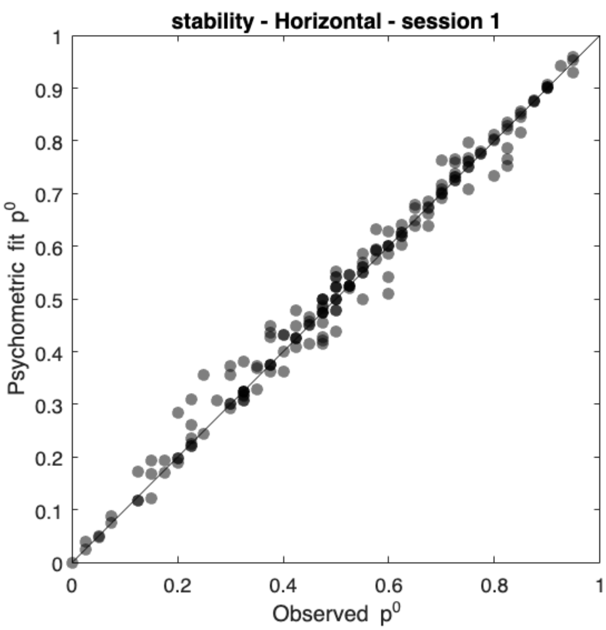



```
feedback - Vertical: obs/psychometric fit p0 correlation (1st session):
```

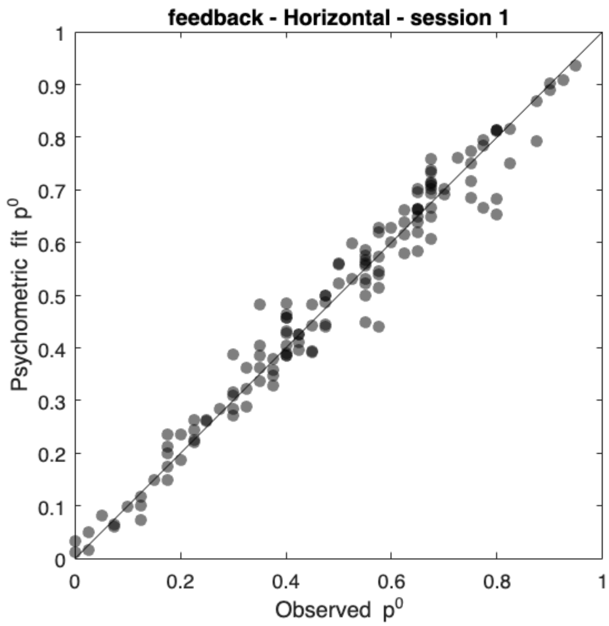
```
rho = 0.9920
pval = 2.4288e-122
```




```
stability - Horizontal: obs/psychometric fit p0 correlation (1st session):
rho = 0.9924
pval = 1.6284e-166
```




```
feedback - Horizontal: obs/psychometric fit p0 correlation (1st session):
rho = 0.9816
pval = 3.3357e-98
```




```
% Display 1st session ICB raw/psych corr. - by task:
disp('Vertical: obs/psychometric fit p0 correlation (1st session):')
```

```
Vertical: obs/psychometric fit p0 correlation (1st session):
```

```
[rho,pval] = corr( obs_P0_sess1.Vertical, ...
    psyc_P0_sess1.Vertical )
```

```
rho = 0.9878
pval = 3.4099e-258
```

```
disp('Horizontal: obs/psychometric fit p0 correlation (1st session):')
```

```
Horizontal: obs/psychometric fit p0 correlation (1st session):
```

```
[rho,pval] = corr( obs_P0_sess1.Horizontal, ...
    psyc_P0_sess1.Horizontal )
```

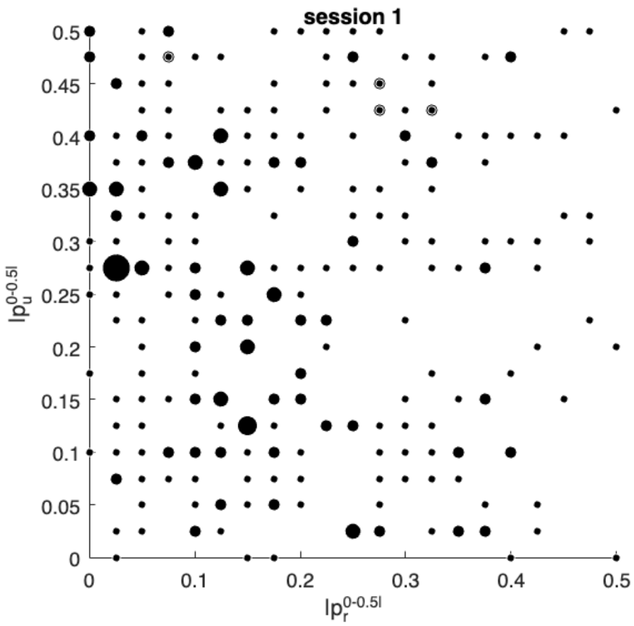
```
rho = 0.9878
pval = 2.8407e-258
```

```
dat = 1;
```

Fig. S10: | ICB -.5 | vertical vs horizontal in 1st session - both datasets:

```
fig = figure;
ICB_hor_all = obs_P0_sess1.Horizontal;
ICB_ver_all = obs_P0_sess1.Vertical;
magICB_hor_all = abs( ICB_hor_all -.5);
magICB_ver_all = abs( ICB_ver_all -.5);
bias_hor_ver_unique = unique( [magICB_hor_all, magICB_ver_all], 'rows' );
all_mSize_check = nan(1, length(bias_hor_ver_unique) );
for i = 1:length(bias_hor_ver_unique)
    mSize = sum( ( magICB_hor_all == bias_hor_ver_unique(i,1) ) .* ...
```

```
        ( magICB_ver_all == bias_hor_ver_unique(i,2) ) );
    all_mSize_check(i) = mSize;
    plotDots = plot( bias_hor_ver_unique(i,1), ...
        bias_hor_ver_unique(i,2), ...
        'Marker', 'o', 'MarkerSize', 4+2*(mSize-1), ...
        'MarkerFaceColor', [0,0,0], 'Color', [1 1 1] ); hold on;
end
xlabel('|p_{r}^0-0.5|');
ylabel('|p_{u}^0-0.5|');
title('session 1');
box off; axis square;
```




```
savefig(fig, 'figures/FigureS10.fig')
% compute corr.:
disp('Horizontal/Vertical obs. p0 correlation (1st session):')
```

```
Horizontal/Vertical obs. p0 correlation (1st session):
```

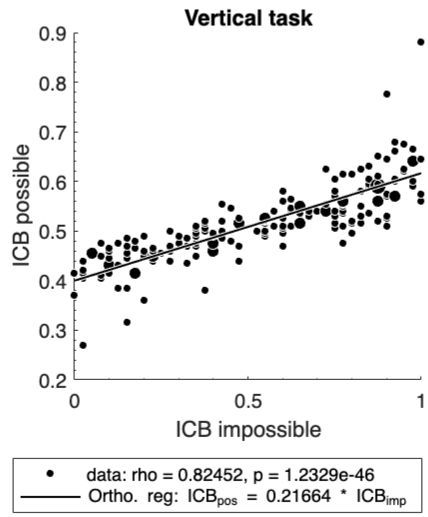
```
[rho,pval] = corr( magICB_hor_all, magICB_ver_all )
```

```
rho = -0.0419
pval = 0.4556
```

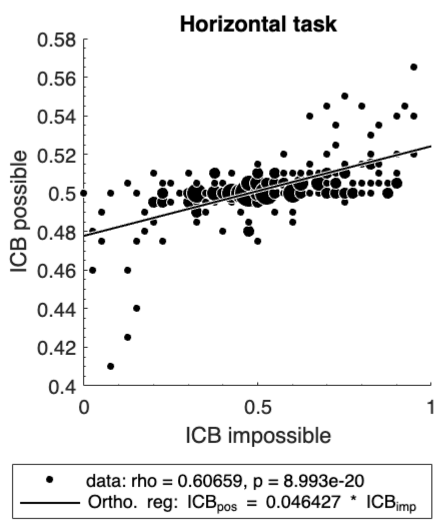
Fig. S1 (&S4C): Impossible vs possible ICB:

```
% Extended data Fig. 1 - ICB impossible vs. possible:
for task = 1:length(taskNames)
    taskName = taskNames{task};
    if task==1
        figName = 'FigureA1';
    elseif task==2
        figName = 'FigureS4C';
    end
```

```
    fig = figure;
    pPos = mean( pMat.(taskName)(:,[1:5,7:end]), 2 );
    pImp = pMat.(taskName)(:,6);
    bias_imp_pos_unique = unique( [pImp, pPos], 'rows' );
    all_mSize_check = nan(1, length(bias_imp_pos_unique) );
    for i = 1:length(bias_imp_pos_unique)
        mSize = sum( ( pImp == bias_imp_pos_unique(i,1) ) .* ...
            ( pPos == bias_imp_pos_unique(i,2) ) );
        all_mSize_check(i) = mSize;
        plotDots = plot( bias_imp_pos_unique(i,1), ...
            bias_imp_pos_unique(i,2), ...
            'Marker', 'o', 'MarkerSize', 4+2*(mSize-1), ...
            'MarkerFaceColor', [0,0,0], 'Color', [1 1 1] ); hold on;
    end
    % Orthogonal regression:
    v = pca([pImp pPos]);
    slope = v(2,1)/v(1,1);
    k = mean( pPos ) - slope * mean( pImp );
    plot( [0,1], slope * [0,1] + k, 'Color', [1,1,1], 'lineWidth', 2 );
    hold on;
    h = plot( [0,1], slope * [0,1] + k, 'Color', [0,0,0], 'lineWidth', 1 );
    hold on;
    mean_imp = mean( pImp );
    mean_pos = mean( pPos );
    sem_imp = std( pImp ) / sqrt( length(pImp) );
    sem_pos = std( pPos ) / sqrt( length(pPos) );
    [rho, pVal] = corr( pImp, pPos );
    legend( [plotDots,h], ['data: rho = ' num2str(rho) ...
        ', p = ' num2str(pVal)], ...
        ['Ortho. reg: ICB_{pos} = ' num2str(slope) ' * ICB_{imp}'], ...
        'Location','SouthOutside');
    xlabel('ICB impossible');
    ylabel('ICB possible')
    box off; axis square;
    ggg = gca; ggg.XMinorTick = 'on'; ggg.YMinorTick = 'on';
    title([taskName ' task']);
    savefig(fig, ['figures/' figName '.fig']);
    [R,P,RL,RU] = corrcoef( pImp, pPos, 'Alpha', 0.05 )
end
```




```
R = 2×2
    1.0000    0.8245
    0.8245    1.0000
P = 2×2
    1.0000    0.0000
    0.0000    1.0000
RL = 2×2
    1.0000    0.7718
    0.7718    1.0000
RU = 2×2
    1.0000    0.8660
    0.8660    1.0000
```




```
R = 2×2
    1.0000    0.6066
    0.6066    1.0000
P = 2×2
    1.0000    0.0000
    0.0000    1.0000
RL = 2×2
    1.0000    0.5061
    0.5061    1.0000
RU = 2×2
    1.0000    0.6909
```

```
    0.6909    1.0000
```

Fig. 1 - stabiliy - tests:

Read participants ICBs in the first session:

```
ICB1 = pMat.Vertical(:,6);
```

Binomial tests for significant ICBs:

Count praticipants with significant ICBs (not corrected for mupltiple comparison) w/ 2-sided binomial tests:

```
sigBiasesLoc = (myBinomTest( 40*ICB1, 40, .5 ) < .05);
sumSigBias = sum( sigBiasesLoc );
percentSigBias = mean( sigBiasesLoc )
```

```
percentSigBias = 0.6885
```

```
percentSigUpBias = mean( sigBiasesLoc & (ICB1 > .5) )
```

```
percentSigUpBias = 0.3934
```

```
percentSigDownBias = mean( sigBiasesLoc & (ICB1 < .5) )
```

```
percentSigDownBias = 0.2951
```

```
% significant biases correspond to pUp<=0.325(13/40) or pUp>=0.675(27/40):
pdfBinom = pdf('Binomial',0:40,40,0.5);
maximalSigAlpha = sum(pdfBinom(1:14))*2;
```

Compute significance for the 3 participants in Fig. 1A:

```
pUp_sig_mat = nan(3,2);
for k =1:3
    pUp_sig_mat(k,1) = pMat.Vertical( subPsycho.Vertical(k), 6 );
    pUp_sig_mat(k,2) = myBinomTest( 40 * pUp_sig_mat(k,1), 40, 1/2 );
end
disp('significance for the 3 participants:')
```

```
significance for the 3 participants:
```

```
pUp_sig_mat
```

```
pUp_sig_mat = 3×2
    0.1000    0.0000
    0.4750    0.8746
    0.8750    0.0000
```

Compute ICB mean absolute deviation:

```
% MAD ICB:
mad_ICB = mad( ICB1 )
```

```
mad_ICB = 0.2633
```

```
% mean+-SEM ICB in possible trials:
```

```
ICB1pos = mean( pMat.Vertical(:,[1:5,7:end]), 2 );
disp('MAD ICB possible 1st session:')
```

```
MAD ICB possible 1st session:
```

```
mad( ICB1pos )
```

```
ans = 0.0574
```

Compute ICB correlation in im/possible trials:

```
disp('ICB im/possible correlation 1st session:')
```

```
ICB im/possible correlation 1st session:
```

```
[cRho, cPValue] = corr( ICB1, ICB1pos )
```

```
cRho = 0.8245
cPValue = 1.2329e-46
```

Bootstrap test for global bias:

```
nSim = 1e6;
nImpossibleTrials = 40;
sim_avgPup = nan( nSim,1 );
for sim = 1:nSim
    pUp_sim = (1 / nImpossibleTrials) * binornd( nImpossibleTrials, ...
        datasample( ICB1, length(ICB1) )  );
    sim_avgPup(sim) = mean( pUp_sim );
end
disp('bootstrap global bias 1st session:')
```

```
bootstrap global bias 1st session:
```

```
avgPup_95CI = quantile( sim_avgPup, [.025, 0.975] )
```

```
avgPup_95CI = 1×2
    0.4898    0.5779
```

Bootstrap the standard deviation:

```
nSim = 1e5;
real_avgPup = mean( ICB1 ); % Bernoulli process with p = average pUp
real_stdPup = std( ICB1 );
sim_stdPup = std( (1 / nImpossibleTrials) * ...
    binornd( nImpossibleTrials, real_avgPup, length(ICB1), nSim  ) );
disp('bootstrap std 1st session:')
```

```
bootstrap std 1st session:
```

```
sigLevel = sum( sim_stdPup > real_stdPup ) / nSim
```

```
sigLevel = 0
```

sig. test ICB dist:

```
nSim = 1e5;
```

```
samp_std = nan( nSim,1 );
bino_std = nan( nSim,1 );
for s = 1:nSim
    samp = datasample( ICB1, length(ICB1) );
    samp_std(s) = std( samp );
    samp_mean = mean(samp);
    bino_std(s) = std( (1 / nImpossibleTrials) * binornd( ...
        nImpossibleTrials, samp_mean, length(ICB1), 1 ) );
end
disp('sig. test ICB dist:')
```

```
sig. test ICB dist:
```

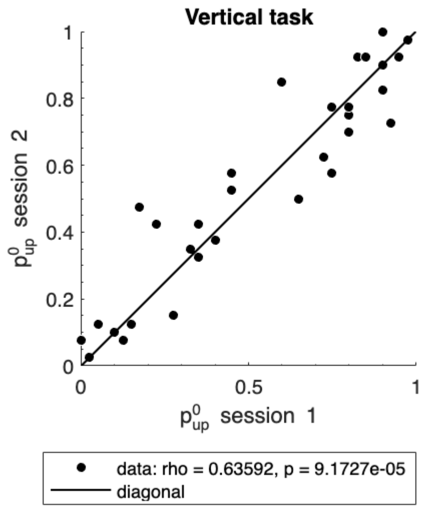
```
sigLevel = sum( bino_std > samp_std ) / nSim
```

```
sigLevel = 0
```

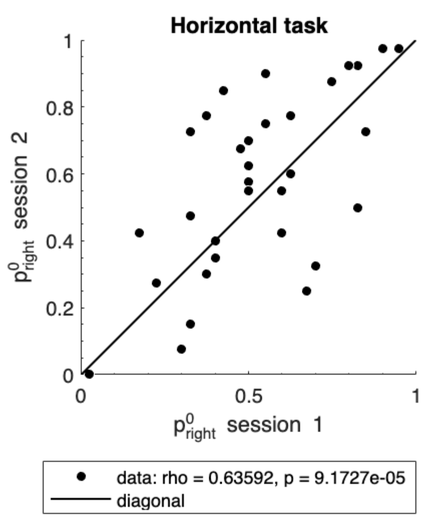
Fig. 2 - stabiliy - ICB in the first vs. last session

Fig. 2B: 8 months delay group

```
dataName = 'stability';
timeName = 'months8';
for task = 1:length(taskNames)
    taskName = taskNames{task};
    fig = figure;
    if task==1
        figName = 'Figure2B';
    elseif task==2
        figName = 'FigureS5A';
    end
    p1 = behav.(dataName).(taskName).(timeName).sess1.dev0.response.mean;
    p2 = behav.(dataName).(taskName).(timeName).sess2.dev0.response.mean;
    plotDots = plot(p1, p2, 'Marker','o','MarkerSize',5, ...
        'MarkerFaceColor', [0,0,0],'Color',[1 1 1]); hold on;
    h = plot( [0,1], [0,1], 'Color', [0,0,0], 'lineWidth', 1 );
    hold on;
    legend( [plotDots,h], ['data: rho = ' num2str(rho) ', p = ' ...
        num2str(pVal)], 'diagonal', 'Location','SouthOutside');
    xlabel([yLab.(taskName) '^0 session 1']);
    ylabel([yLab.(taskName) '^0 session 2']);
    box off; axis square; xlim([0,1]); ylim([0,1]);
    ggg = gca; ggg.XMinorTick = 'on'; ggg.YMinorTick = 'on';
    title([taskName ' task']);
    [R,P,RL,RU] = corrcoef( p1, p2, 'Alpha', 0.05 )
    savefig(fig, ['figures/' figName '.fig']);
end
```




```
R = 2×2
    1.0000    0.9275
    0.9275    1.0000
P = 2×2
    1.0000    0.0000
    0.0000    1.0000
RL = 2×2
    1.0000    0.8554
    0.8554    1.0000
RU = 2×2
    1.0000    0.9643
    0.9643    1.0000
```




```
R = 2×2
    1.0000    0.6359
    0.6359    1.0000
P = 2×2
    1.0000    0.0001
    0.0001    1.0000
RL = 2×2
    1.0000    0.3691
    0.3691    1.0000
RU = 2×2
    1.0000    0.8059
```

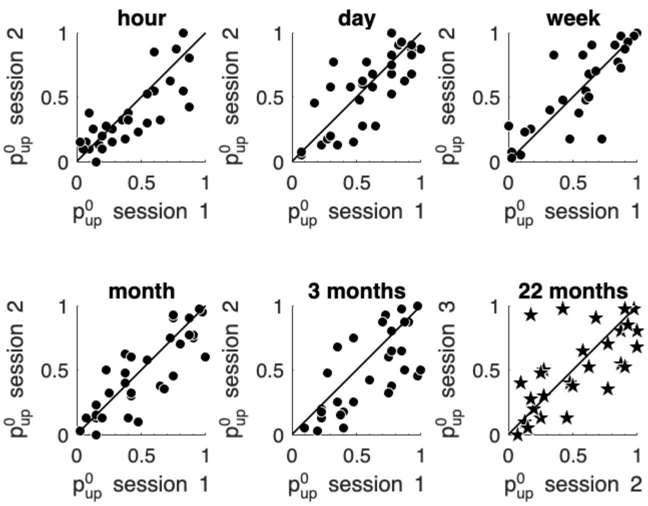
```
    0.8059    1.0000
```

Fig. S2A-F (&S5A): all other groups

```
timeNames = dataTimeGroupNames.stability( ...
    ~strcmp( dataTimeGroupNames.stability, 'months8' ) );
timeNames2 = dataTimeGroupNames2.stability( ...
    ~strcmp( dataTimeGroupNames.stability, 'months8' ) );
for task = 1:length(taskNames)
    taskName = taskNames{task};
    fig = figure;
    if task==1
        figName = 'FigureS2';
    elseif task==2
        figName = 'FigureS5A2';
    end
    for ti = 1:length(timeNames)
        timeName = timeNames{ti};
        timeName2 = timeNames2{ti};
        subplot(2,3,ti);
        if strcmp(timeName,'years')
            sessA = '2';
            sessB = '3';
            mark = 'Pentagram';
            markSize = 10;
        else
            sessA = '1';
            sessB = '2';
            mark = 'o';
            markSize = 5;
        end
        pA = behav.stability.(taskName).(timeName).sess1.dev0.response.mean;
        pB = behav.stability.(taskName).(timeName).sess2.dev0.response.mean;
        plot(pA, pB, 'Marker',mark,'MarkerSize',markSize, ...
            'MarkerFaceColor', [0,0,0],'Color',[1 1 1]); hold on;
        plot( [0,1], [0,1], 'Color', [0,0,0], 'lineWidth', 1 );
        xlabel([yLab.(taskName) '^0 session ' sessA]);
        ylabel([yLab.(taskName) '^0 session ' sessB])
        title(timeName2);
        box off; axis square; xlim([0,1]); ylim([0,1]);
        ggg = gca; ggg.XMinorTick = 'on'; ggg.YMinorTick = 'on';
        disp([taskName ' - ' timeName2 ': ']);
        [R,P,RL,RU] = corrcoef( pA, pB, 'Alpha', 0.05 )
        savefig(fig, ['figures/' figName '.fig']);
    end

end
```

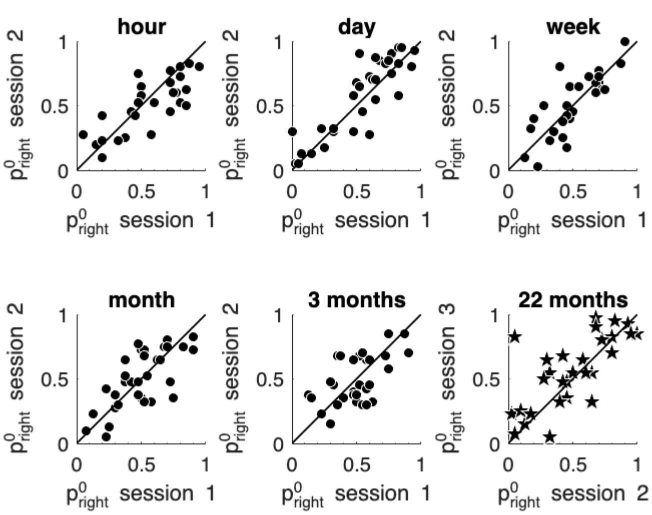
```
Vertical - hour:
R = 2×2
```

```
    1.0000    0.8078
    0.8078    1.0000
P = 2×2
    1.0000    0.0000
    0.0000    1.0000
RL = 2×2
    1.0000    0.6269
    0.6269    1.0000
RU = 2×2
    1.0000    0.9060
    0.9060    1.0000
Vertical - day:
R = 2×2
    1.0000    0.7757
    0.7757    1.0000
P = 2×2
    1.0000    0.0000
    0.0000    1.0000
RL = 2×2
    1.0000    0.5853
    0.5853    1.0000
RU = 2×2
    1.0000    0.8850
    0.8850    1.0000
Vertical - week:
R = 2×2
    1.0000    0.8188
    0.8188    1.0000
P = 2×2
    1.0000    0.0000
    0.0000    1.0000
RL = 2×2
    1.0000    0.6370
    0.6370    1.0000
RU = 2×2
    1.0000    0.9143
    0.9143    1.0000
Vertical - month:
R = 2×2
    1.0000    0.8443
    0.8443    1.0000
P = 2×2
    1.0000    0.0000
    0.0000    1.0000
RL = 2×2
    1.0000    0.7055
    0.7055    1.0000
RU = 2×2
    1.0000    0.9207
    0.9207    1.0000
Vertical - 3 months:
R = 2×2
    1.0000    0.7323
    0.7323    1.0000
P = 2×2
    1.0000    0.0000
    0.0000    1.0000
RL = 2×2
    1.0000    0.5054
    0.5054    1.0000
RU = 2×2
    1.0000    0.8645
    0.8645    1.0000
```




```
Vertical - 22 months:
R = 2×2
    1.0000    0.6699
    0.6699    1.0000
P = 2×2
    1.0000    0.0001
    0.0001    1.0000
RL = 2×2
    1.0000    0.4022
    0.4022    1.0000
RU = 2×2
    1.0000    0.8321
    0.8321    1.0000
Horizontal - hour:
R = 2×2
    1.0000    0.7768
    0.7768    1.0000
P = 2×2
    1.0000    0.0000
    0.0000    1.0000
RL = 2×2
    1.0000    0.5735
    0.5735    1.0000
RU = 2×2
    1.0000    0.8899
    0.8899    1.0000
Horizontal - day:
R = 2×2
    1.0000    0.8711
    0.8711    1.0000
P = 2×2
    1.0000    0.0000
    0.0000    1.0000
RL = 2×2
    1.0000    0.7503
    0.7503    1.0000
RU = 2×2
    1.0000    0.9356
    0.9356    1.0000
Horizontal - week:
R = 2×2
    1.0000    0.8024
    0.8024    1.0000
```

```
P = 2×2
    1.0000    0.0000
    0.0000    1.0000
RL = 2×2
    1.0000    0.6077
    0.6077    1.0000
RU = 2×2
    1.0000    0.9061
    0.9061    1.0000
Horizontal - month:
R = 2×2
    1.0000    0.7238
    0.7238    1.0000
P = 2×2
    1.0000    0.0000
    0.0000    1.0000
RL = 2×2
    1.0000    0.5063
    0.5063    1.0000
RU = 2×2
    1.0000    0.8547
    0.8547    1.0000
Horizontal - 3 months:
R = 2×2
    1.0000    0.5764
    0.5764    1.0000
P = 2×2
    1.0000    0.0009
    0.0009    1.0000
RL = 2×2
    1.0000    0.2728
    0.2728    1.0000
RU = 2×2
    1.0000    0.7756
    0.7756    1.0000
```




```
Horizontal - 22 months:
R = 2×2
    1.0000    0.7201
    0.7201    1.0000
P = 2×2
    1.0000    0.0000
    0.0000    1.0000
RL = 2×2
```

```
    1.0000    0.4803
    0.4803    1.0000
RU = 2×2
    1.0000    0.8597
    0.8597    1.0000
```

Fig. 2B - stabiliy - tests:

```
% Figure 2 tests (differences between means or variance in the first sess):
% Figure S2-2: Also, plot the summary of comparisons:
% Brown-Forsythe test computed by performing ANOVA on the absolute
% deviations of the data values from the group medians:
figure;
p = vartestn( pMat.Vertical(:,6), timeCell, 'TestType', 'BrownForsythe' )
```

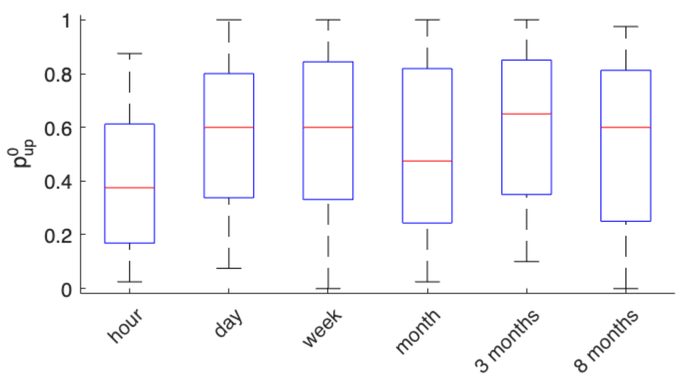
Group Summary Table

Group	Count	Mean	Std Dev
hour	29	0.40776	0.27598
day	32	0.5875	0.27068
week	27	0.55093	0.31535
month	33	0.53712	0.30715
3 months	30	0.5775	0.28942
8 months	32	0.53594	0.32066
Pooled	183	0.53388	0.29711

Brown-Forsythe statistic	0.593
Degrees of freedom	5, 177
p-value	0.7054

```
p = 0.7054
```

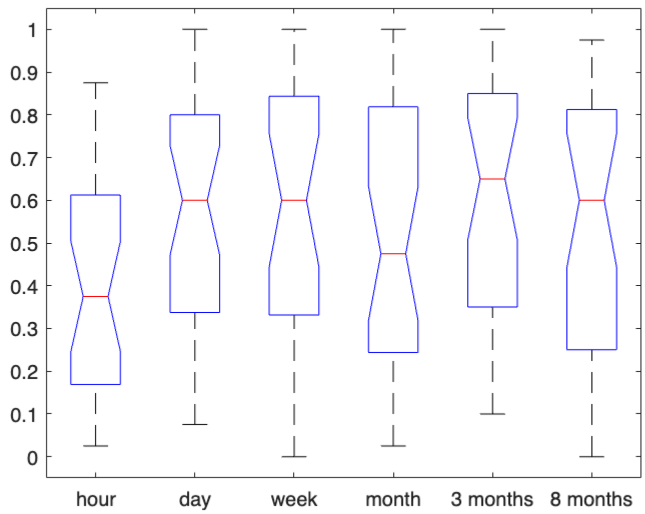
```
xtickangle(45); ylim([-.02,1.02]); ylabel('p_{up}^0'); box off;
```




```
% one-way ANOVA of ranks:
figure;
[p,~,stats] = kruskalwallis( pMat.Vertical(:,6), timeCell )
```

Kruskal-Wallis ANOVA Table

Source	SS	df	MS	Chi-sq	Prob>Chi-sq
Groups	19659.5	5	3931.91	7.01	0.2197
Error	490531.5	177	2771.36		
Total	510191	182			




```
p = 0.2197
stats = struct with fields:
      gnames: {6×1 cell}
           n: [29 32 27 33 30 32]
      source: 'kruskalwallis'
   meanranks: [69.2586 101.0938 94.9444 93.2121 99.5667 92.6875]
        sumt: 6012
```

Fig. 2C (&S5B) - stability - ICB correlation across sessions and tests:

Load processed data and definitions:

```
%load('behavioralDefs.mat');
%load('behavioralData.mat');
```

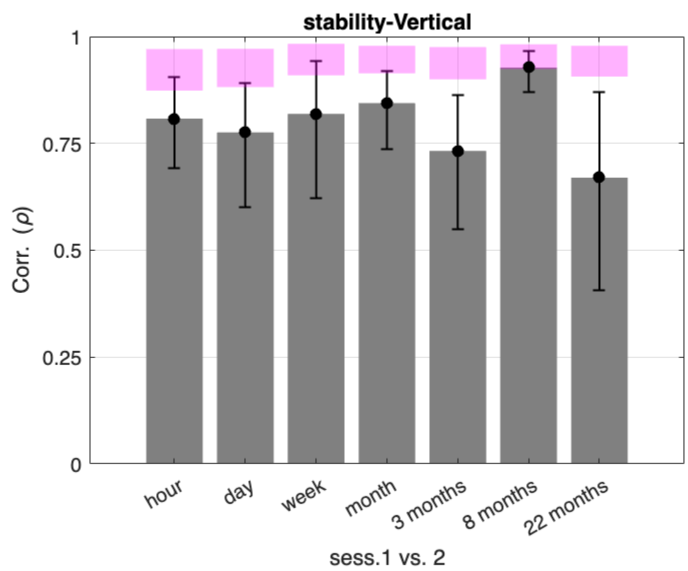
Compute delay-group between session ICB correlation and 95% CI's:

```
choiceFields.stability = 'response';
nLastSess.stability = 2;
nComps.stability = 1;
nSims = 1e5;
dataName = 'stability';

% read mean days between sessions:
deltaTimeTable = readtable('stability_deltaTime1stLast.csv');
addTimeName = '';
timeNames = dataTimeGroupNames.(dataName);
dayMean.(dataName) = nan(1,length(timeNames));
for ti = 1:length(timeNames)
    timeName = timeNames{ti};
    dayMean.(dataName)(ti) = deltaTimeTable( strcmp( ...
        deltaTimeTable.timeCondition, [addTimeName timeName]), : ).mean;
end

% Compute delay-group between session ICB correlation and 95% CI's:
dataName = dataNames{dat};
```

```
nComp = nComps.(dataName);
timeNames = dataTimeGroupNames.(dataName);
timeNames2 = dataTimeGroupNames2.(dataName);
for task = 1:length(taskNames)
    taskName = taskNames{task};
    figBars = figure;
    if task==1
        figName = 'Figure2C';
    elseif task==2
        figName = 'FigureS5B';
    end
    nSessions = nLastSess.(dataName);
    for oth = 1:(nSessions-1)
        for oth2 = oth+1:nSessions
            corrTask = nan(1,length(timeNames));
            sigTask = nan(1,length(timeNames));
            corrTask_95sim_sub = nan(2,length(timeNames));
            corrTask_95sim_noStab = nan(2,length(timeNames));
            corrTask_95sim_compStab = nan(2,length(timeNames));
            pVal_corrTask_sim_compStab = nan(1,length(timeNames));
            for ti = 1:length(timeNames)
                timeName = timeNames{ti};
                fieldName = choiceFields.(dataName);
                p1 = behav.(dataName).(taskName).(timeName).(...
                    ['sess' num2str(oth)]).dev0.(fieldName).mean;
                pOther = behav.(dataName).(taskName).(timeName).(...
                    ['sess' num2str(oth2)]).dev0.(fieldName).mean;
                [rho,pVal] = corr(p1,pOther);
                corrTask(ti) = rho;
                sigTask(ti) = pVal;
                simCorr = nan(nSims,1);
                simCorr_noStab = nan(nSims,1);
                simCorr_compStab = nan(nSims,1);
                for s = 1:nSims
                    locSim = datasample( 1:length(p1), length(p1) );
                    locSim2 = datasample( 1:length(p1), length(p1) );
                    % bootstrap corr by subjects:
                    p1Sim = p1(locSim);
                    pOtherSim = pOther(locSim);
                    simCorr(s) = corr(p1Sim,pOtherSim);
                    % bootstrap corr by subjects assuming no stability:
                    p1Sim = p1(locSim);
                    pOtherSim = pOther(locSim2);
                    simCorr_noStab(s) = corr(p1Sim,pOtherSim);
                    % assuming complete stability:
                    % Here, we boostap and also binomrnd the mean p's, to
                    % simulate the corr expected under the assumption that
                    % the inherent p hadn't changed. Note that this will
                    % only serve as a lower bound for complete stability,
                    % and that this simulation is biased, e.g.,
```

```
                % beacause it has the potential to decrease the
                % variance between participants.
                pMeanBoot = .5 * (p1(locSim) + pOther(locSim) );
                p1Sim = (1/nTrialsDevSessImp) * binornd( ...
                    nTrialsDevSessImp, pMeanBoot );
                pOtherSim = (1/nTrialsDevSessImp) * binornd( ...
                    nTrialsDevSessImp, pMeanBoot );
                simCorr_compStab(s) = corr(p1Sim,pOtherSim);
            end
            corrTask_95sim_sub(:,ti) = quantile( simCorr, [.025;.975] );
            corrTask_95sim_noStab(:,ti) = quantile( simCorr_noStab, ...
                [.025;.975] );
            corrTask_95sim_compStab(:,ti) = quantile( ...
                simCorr_compStab, [.025;.975] );
            pVal_corrTask_sim_compStab(ti) = mean( ...
                simCorr_compStab < corrTask(ti) );
        end

        % plot correlation and bootstrap-based 95% CI's:
        figure(figBars);
        b = bar( 1:length(timeNames), corrTask, 'faceColor',
[.5,.5,.5], ...
            'edgeColor', 'none');
        hold on;
        errorbar( 1:length(timeNames), corrTask, ...
            corrTask - corrTask_95sim_sub(1,:), ...
            -corrTask + corrTask_95sim_sub(2,:), 'lineStyle', 'none',
...
            'Color', 'k', 'lineWidth', 1 ); hold on;
        barWidth = b.BarWidth;
        for ttt = 1:length(timeNames)
            patch( [ttt-.5*barWidth, ttt-.5*barWidth, ...
                ttt+.5*barWidth, ttt+.5*barWidth], ...
                [corrTask_95sim_compStab(1,ttt), ...
                corrTask_95sim_compStab(2,ttt), ...
                corrTask_95sim_compStab(2,ttt), ...
                corrTask_95sim_compStab(1,ttt)], ...
                'm', 'EdgeColor', 'none', 'FaceAlpha', .3 ); hold on;
            plot( ttt, corrTask(ttt), 'marker', 'o', ...
                'MarkerFaceColor', 'k', 'MarkerEdgeColor', 'none' );
            hold on;
        end
        xticks( 1:length(timeNames) ); xticklabels( timeNames2 );
        ylim([0,1]); yticks(0:.25:1); ylabel('Corr. (\rho)');
        grid on;
        xlabel(['sess.' num2str(oth) ' vs. ' num2str(oth2)]);
        title([dataName '-' taskName]);
        savefig(figBars, ['figures/' figName '.fig']);
    end
end
```

```
end
```



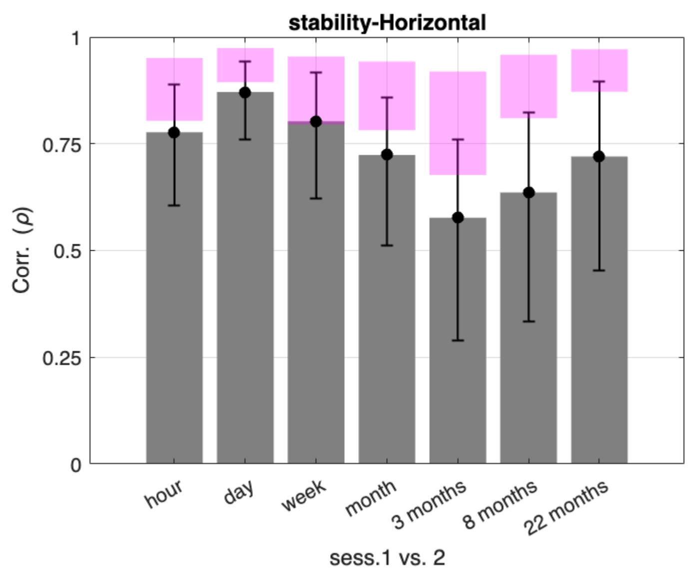


Fig. 2C - stability - test: 95% CI of exponential decay Tau:

```
for task = 1:numel(taskNames)
    taskName = taskNames{task};
    rho_vect = nan(1,numel(dataTimeGroupNames.stability));
    delays = [1/(24*30.44), 1/30.44, 7/30.44, 1, 3, 8, 22]; % time in months
    % Compute correlation
    for ti = 1:numel(dataTimeGroupNames.stability)
        timeName = dataTimeGroupNames.stability{ti};
        % compute correlation:
        p1 = behav.stability.(taskName).(timeName).sess1.dev0.response.mean;
        p2 = behav.stability.(taskName).(timeName).sess2.dev0.response.mean;
        rho = corr(p1, p2);
        rho_vect(ti) = rho;
```

```
    end
    % Fit to exponential decay:
    options = optimoptions('lsqcurvefit', ...
        'Display', 'off', ...
        'MaxIterations', 5000, ...
        'MaxFunctionEvaluations', 15000, ...
        'FunctionTolerance', 1e-8, ...
        'StepTolerance', 1e-8);
    model2 = @(params, t) params(1) * exp(-t / params(2));  % [A0, tau]
    params0_2 = [0.85, 1];
    lb2 = [-1, 0];
    ub2 = [1, Inf];
    [fit2, rss2, res2] = lsqcurvefit(model2, params0_2, delays, rho_vect,
lb2, ub2, options);
    fit_A0 = fit2(1);
    fit_tau = fit2(2);

    % Compute TAU 95% by boostrapping participants:
    nSims = 1e4;
    rho_sim_mat = nan(nSims,numel(dataTimeGroupNames.stability));
    % Boostrap participants --> bootstrapped rho's
    for ti = 1:numel(dataTimeGroupNames.stability)
        timeName = dataTimeGroupNames.stability{ti};
        % compute correlation:
        p1 = behav.stability.(taskName).(timeName...
            ).sess1.dev0.response.mean;
        p2 = behav.stability.(taskName).(timeName...
            ).sess2.dev0.response.mean;
        for s = 1:nSims
            locs = datasample( 1:length(p1), length(p1) );
            rho_sim_mat(s,ti) = corr( p1(locs), p2(locs) );
        end
    end
    % Fit the bootstrapped rhos --> bootstrapped TAU
    fit_sim_A0 = nan(nSims,1);
    fit_sim_tau = nan(nSims,1);
    for s = 1:nSims
        [fit2, ~, ~] = lsqcurvefit(model2, params0_2, delays, ...
            rho_sim_mat(s,:), lb2, ub2, options);
        fit_sim_A0(s) = fit2(1);
        fit_sim_tau(s) = fit2(2);
    end
    display([taskName ' real rho fit: A0=' num2str(fit_A0) ...
        ',tau=' num2str(fit_tau)]);
    disp([taskName 'exp decay FIT, nSims = ' num2str(nSims) ':']);
    disp('A0:');
    disp(['Range=[' ...
        num2str(min(fit_sim_A0)) ',' num2str(max(fit_sim_A0)) '], '...
        'mean=' num2str(mean(fit_sim_A0)) ', ' ...
        'q25=' num2str(quantile(fit_sim_A0,.25)) ', ' ...
```

```
        'median=' num2str(median(fit_sim_A0)) ', ' ...
        'q75=' num2str(quantile(fit_sim_A0,.75)) ', ' ...
        'std=' num2str(std(fit_sim_A0)) ', ' ...
        'sem=' num2str(std(fit_sim_A0)/sqrt(length(fit_sim_A0))) ', ' ...
        '95%CI=[' num2str(quantile(fit_sim_A0,.025)) ',' ...
        num2str(quantile(fit_sim_A0,.975)) ']' ]);
    disp('TAU:');
    disp(['Range=[' ...
        num2str(min(fit_sim_tau)) ',' num2str(max(fit_sim_tau)) '], '...
        'mean=' num2str(mean(fit_sim_tau)) ', ' ...
        'q25=' num2str(quantile(fit_sim_tau,.25)) ', ' ...
        'median=' num2str(median(fit_sim_tau)) ', ' ...
        'q75=' num2str(quantile(fit_sim_tau,.75)) ', ' ...
        'std=' num2str(std(fit_sim_tau)) ', ' ...
        'sem=' num2str(std(fit_sim_tau)/sqrt(length(fit_sim_tau))) ', ' ...
        '95%CI=[' num2str(quantile(fit_sim_tau,.025)) ',' ...
        num2str(quantile(fit_sim_tau,.975)) ']' ]);
end
```

```
Vertical real rho fit: A0=0.81962,tau=166.4468
Verticalexp decay FIT, nSims = 10000:
A0:
Range=[0.71188,0.91437], mean=0.81986, q25=0.80146, median=0.8209, q75=0.83983, std=0.029071, sem=0.00029
TAU:
Range=[20.0096,1392681.6667], mean=144417.1207, q25=95.0491, median=188.481, q75=1141.8559, std=307111.27
Horizontal real rho fit: A0=0.74858,tau=183.4214
Horizontalexp decay FIT, nSims = 10000:
A0:
Range=[0.59567,0.8863], mean=0.74801, q25=0.72489, median=0.75011, q75=0.77273, std=0.036589, sem=0.00036
TAU:
Range=[1.7566,1392883.1972], mean=281343.7676, q25=87.3918, median=211.5359, q75=696253.4779, std=477373.
```

Fig. 4 - feedback - Feedback effect in the second session:

Load processed data and definitions:

```
%load('behavioralDefs.mat');
%load('behavioralData.mat');
```

Load delay times:

```
delDay31Table = readtable('feedback13_deltaTime1stLast.csv');
delDay32Table = readtable('feedback13_deltaTime2ndLast.csv');
mDelDay31_day = delDay31Table.mean( strcmp(delDay31Table.timeCondition, ...
    '1day') );
mDelDay32_day = delDay32Table.mean( strcmp(delDay32Table.timeCondition, ...
    '1day') );
mDelDay31_month = delDay31Table.mean( ...
    strcmp(delDay31Table.timeCondition, '1month') );
mDelDay32_month = delDay32Table.mean( ...
    strcmp(delDay32Table.timeCondition, '1month') );
```

Fig. 4 (&S7) - feedback - pCon moving avg. and avg. psychometric curves for each biased-feedback group and each experimental session:

Computes and plots:

(A) The feedback effect in the impossible trials: group average of P in a sliding window of 10 impossible trials.

(B) The feedback effect in all trials: group average psychometric curve.

```
xLab.Vertical = '\DeltaL/\SigmaL';
xLab.Horizontal = '\DeltaR/\SigmaR';
winSize = 10;
thisMans = [-1,1];
manipNames = {'decrease','increase'};
colMans = [0,0,1; 1,0,0];
firstDay = 1;
dataName = 'feedback';
timeNames = dataTimeGroupNames.(dataName);
relField = 'oldResponse';

for task = 1:length(taskNames)
    taskName = taskNames{task};
    devVect = devs.(dataName).(taskName);

    fig = figure;
    if task==1
        figName = 'Figure4';
    elseif task==2
        figName = 'FigureS7';
    end

    cell0Group1 = cell(length(timeNames)*length(manipNames),1);
    cellpGroup1 = cell(length(timeNames)*length(manipNames),11);
    for mm = 1:length(manipNames)
        cell0Group2.(manipNames{mm}) = cell(length(timeNames),1);
        cellpGroup2.(manipNames{mm}) = cell(length(timeNames),11);
        for tii = 1:length(timeNames)
            cell0Group3.(manipNames{mm}).(timeNames{tii}) = cell(1,1);
            cellpGroup3.(manipNames{mm}).(timeNames{tii}) = cell(1,11);
        end
    end

    % load relevant data:
    for ti = 1:length(timeNames)
        timeName = timeNames{ti};
        for m = 1:length(thisMans)
            thisMan = thisMans(m);
            manipName = manipNames{m};
            man =  behav.(dataName).(taskName).(timeName).manip;
            cell0Group1{m+length(thisMans)*(ti-1)} = ...
                behav.(dataName).(taskName).(timeName...
```

```
            ).sess1.dev0.(relField).mat( man == thisMan, : );
        cell0Group2.(manipName){ti,1} = ...
            behav.(dataName).(taskName).(timeName...
            ).sess2.dev0.(relField).mat( man == thisMan, : );
        cell0Group3.(timeName).(manipName){1,1} = ...
            behav.(dataName).(taskName).(timeName...
            ).sess3.dev0.(relField).mat( man == thisMan, : );

        for d = 1:length(devVect)
            thisDev = devVect(d);
            if thisDev >=0
                devName = ['dev' num2str(thisDev)];
            else
                devName = ['dev' 'm' num2str(abs(thisDev))];
            end
            cellpGroup1{m+length(thisMans)*(ti-1),d} = ...
                behav.(dataName).(taskName).(timeName...
                ).sess1.(devName).(relField).mean( man == thisMan );
            cellpGroup2.(manipName){ti,d} = ...
                behav.(dataName).(taskName).(timeName...
                ).sess2.(devName).(relField).mean( man == thisMan );
            cellpGroup3.(timeName).(manipName){1,d} = ...
                behav.(dataName).(taskName).(timeName...
                ).sess3.(devName).(relField).mean( man == thisMan );
        end
    end
end

% plot running window:

% 1st session (all manips, all time groups):
subplot(2,4,1);
runningWindow( cell2mat(cell0Group1), winSize, 'on', [0,0,0] );
xlabel('# trial'); ylabel(yLab.(taskName));
title(['day ' num2str( round(firstDay) )]);
for mmm = 1:length(manipNames)
    % 2nd session (separate manipulations, unite time conditions):
    subplot(2,4,2);
    runningWindow( cell2mat(cell0Group2.(manipNames{mmm})), ...
        winSize, 'on', colMans(mmm,:) ); hold on;
    for tiii = 1:length(timeNames)
        % 3rd session (separate manipulations and time conditions):
        subplot(2,4,2+tiii);
        runningWindow( cell2mat(cell0Group3.(timeNames{tiii}...
            ).(manipNames{mmm})), winSize, 'on', colMans(mmm,:) );
        hold on;
    end
end
subplot(2,4,2);
title(['day ' num2str( round(firstDay+.5*( ...
```

```
        mDelDay31_day - mDelDay32_day + ...
        mDelDay31_month - mDelDay32_month)) )]);
    subplot(2,4,3);
    title(['day ' num2str( round(firstDay + mDelDay31_day) )]);
    subplot(2,4,4);
    title(['day ' num2str( round(firstDay + mDelDay31_month) )]);

    % plot psychometric curve:

    % 1st session (all manips, all time groups):
    subplot(2,4,5);
    psychometric( cell2mat(cellpGroup1), devVect / toNormDev.(taskName), ...
        'on', [0,0,0] );
    ylabel(yLab.(taskName));
    for mmm = 1:length(manipNames)
        % 2nd session (separate manipulations, unite time conditions):
        subplot(2,4,6);
        psychometric( cell2mat(cellpGroup2.(manipNames{mmm})), ...
            devVect / toNormDev.(taskName), 'on', colMans(mmm,:) ); hold on;
        for tiii = 1:length(timeNames)
            % 3rd session (separate manipulations and time conditions):
            subplot(2,4,6+tiii);
            psychometric( cell2mat(cellpGroup3.(timeNames{tiii}...
                ).(manipNames{mmm})), devVect / toNormDev.(taskName), ...
                'on', colMans(mmm,:) ); hold on;
        end
    end

    for i = 1:4
        subplot(2,4,i);
        ylim([0,1]); yticks(0:.25:1); xlabel('# trial'); axis square;
        subplot(2,4,4+i);
        ylim([0,1]); yticks(0:.25:1); xlabel(xLab.(taskName)); axis square;
    end
    savefig(fig, ['figures/' figName '.fig']);

end
```

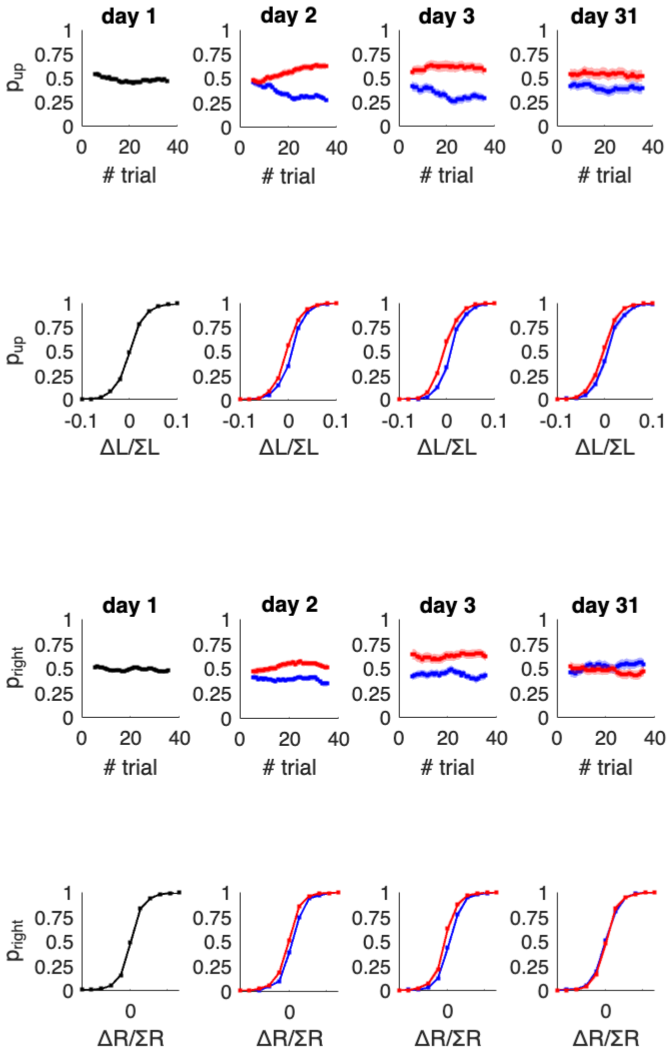


Fig. 4 - feedback - tests:

Tests for differences between means in the first session:

```
dayUp = behav.feedback.Vertical.day.sess1.dev0.oldResponse.mean( ...
    behav.feedback.Vertical.day.manip == 1 );
dayUpName = cell( size(dayUp) );
dayUpName(:) = {'day Up'};
dayDown = behav.feedback.Vertical.day.sess1.dev0.oldResponse.mean( ...
    behav.feedback.Vertical.day.manip == -1 );
dayDownName = cell( size(dayDown) );
dayDownName(:) = {'day Down'};
monthUp = behav.feedback.Vertical.month.sess1.dev0.oldResponse.mean( ...
    behav.feedback.Vertical.month.manip == 1 );
monthUpName = cell( size(monthUp) );
monthUpName(:) = {'month Up'};
monthDown = behav.feedback.Vertical.month.sess1.dev0.oldResponse.mean( ...
```

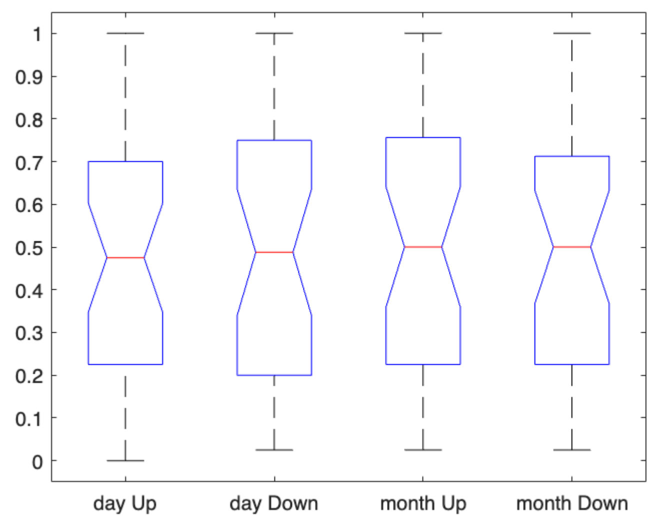
```
    behav.feedback.Vertical.month.manip == -1 );
monthDownName = cell( size(monthDown) );
monthDownName(:) = {'month Down'};
allFeed1 = [dayUp; dayDown; monthUp; monthDown];
allFeed1Name = [dayUpName; dayDownName; monthUpName; monthDownName];
disp('differences between means in the first session:')
```

```
differences between means in the first session:
```

```
figure;
[p,~,stats] = kruskalwallis( allFeed1, allFeed1Name )
```

Kruskal-Wallis ANOVA Table

Source	SS	df	MS	Chi-sq	Prob>Chi-sq
Groups	233	3	77.67	0.15	0.9852
Error	209155.5	132	1584.51		
Total	209388.5	135			




```
p = 0.9852
stats = struct with fields:
       gnames: {4×1 cell}
            n: [34 34 35 33]
       source: 'kruskalwallis'
    meanranks: [66.6912 67.8382 69.9429 69.5152]
         sumt: 2658
```

Compare each group individually to 0.5:

```
disp('signrank test for ICB-0.5 in delay X feedback groups:')
```

```
signrank test for ICB-0.5 in delay X feedback groups:
```

```
p = signrank( dayUp-.5 )
```

```
p = 0.5980
```

```
p = signrank( dayDown-.5 )
```

```
p = 0.7613
```

```
p = signrank( monthUp-.5 )
```

```
p = 0.9255
```

```
p = signrank( monthDown-.5 )
```

```
p = 0.9702
```

Wilcoxon rank sum test for the difference in second session ICB medians between-feedback groups (two-sided):

```
pDay_manUp = behav.feedback.Vertical.day.sess2.dev0.oldResponse.mean( ...
    behav.feedback.Vertical.day.manip == 1 );
pDay_manDown = behav.feedback.Vertical.day.sess2.dev0.oldResponse.mean( ...
    behav.feedback.Vertical.day.manip == -1 );
pMonth_manUp = behav.feedback.Vertical.month.sess2.dev0.oldResponse.mean(
...
    behav.feedback.Vertical.month.manip == 1 );
pMonth_manDown = behav.feedback.Vertical.month.sess2.dev0.oldResponse.mean(
...
    behav.feedback.Vertical.month.manip == -1 );
pManUp = [pDay_manUp; pMonth_manUp];
pManDown = [pDay_manDown; pMonth_manDown];
disp('ranksum test upVsDown p0sess2:')
```

```
ranksum test upVsDown p0sess2:
```

```
[p,~,stats] = ranksum(pManUp,pManDown)
```

```
p = 2.5020e-06
stats = struct with fields:
       zval: 4.7080
    ranksum: 5808
```

Wilcoxon rank sum test for the difference in second session MOVING ICB MEDIANS between-feedback groups (one-sided):

```
pVal = nan(31,1);
for r = 1:31
    pDay_manUp = mean( ...
        behav.feedback.Vertical.day.sess2.dev0.oldResponse.mat( ...
        behav.feedback.Vertical.day.manip == 1, r:r+10-1 ), 2 );
    pDay_manDown = mean( ...
        behav.feedback.Vertical.day.sess2.dev0.oldResponse.mat( ...
        behav.feedback.Vertical.day.manip == -1, r:r+10-1 ), 2 );
    pMonth_manUp = mean( ...
        behav.feedback.Vertical.month.sess2.dev0.oldResponse.mat( ...
        behav.feedback.Vertical.month.manip == 1, r:r+10-1 ), 2 );
    pMonth_manDown = mean( ...
        behav.feedback.Vertical.month.sess2.dev0.oldResponse.mat( ...
        behav.feedback.Vertical.month.manip == -1, r:r+10-1 ), 2 );
    pManUp = [pDay_manUp; pMonth_manUp];
    pManDown = [pDay_manDown; pMonth_manDown];
    pVal(r) = ranksum(pManUp,pManDown,'tail','right');
end
```

```
figure;
iComp = (1:31)';
plot( iComp, pVal, 'k', 'lineWidth', 1 ); hold on;
sigComps = plot( iComp(pVal<.05), pVal(pVal<.05), 'r*' );
hold on;
xlabel('k');
ylabel('pValue for trials k:k+10-1');
title('Rank sum test for p_{Up}^0 in sess2 up vs down manip. -by trials')
legend(sigComps,'pVal<.05, not corrected for mult. comp.')
```

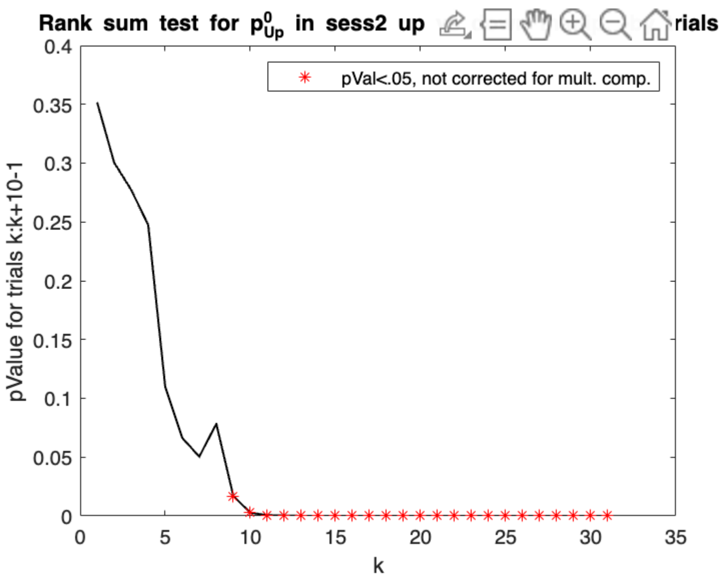


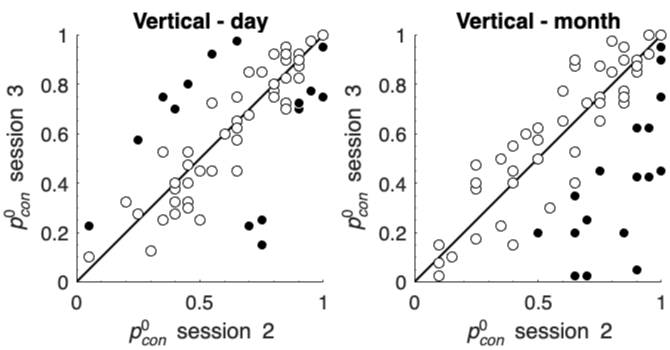
Fig. 5 - feedback - Decay of the feedback effect

Fig. 5A (&S8A) - feedback - ICB in second (2nd half) vs last session by delay group:

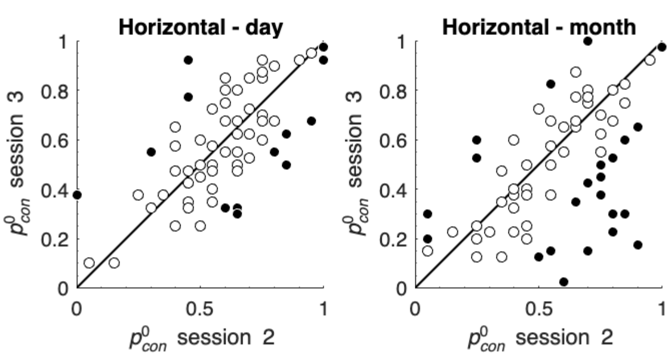
```
dataName = 'feedback';
timeNames = dataTimeGroupNames.(dataName);
for task = 1:length(taskNames)
    taskName = taskNames{task};
    fig = figure;
    if task==1
        figName = 'Figure5A';
    elseif task==2
        figName = 'FigureS8A';
    end
    for ti = 1:length(timeNames)
        timeName = timeNames{ti};
        subplot(1,2,ti);
        pSess3 = behav.feedback.(taskName).(timeName...
            ).sess3.dev0.responseCongruent.mean;
        pSess2LastHalf = mean( ...
            behav.feedback.(taskName).(timeName...
            ).sess2.dev0.responseCongruent.mat(:,21:40), 2 );
        % Comparing two independent proportions (two-sided, not corrected
```

```
        % for mult. comp):
        pBoth = ( (20*pSess2LastHalf) + (40*pSess2LastHalf) ) / ...
            ( 20 + 40 );
        zScore = (pSess2LastHalf - pSess3) ./ ...
            sqrt( pBoth .* (1-pBoth) * ( (1/20) +(1/40) ) );
        pVal = 2*(1-normcdf(abs(zScore)));
        % Store num sig. in each direction
        pCon32NumSigChange.(taskName).(timeName).increase = ...
            sum( (pVal<=0.05) & (pSess3 > pSess2LastHalf) );
        pCon32NumSigChange.(taskName).(timeName).decrease = ...
            sum( (pVal<=0.05) & (pSess3 < pSess2LastHalf) );
        % Store max pVal in each direction:
        pCon32MaxPValSigChange.(taskName).(timeName).increase = ...
            max( pVal( (pVal<=0.05) & (pSess3 > pSess2LastHalf) ) );
        pCon32MaxPValSigChange.(taskName).(timeName).decrease = ...
            max( pVal( (pVal<=0.05) & (pSess3 < pSess2LastHalf) ) );
        % Plot:
        plot( [0,1], [0,1], 'k', 'lineWidth', 1 ); hold on;
        plot( pSess2LastHalf(pVal<=0.05), pSess3(pVal<=0.05), ...
            'Marker', 'o', 'MarkerSize', 5, ...
            'MarkerFaceColor', 'k', 'MarkerEdgeColor', [1 1 1], ...
            'lineStyle', 'none'); hold on;
        plot( pSess2LastHalf(pVal>0.05), pSess3(pVal>0.05), ...
            'Marker', 'o', 'MarkerSize', 5, ...
            'MarkerFaceColor', [1 1 1], 'MarkerEdgeColor', [0 0 0], ...
            'lineStyle', 'none'); hold on;
        % Add nan pVal (not sig., both pCon2 and pCon3 = 0 or 1):
        plot( pSess2LastHalf(isnan(pVal)), pSess3(isnan(pVal)), ...
            'Marker', 'o', 'MarkerSize', 5, ...
            'MarkerFaceColor', [1 1 1], 'MarkerEdgeColor', [0 0 0], ...
            'lineStyle', 'none'); hold on;
        xlabel('{\itp}^0_{{\itcon}} session 2');
        ylabel('{\itp}^0_{{\itcon}} session 3')
        box off; axis square; xlim([0,1]); ylim([0,1]);
        ggg = gca; ggg.XMinorTick = 'on'; ggg.YMinorTick = 'on';
        title([taskName ' - ' timeName]);
        savefig(fig, ['figures/' figName '.fig']);
    end
    % Print num. sig. pCon increase/decrease in each delay-group and
    % corresp. max(pVal)
    disp([taskName ' - day: nSigIncrease = ' num2str(...
        pCon32NumSigChange.(taskName).day.increase)]);
    disp([taskName ' - day: max(p.value| sig. increase) = ' ...
        num2str(pCon32MaxPValSigChange.(taskName).day.increase)]);
    disp([taskName ' - day: nSigDecrease = ' num2str(...
        pCon32NumSigChange.(taskName).day.decrease)]);
    disp([taskName ' - day: max(p.value| sig. decrease) = ' ...
        num2str(pCon32MaxPValSigChange.(taskName).day.decrease)]);
    disp([taskName ' - month: nSigIncrease = ' num2str(...
        pCon32NumSigChange.(taskName).month.increase)]);
```

```
    disp([taskName ' - month: max(p.value| sig. increase) = ' ...
        num2str(pCon32MaxPValSigChange.(taskName).month.increase)]);
    disp([taskName ' - month: nSigDecrease = ' num2str(...
        pCon32NumSigChange.(taskName).month.decrease)]);
    disp([taskName ' - month: max(p.value| sig. decrease) = ' ...
        num2str(pCon32MaxPValSigChange.(taskName).month.decrease)]);

end
```




```
Vertical - day: nSigIncrease = 7
Vertical - day: max(p.value| sig. increase) = 0.025347
Vertical - day: nSigDecrease = 10
Vertical - day: max(p.value| sig. decrease) = 0.033169
Vertical - month: nSigIncrease = 0
Vertical - month: max(p.value| sig. increase) =
Vertical - month: nSigDecrease = 20
Vertical - month: max(p.value| sig. decrease) = 0.02846
```




```
Horizontal - day: nSigIncrease = 4
Horizontal - day: max(p.value| sig. increase) = 0.046366
Horizontal - day: nSigDecrease = 9
Horizontal - day: max(p.value| sig. decrease) = 0.040391
```

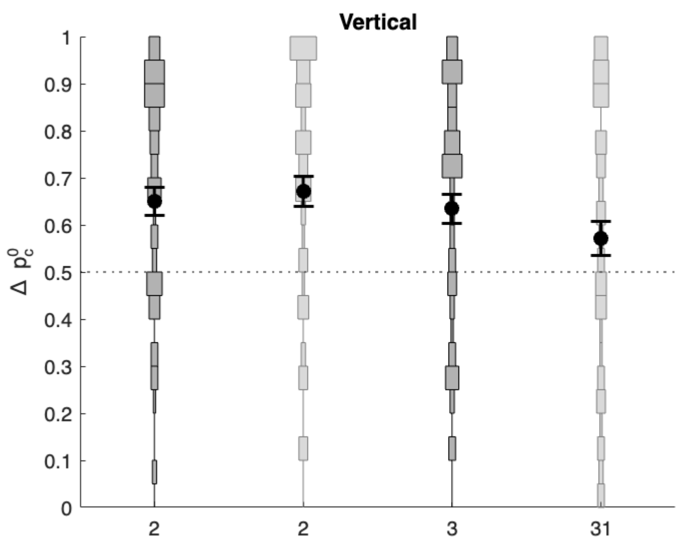
```
Horizontal - month: nSigIncrease = 7
Horizontal - month: max(p.value| sig. increase) = 0.043546
Horizontal - month: nSigDecrease = 17
Horizontal - month: max(p.value| sig. decrease) = 0.035015
```

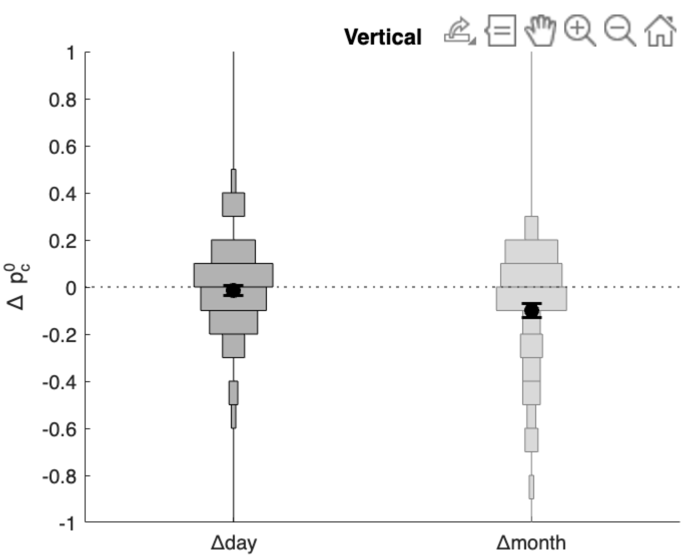
Fig. 5B (&S8B) - feedback - ICB in second vs last session by delay group - discrete violins:

Plot doscrete violins of mean delta p = p3-p2:

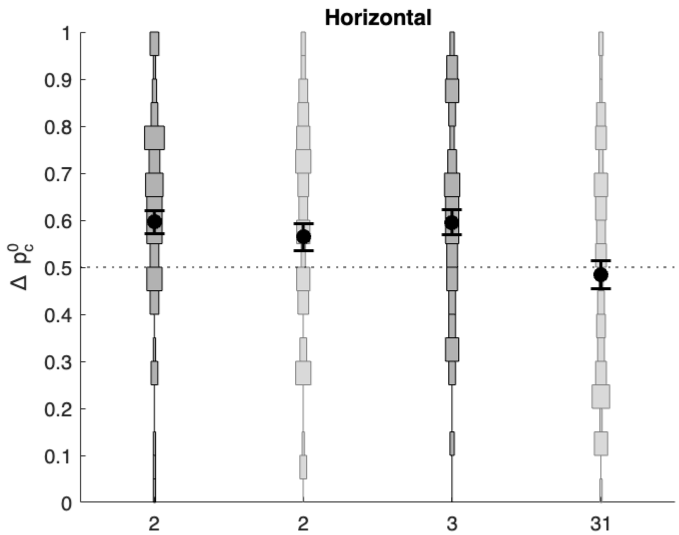
```
dataName = 'feedback';
timeNames = dataTimeGroupNames.(dataName);
for task = 1:2
    taskName = taskNames{task};
    if task==1
        figName = 'Figure5B';
    elseif task==2
        figName = 'FigureS8B';
    end
    % Prepare data
    pSess3_day = behav.feedback.
(taskName).day.sess3.dev0.responseCongruent.mean;
    pSess2LastHalf_day = mean( behav.feedback.(taskName...
        ).day.sess2.dev0.responseCongruent.mat(:,21:40), 2 );
    pSess3_month = behav.feedback.(taskName...
        ).month.sess3.dev0.responseCongruent.mean;
    pSess2LastHalf_month = mean( behav.feedback.(taskName...
        ).month.sess2.dev0.responseCongruent.mat(:,21:40), 2 );
    % Plot violins of second AND last session by delay group:
    plotDiscreteViolin( ...
        {pSess2LastHalf_day, pSess2LastHalf_month, pSess3_day,
pSess3_month}, ...
        0:.05:1, ...
        {'2', '2', '3', '31'}, ...
        taskNames(task), ...
        [0 0 0; .5 .5 .5; 0 0 0; .5 .5 .5] );
    savefig(gcf,['figures/' figName '1.fig']);
    % Plot violins of second MINUS last session by delay group:
    deltaP_day = pSess3_day - pSess2LastHalf_day;
    deltaP_month = pSess3_month - pSess2LastHalf_month;
    plotDiscreteViolin( ...
        {deltaP_day, deltaP_month}, ...
        -1:.1:1, ...
        {'\Deltaday', '\Deltamonth'}, ...
        taskNames(task), ...
        [0 0 0; .5 .5 .5; 0 0 0; .5 .5 .5] );
    savefig(gcf,['figures/' figName '2.fig']);
    % Also run ranksum per delay group:
    for ti = 1:length(timeNames)
        timeName = timeNames{ti};
        pSess3 = behav.feedback.(taskName).(timeName...
```

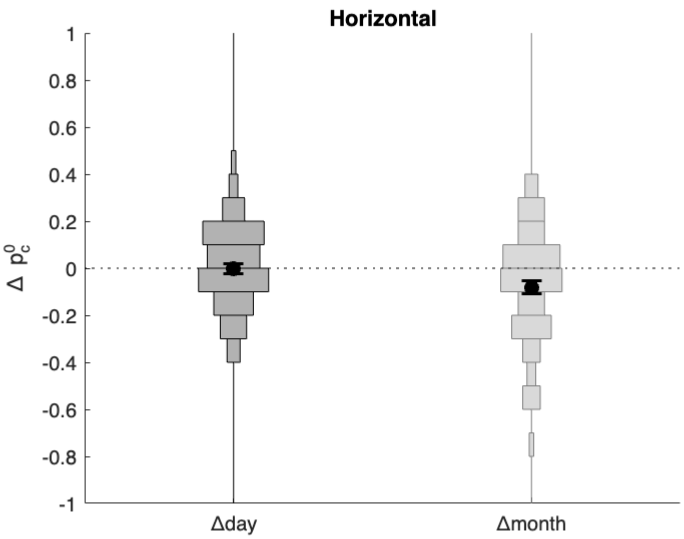
```
            ).sess3.dev0.responseCongruent.mean;
        pSess2LastHalf = mean( ...
            behav.feedback.(taskName).(timeName...
            ).sess2.dev0.responseCongruent.mat(:,21:40), 2 );
        [p,h,stats] = signrank(pSess2LastHalf-pSess3);
        pVal_ranksum.(taskName).(timeName) = p;
        zVal_ranksum.(taskName).(timeName) = stats.zval;
    end
    disp([taskName ' - day signrank: p=' num2str( ...
        pVal_ranksum.(taskName).day ) ', zval=' num2str( ...
        zVal_ranksum.(taskName).day)])
    disp([taskName ' - month signrank: p=' num2str( ...
        pVal_ranksum.(taskName).month ) ', zval=' num2str( ...
        zVal_ranksum.(taskName).month)])
end
```






```
Vertical - day signrank: p=0.4313, zval=0.78697
Vertical - month signrank: p=0.013029, zval=2.483
```



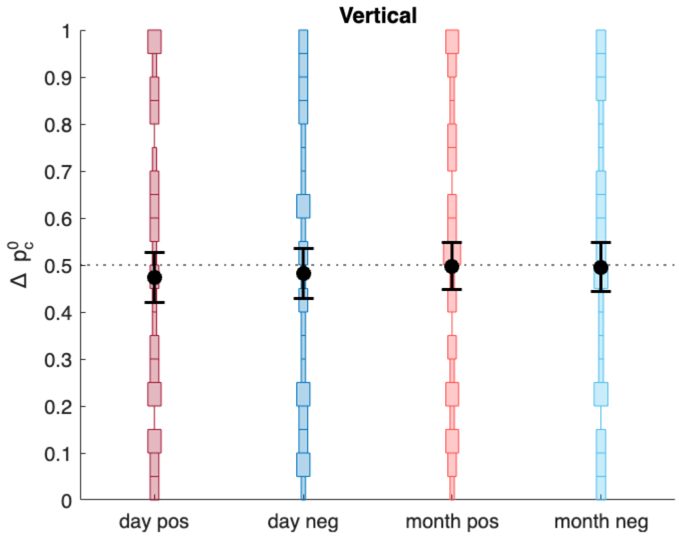



```
Horizontal - day signrank: p=0.88563, zval=0.14384
Horizontal - month signrank: p=0.020072, zval=2.325
```

Repeat for Extended data Fig. 3B (&S6B)

```
for task = 1:2
    taskName = taskNames{task};
    % Prepare data
    pDay_manPos = ...
        behav.feedback.(taskName).day.sess1.dev0.oldResponse.mean( ...
        behav.feedback.(taskName).day.manip == 1 );
    pDay_manNeg = ...
        behav.feedback.(taskName).day.sess1.dev0.oldResponse.mean( ...
        behav.feedback.(taskName).day.manip == -1 );
    pMonth_manPos = ...
        behav.feedback.(taskName).month.sess1.dev0.oldResponse.mean( ...
        behav.feedback.(taskName).month.manip == 1 );
    pMonth_manNeg = ...
        behav.feedback.(taskName).month.sess1.dev0.oldResponse.mean( ...
```

```
        behav.feedback.(taskName).month.manip == -1 );
    % Plot violins by delay * manip group:
    plotDiscreteViolin( ...
        {pDay_manPos, pDay_manNeg, pMonth_manPos, pMonth_manNeg}, ...
        0:.05:1, ...
        {'day pos', 'day neg', 'month pos', 'month neg'}, ...
        taskNames(task), ...
        [.64,.08,.18; 0,.45,.74; 1,.3,.3; .3,.75,.93] );
end
```



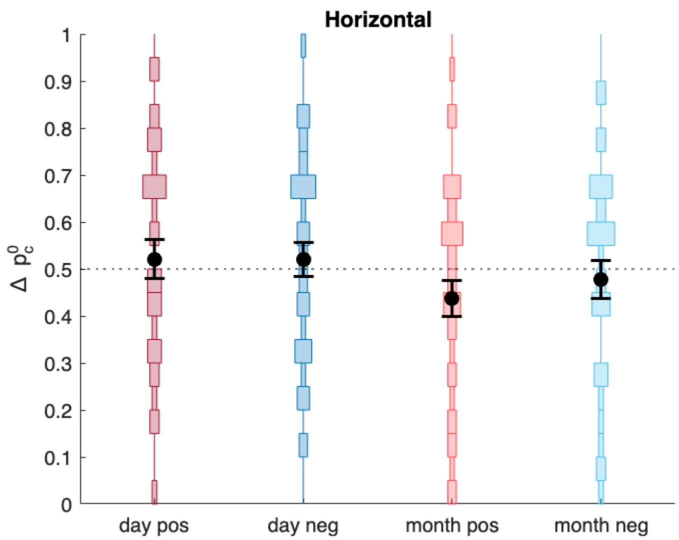


Fig. 5 - feedback - tests:

Wilcoxon rank sum test for the difference in third session ICB medians between-feedback groups (two-sided) IN EACH DELAY GROUP:

```
pDay_manUp = ...
    behav.feedback.Vertical.day.sess3.dev0.oldResponse.mean( ...
    behav.feedback.Vertical.day.manip == 1 );
```

```
pDay_manDown = ...
    behav.feedback.Vertical.day.sess3.dev0.oldResponse.mean( ...
    behav.feedback.Vertical.day.manip == -1 );
pMonth_manUp = ...
    behav.feedback.Vertical.month.sess3.dev0.oldResponse.mean( ...
    behav.feedback.Vertical.month.manip == 1 );
pMonth_manDown = ...
    behav.feedback.Vertical.month.sess3.dev0.oldResponse.mean( ...
    behav.feedback.Vertical.month.manip == -1 );
% compare effects in the third session - 1 day:
disp('ranksum test upVsDown p0sess3 day:')
```

```
ranksum test upVsDown p0sess3 day:
```

```
[p,~,stats] = ranksum(pDay_manUp,pDay_manDown)
```

```
p = 6.6073e-05
stats = struct with fields:
       zval: 3.9900
    ranksum: 1.4985e+03
```

```
% compare effects in the third session - 1 month:
disp('ranksum test upVsDown p0sess3 month:')
```

```
ranksum test upVsDown p0sess3 month:
```

```
[p,~,stats] = ranksum(pMonth_manUp,pMonth_manDown)
```

```
p = 0.0629
stats = struct with fields:
       zval: 1.8601
    ranksum: 1.3595e+03
```

Exponential decay, estimated tau and tau bootstrapped 95% upper bound:

```
disp('Decay estimates:');
```

```
Decay estimates:
```

```
for task = 1:numel(taskNames)
    taskName = taskNames{task};
    pSess3_month = behav.feedback.(taskName...
        ).month.sess3.dev0.responseCongruent.mean;
    pSess2LastHalf_month = mean( behav.feedback.(taskName...
        ).month.sess2.dev0.responseCongruent.mat(:,21:40), 2 );
    rFeed.(taskName) = (mean(pSess3_month)-.5) / ...
        (mean(pSess2LastHalf_month)-.5);
    disp([taskName ' (p3-0.5)/(p2-0.5) = ' ...
        num2str(rFeed.(taskName))]);
end
```

```
Vertical (p3-0.5)/(p2-0.5) = 0.41416
Horizontal (p3-0.5)/(p2-0.5) = -0.26437
```

```
% --> Focus on vertical as horizontal r < 0.
taskName = 'Vertical';
pSess3_month = behav.feedback.(taskName...
    ).month.sess3.dev0.responseCongruent.mean;
pSess2LastHalf_month = mean( behav.feedback.(taskName...
    ).month.sess2.dev0.responseCongruent.mat(:,21:40), 2 );
% Compute tau (in months):
estimated_tau = -1 / log(rFeed.(taskName));
disp([taskName ' estimated tau, assuming:']);
```

```
Vertical estimated tau, assuming:
```

```
disp('[p(t=1)-0.5] = [p(t=0)-0.5]*exp(-t/tau)');
```

```
[p(t=1)-0.5] = [p(t=0)-0.5]*exp(-t/tau)
```

```
disp(['--> tau = ' num2str(estimated_tau) ' months']);
```

```
--> tau = 1.1344 months
```

```
estimated_decayTo1per = -estimated_tau * log(.01);
disp(['--> t|1% = ' num2str(estimated_decayTo1per) ' months']);
```

```
--> t|1% = 5.2243 months
```

```


% Bootstrap participants for estimated tau 95% CI:
nSims = 1e6;
rFeedVerSim = nan(nSims,1);
nLocs = length(pSess3_month);
posLocs = 1:nLocs;
for s = 1:nSims
    locSim = datasample( posLocs, nLocs );
    sim_pSess3_month = pSess3_month(locSim);
    sim_pSess2LastHalf_month = pSess2LastHalf_month(locSim);
    rFeedVerSim(s) = (mean(sim_pSess3_month)-.5) / ...
        (mean(sim_pSess2LastHalf_month)-.5);
end
sim_r_q95 = quantile(rFeedVerSim,.95);
disp([taskName ' bootstrap (p3-0.5)/(p2-0.5):']);
```

```
Vertical bootstrap (p3-0.5)/(p2-0.5):
```

```
disp(['r SEM (bootstrap std) = ' num2str(std(rFeedVerSim))]);
```

```
r SEM (bootstrap std) = 0.18445
```

```
disp(['r 95% upper: ' num2str(sim_r_q95)]);
```

```
r 95% upper: 0.67778
```

```
disp(['Corresponding tau 95% upper: ' ...
    num2str(-1 / log(sim_r_q95)) ' months']);
```

```
Corresponding tau 95% upper: 2.5711 months
```

Fig. 6 - feedback - Instability of the feedback effect:

Load processed data and definitions:

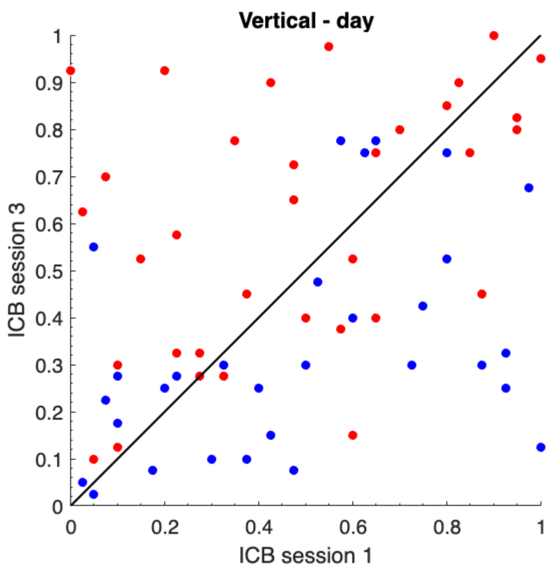
```
%load('behavioralDefs.mat');
%load('behavioralData.mat');
```

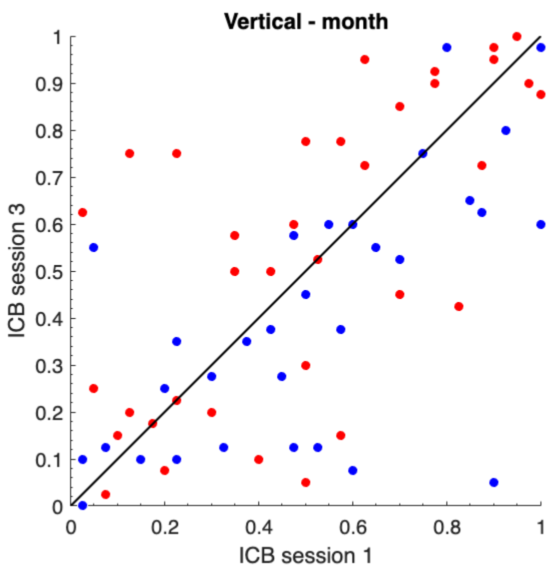
Compute delay-group between session ICB correlation and 95% CI's:

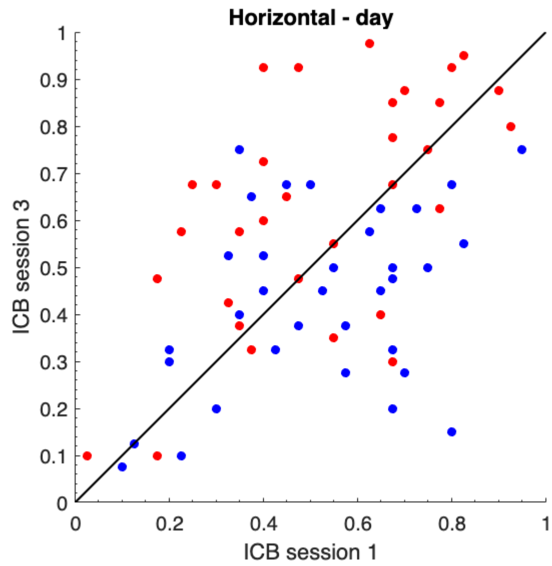
Fig. 6A (&S9A) - feedback - ICB in the first vs last session by delay group and biased-feedback:

```
dataName = 'feedback';
timeNames = dataTimeGroupNames.(dataName);
leg = cell(1,4);
for task = 1:length(taskNames)
    taskName = taskNames{task};
    if task==1
        figName = 'Figure6A';
    elseif task==2
        figName = 'FigureS9A';
    end
    for ti = 1:length(timeNames)
        timeName = timeNames{ti};
        fig = figure;
        p1 = behav.(dataName).(taskName).(timeName ...
            ).sess1.dev0.oldResponse.mean;
        p3 = behav.(dataName).(taskName).(timeName ...
            ).sess3.dev0.oldResponse.mean;
        man =  behav.(dataName).(taskName).(timeName).manip;
        clear plt leg;
        for m = 1:2
            thisMan = thisMans(m);
            colMan = colMans(m,:);
            p1m = p1(man == thisMan);
            p3m = p3(man == thisMan);
            plt(1+2*(m-1)) = plot( p1m, p3m, ...
                'Marker', 'o', 'MarkerSize', 5, ...
                'MarkerFaceColor', colMan, 'MarkerEdgeColor', [1 1 1], ...
                'lineStyle', 'none'); hold on;
            plt(2+2*(m-1)) = plot( [0,1], [0,1], 'Color', 'k', ...
                'lineWidth', 1 ); hold on;
        end
        xlabel('ICB session 1');
        ylabel('ICB session 3')
        box off; axis square; xlim([0,1]); ylim([0,1]);
        ggg = gca; ggg.XMinorTick = 'on'; ggg.YMinorTick = 'on';
        title([taskName ' - ' timeName]);
        savefig(fig,['figures/' figName '_' num2str(ti) '.fig']);
```

```
    end
end
```


Vertical - day
ICB session 3
ICB session 1


Vertical - month
ICB session 3
ICB session 1



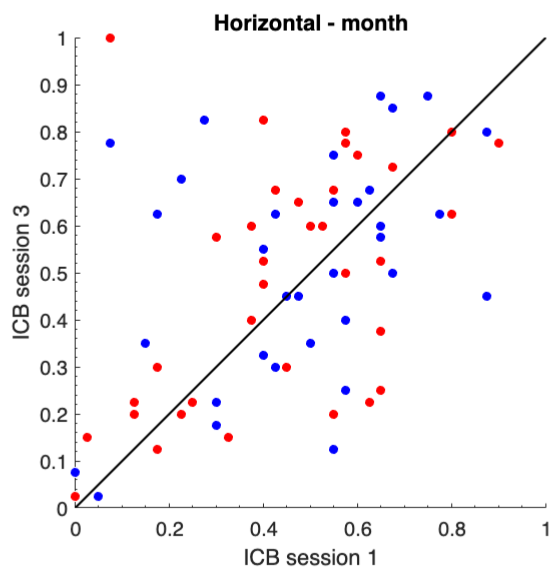


Fig. 6B (&S9B) - feedback - ICB correlation across sessions:

Load processed data and definitions:

```
%load('behavioralDefs.mat');
%load('behavioralData.mat');
```

Compute delay-group between session ICB correlation and 95% CI's:

```
choiceFields.feedback = 'oldResponse';
nLastSess.feedback = 3;
nComps.feedback = 3;
nSims = 1e5;
dataName = 'feedback';

% read mean days between sessions:
deltaTimeTable = readtable('feedback13_deltaTime2ndLast.csv');
addTimeName = '1';
```

```
timeNames = dataTimeGroupNames.(dataName);
dayMean.(dataName) = nan(1,length(timeNames));
for ti = 1:length(timeNames)
    timeName = timeNames{ti};
    dayMean.(dataName)(ti) = deltaTimeTable( strcmp( ...
        deltaTimeTable.timeCondition, [addTimeName timeName]), : ).mean;
end

% Compute delay-group between session ICB correlation and 95% CI's:
dat = 2;
dataName = dataNames{dat};
nComp = nComps.(dataName);
timeNames = dataTimeGroupNames.(dataName);
timeNames2 = dataTimeGroupNames2.(dataName);
figBars = figure;
for task = 1:length(taskNames)
    taskName = taskNames{task};
    nSessions = nLastSess.(dataName);
    if task==1
        figName = 'Figure6B';
    elseif task==2
        figName = 'FigureS9B';
    end
    for oth = 1:(nSessions-1)
        for oth2 = oth+1:nSessions
            figure(figBars);
            subplot(2,nComp, oth+oth2 - 2 + (nComp)*(task-1));
            corrTask = nan(1,length(timeNames));
            sigTask = nan(1,length(timeNames));
            corrTask_95sim_sub = nan(2,length(timeNames));
            corrTask_95sim_noStab = nan(2,length(timeNames));
            corrTask_95sim_compStab = nan(2,length(timeNames));
            pVal_corrTask_sim_compStab = nan(1,length(timeNames));
            for ti = 1:length(timeNames)
                timeName = timeNames{ti};
                fieldName = choiceFields.(dataName);
                p1 = behav.(dataName).(taskName).(timeName).(...
                    ['sess' num2str(oth)]).dev0.(fieldName).mean;
                pOther = behav.(dataName).(taskName).(timeName).(...
                    ['sess' num2str(oth2)]).dev0.(fieldName).mean;
                [rho,pVal] = corr(p1,pOther);
                corrTask(ti) = rho;
                sigTask(ti) = pVal;
                simCorr = nan(nSims,1);
                simCorr_noStab = nan(nSims,1);
                simCorr_compStab = nan(nSims,1);
                for s = 1:nSims
                    locSim = datasample( 1:length(p1), length(p1) );
                    locSim2 = datasample( 1:length(p1), length(p1) );
                    % bootstrap corr by subjects:
```

```
                p1Sim = p1(locSim);
                pOtherSim = pOther(locSim);
                simCorr(s) = corr(p1Sim,pOtherSim);
                % bootstrap corr by subjects assuming no stability:
                p1Sim = p1(locSim);
                pOtherSim = pOther(locSim2);
                simCorr_noStab(s) = corr(p1Sim,pOtherSim);
                % assuming complete stability:
                % Here, we boostap and also binomrnd the mean p's, to
                % simulate the corr expected under the assumption that
                % the inherent p hadn't changed. Note that this will
                % only serve as a lower bound for complete stability,
                % and that this simulation is biased, e.g.,
                % beacause it has the potential to decrease the
                % variance between participants.
                pMeanBoot = .5 * (p1(locSim) + pOther(locSim) );
                p1Sim = (1/nTrialsDevSessImp) * binornd( ...
                    nTrialsDevSessImp, pMeanBoot );
                pOtherSim = (1/nTrialsDevSessImp) * binornd( ...
                    nTrialsDevSessImp, pMeanBoot );
                simCorr_compStab(s) = corr(p1Sim,pOtherSim);
            end
            corrTask_95sim_sub(:,ti) = quantile( simCorr, [.025;.975] );
            corrTask_95sim_noStab(:,ti) = quantile( simCorr_noStab, ...
                [.025;.975] );
            corrTask_95sim_compStab(:,ti) = quantile( ...
                simCorr_compStab, [.025;.975] );
            pVal_corrTask_sim_compStab(ti) = mean( ...
                simCorr_compStab < corrTask(ti) );
        end

        % plot correlation and bootstrap-based 95% CI's:
        figure(figBars);
        b = bar( 1:length(timeNames), corrTask, 'faceColor',
[.5,.5,.5], ...
            'edgeColor', 'none');
        hold on;
        errorbar( 1:length(timeNames), corrTask, ...
            corrTask - corrTask_95sim_sub(1,:), ...
            -corrTask + corrTask_95sim_sub(2,:), 'lineStyle', 'none',
...
            'Color', 'k', 'lineWidth', 1 ); hold on;
        barWidth = b.BarWidth;
        for ttt = 1:length(timeNames)
            patch( [ttt-.5*barWidth, ttt-.5*barWidth, ...
                ttt+.5*barWidth, ttt+.5*barWidth], ...
                [corrTask_95sim_compStab(1,ttt), ...
                corrTask_95sim_compStab(2,ttt), ...
                corrTask_95sim_compStab(2,ttt), ...
                corrTask_95sim_compStab(1,ttt)], ...
```

```
                    'm', 'EdgeColor', 'none', 'FaceAlpha', .3 ); hold on;
                plot( ttt, corrTask(ttt), 'marker', 'o', ...
                    'MarkerFaceColor', 'k', 'MarkerEdgeColor', 'none' );
                hold on;
            end
            xticks( 1:length(timeNames) ); xticklabels( timeNames2 );
            ylim([0,1]); yticks(0:.25:1); ylabel('Corr. (\rho)');
            grid on;
            xlabel(['sess.' num2str(oth) ' vs. ' num2str(oth2)]);
            title([dataName '-' taskName]);
            savefig(figBars,['figures/' figName '.fig']);
        end
    end
end
```

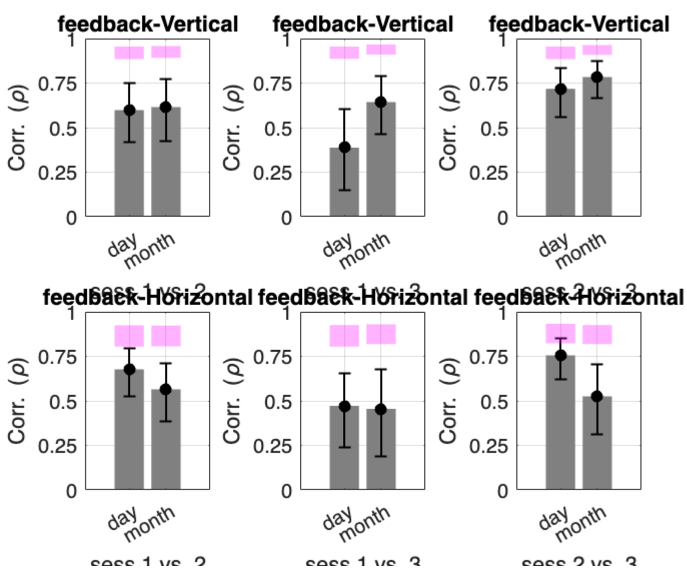


Fig. 6B tests - bootstrap difference in first and last session correlations between delay groups:

Load processed data and definitions:

```
%load('behavioralDefs.mat');
%load('behavioralData.mat');
```

Compute difference in pUp first and last session correlation: month - day

```
d1 = behav.feedback.Vertical.day.sess1.dev0.oldResponse.mean;
d3 = behav.feedback.Vertical.day.sess3.dev0.oldResponse.mean;
m1 = behav.feedback.Vertical.month.sess1.dev0.oldResponse.mean;
m3 = behav.feedback.Vertical.month.sess3.dev0.oldResponse.mean;
corrMonth = corr( m3, m1 );
corrDay = corr( d3, d1 );
realCorrDiff = corrMonth - corrDay;
```

Exact test - correlation test via Fisher transformation:

```
TransCorrMonth = .5 * log( (1 + corrMonth) / (1 - corrMonth) );
TransCorrDay = .5 * log( (1 + corrDay) / (1 - corrDay) );
s = sqrt( ( 1 / ( length(d1) - 3 ) ) + ( 1 / ( length(m1) - 3 ) )  );
disp('pValExact: correlation test via Fisher transformation')
```

```
pValExact: correlation test via Fisher transformation
```

```
pValExact = 1 - normcdf( (TransCorrMonth - TransCorrDay) / s )
```

```
pValExact = 0.0216
```

Bootstrap correlation difference:

```
nSim = 1e6;
simCorrDiff = nan(nSim,1);

% bootsrap corr each individualy -> calc diff:
simCorrDiff_2 = nan(nSim,1);
simCorr2_day = nan(nSim,1);
simCorr2_month = nan(nSim,1);

% bootsrap from both --> calc diff:
simCorrDiff_1 = nan(nSim,1);
dm1 = [d1;m1];
dm3 = [d3;m3];

sss = RandStream('mlfg6331_64');

for s = 1:nSim
    % bootsrap corr each individualy -> calc diff:
    locD = datasample( sss, 1:length(d1), length(d1) );
    locM = datasample( sss, 1:length(m1), length(m1) );
    simCorr2_day(s) = corr( d3(locD), d1(locD) );
    simCorr2_month(s) = corr( m3(locM), m1(locM) );
    simCorrDiff_2(s) = simCorr2_month(s) - simCorr2_day(s);

    % bootsrap from both --> calc diff:
    locDM = datasample( sss, 1:length(dm1), length(dm1) );
    simCorrDiff_1(s) = corr( dm3(locDM(1:length(d1))), dm1( ...
        locDM(1:length(d1))) ) - ...
        corr( dm3(locDM(1+length(d1):end)), dm1(locDM(1+length(d1):end)) );
end

% bootsrap corr each individualy -> calc diff:
mean( simCorrDiff_2 < 0 )
```

```
ans = 0.0374
```

```
% bootsrap from both --> calc diff:
mean( simCorrDiff_1 > realCorrDiff )
```

```
ans = 0.0412
```

Bootstrap correlation difference:

Simulate the difference in corr(pCon0_sess1,pCon0_sess3) between the two delay groups by bootstrapping participants' identities and corresp. pCongruent either:

(a) separately from each delay group, or

(b) irrespective of the delay group.

```
pCon3day = behav.feedback.Vertical.day.sess3.dev0.responseCongruent.mean;
pCon1day = behav.feedback.Vertical.day.sess1.dev0.responseCongruent.mean;
pCon3month = ...
    behav.feedback.Vertical.month.sess3.dev0.responseCongruent.mean;
pCon1month = ...
    behav.feedback.Vertical.month.sess1.dev0.responseCongruent.mean;
realCorrDiff = corr(pCon3month,pCon1month) - corr(pCon3day,pCon1day);
pCon1both = [pCon1day; pCon1month];
pCon3both = [pCon3day; pCon3month];
nSims = 1e6;
simCorrDay = nan(nSims,1);
simCorrMonth = nan(nSims,1);
simCorrDay_rand = nan(nSims,1);
simCorrMonth_rand = nan(nSims,1);
simCorrDay_rand_noRet = nan(nSims,1);
simCorrMonth_rand_noRet = nan(nSims,1);
nDay = length(pCon3day);
nMonth = length(pCon3month);
sss = RandStream('mlfg6331_64');
for s = 1:nSims
    % (a) Bootstrap participants corresp. pCon0's separately for each delay
        % group:
    sLocDay = datasample( sss, 1:nDay, nDay );
    sLocMonth = datasample( sss, 1:nMonth, nMonth );
    simCorrDay(s) = corr( pCon1day(sLocDay), pCon3day(sLocDay) );
    simCorrMonth(s) = corr( pCon1month(sLocDay), pCon3month(sLocDay) );
    % (b1) Bootstrap participants corresp. pCon0's irrespective of delay
        % group [WITH replacement]:
    sLocBoth = datasample( sss, 1:(nDay+nMonth), nDay+nMonth );
    simCorrDay_rand(s) = corr( pCon1both(sLocBoth(1:nDay)), ...
        pCon3both(sLocBoth(1:nDay)) );
    simCorrMonth_rand(s) = corr( pCon1both(sLocBoth(nDay+1:end)), ...
        pCon3both(sLocBoth(nDay+1:end)) );
    % (b2) Bootstrap participants corresp. pCon0's irrespective of delay
        % group [WITHOUT replacement]:
    sLocBothNR = datasample( sss, 1:(nDay+nMonth), nDay+nMonth, ...
        'Replace', false );
    simCorrDay_rand_noRet(s) = corr( pCon1both(sLocBothNR(1:nDay)), ...
        pCon3both(sLocBothNR(1:nDay)) );
    simCorrMonth_rand_noRet(s) = corr( ...
        pCon1both(sLocBothNR(nDay+1:end)), ...
        pCon3both(sLocBothNR(nDay+1:end)) );
```

```
end
% (a) pValue for the difference in corr(pCon0_sess1,pCon0_sess3) between
    % delay groups [sampled WITH replacement, from each delay group]:
disp('pValue bootstrap deltaCorr pCon0Sess1vs3 sampleFromDelayGroups:')
```

```
pValue bootstrap deltaCorr pCon0Sess1vs3 sampleFromDelayGroups:
```

```
mean( simCorrDay > simCorrMonth )
```

```
ans = 0.0455
```

```
% (b1) pValue for the difference in corr(pCon0_sess1,pCon0_sess3) between
    % delay groups [sampled WITH replacement, irrespective of delay group]:
simCorrDiff = simCorrMonth_rand - simCorrDay_rand;
disp('pValue bootstrap_deltaCorr pCon0Sess1vs3 sampleAllParticipants
replaceTrue:')
```

```
pValue bootstrap_deltaCorr pCon0Sess1vs3 sampleAllParticipants replaceTrue:
```

```
mean( simCorrDiff >= realCorrDiff )
```

```
ans = 0.0549
```

```
% (b2) pValue for the difference in corr(pCon0_sess1,pCon0_sess3) between
    % delay groups [sampled WITHOUT replacement, irrespective of delay
    % group]:
simCorrDiff = simCorrMonth_rand_noRet - simCorrDay_rand_noRet;
disp('pValue bootstrap_deltaCorr pCon0Sess1vs3 sampleAllParticipants
replaceFalse:')
```

```
pValue bootstrap_deltaCorr pCon0Sess1vs3 sampleAllParticipants replaceFalse:
```

```
mean( simCorrDiff >= realCorrDiff )
```

```
ans = 0.0560
```

Fig. S3 & S6 - feedback - ICB in the first session:

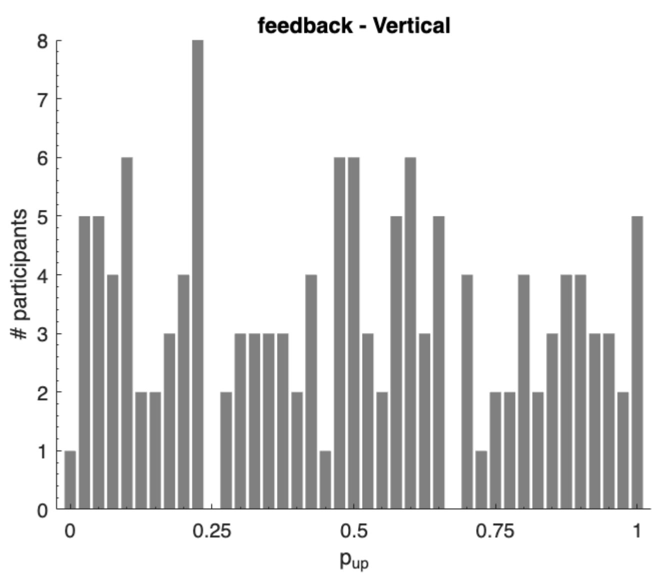
Load processed data and definitions:

```
%load('behavioralDefs.mat');
%load('behavioralData.mat');
```

Fig. S3A & S6A - feedback - ICB distribution in the first session:

```
dataName = 'feedback';
timeNames = dataTimeGroupNames.(dataName);
yLab.Vertical = 'p_{up}';
yLab.Horizontal = 'p_{right}';
for task = 1:length(taskNames)
    taskName = taskNames{task};
    if task==1
        figName = 'FigureS3A';
    elseif task==2
```

```
        figName = 'FigureS6A';
    end
    edges = linspace(0,1,42);
    pUp0FeedSess1 = [];
    for ti = 1:length(timeNames)
        timeName = timeNames{ti};
        pUp0FeedSess1 = [pUp0FeedSess1; ...
            behav.(dataName).(taskName).(timeName ...
            ).sess1.dev0.oldResponse.mean];
    end
    ICB_BL_pdf = histcounts( pUp0FeedSess1, 'binEdges', edges );
    fig = figure;
    bar( 0:(1/40):1, ICB_BL_pdf, 'FaceColor', [.5 .5 .5], 'edgeColor', ...
        'none' );
    xlim([-0.025,1.025]); box off;
    xlabel(yLab.(taskName)); ylabel('# participants');
    ggg = gca; ggg.XMinorTick = 'on'; ggg.YMinorTick = 'on';
    xticks(0:.25:1); hold on;
    title([dataName ' - ' taskName]);
    savefig(fig,['figures/' figName '.fig']);
end
```



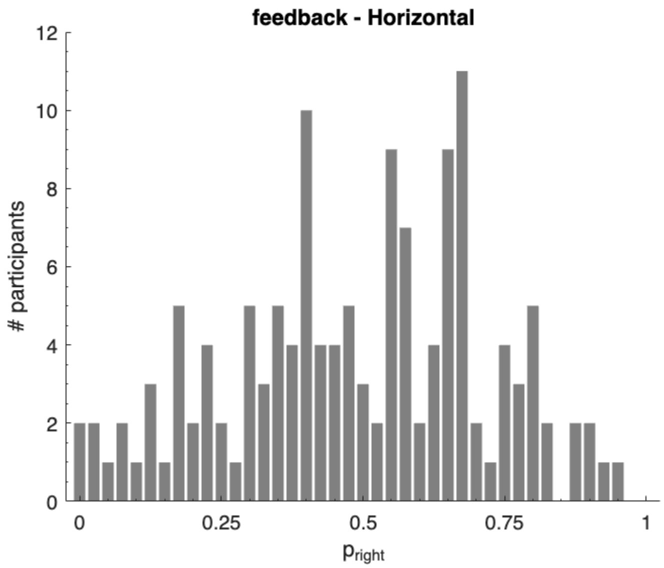
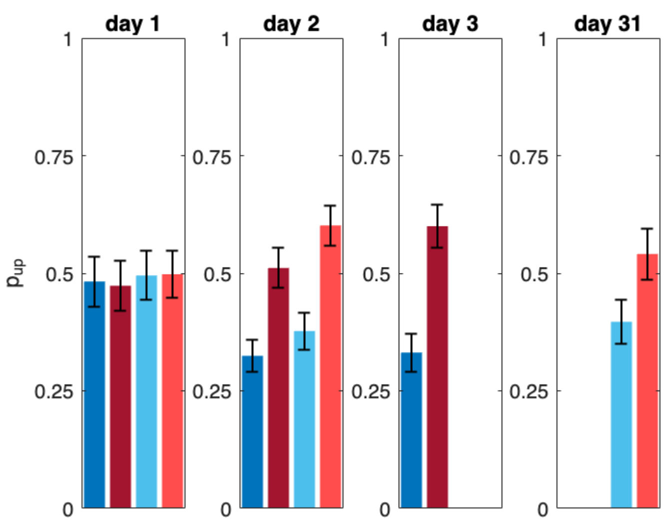


Fig. S3B & S6B - feedback - average ICB by feedback X delay, by sess:

```
yLab.Vertical = 'p_{up}';
yLab.Horizontal = 'p_{right}';
thisMans = [-1,1];
manipNames = {'decrease','increase'};
clear cols;
cols.day.increase = [.64,.08,.18];
cols.month.increase = [1,.3,.3];
cols.day.decrease = [0,.45,.74];
cols.month.decrease = [.3,.75,.93];

firstDay = 1;
delDay31Table = readtable('feedback13_deltaTime1stLast.csv');
delDay32Table = readtable('feedback13_deltaTime2ndLast.csv');
mDelDay31_day = delDay31Table.mean( strcmp(delDay31Table.timeCondition, ...
    '1day') );
mDelDay32_day = delDay32Table.mean( strcmp(delDay32Table.timeCondition, ...
    '1day') );
mDelDay31_month = delDay31Table.mean( ...
    strcmp(delDay31Table.timeCondition, '1month') );
mDelDay32_month = delDay32Table.mean( ...
    strcmp(delDay32Table.timeCondition, '1month') );

nSessions = 3;

dataName = 'feedback';
timeNames = dataTimeGroupNames.(dataName);
relField = 'oldResponse';

for task = 1:length(taskNames)
    taskName = taskNames{task};
```

```
    fig = figure;
    if task==1
        figName = 'FigureS3B';
    elseif task==2
        figName = 'FigureS6B';
    end
    pMean = nan(1,4);
    pSem = nan(1,4);
    colMat = nan(4,3);
    for sess = 1:nSessions
        for ti = 1:length(timeNames)
            timeName = timeNames{ti};
            man = behav.(dataName).(taskName).(timeName).manip;
            for m = 1:length(thisMans)
                thisMan = thisMans(m);
                manipName = manipNames{m};
                pData = behav.(dataName).(taskName).(timeName).(['sess' ...
                    num2str(sess)]).dev0.(relField).mean( ...
                    man == thisMan, : );
                pMean(m+length(thisMans)*(ti-1)) = mean(pData,'omitnan');
                pSem(m+length(thisMans)*(ti-1)) = std(pData,'omitnan') ...
                    / sqrt( sum(~isnan(pData)) );
                colMat(m+length(thisMans)*(ti-1),:) = cols.(timeName).(...
                    manipName);
            end
        end
        if sess ~= 3
            subplot(1,4,sess);
            b = bar( 1:4, pMean );
            b.FaceColor = 'flat';
            b.EdgeColor = 'none';
            b.CData = colMat;
            hold on;
            errorbar( 1:4, pMean, pSem, 'Color', 'k', 'lineWidth', ...
                1, 'lineStyle', 'none' );
            if sess == 1
                ylabel(yLab.(taskName));
            end
        elseif sess == 3
            for tii = 1:2
                subplot(1,4,sess+tii-1);
                locs = (1:2)+2*(tii-1);
                b = bar( locs, pMean(locs) );
                b.FaceColor = 'flat';
                b.EdgeColor = 'none';
                b.CData = colMat(locs,:);
                hold on;
                errorbar( locs, pMean(locs), pSem(locs), 'Color', ...
                    'k', 'lineWidth', 1, 'lineStyle', 'none' );
            end
```

```
        end
    end
    subplot(1,4,1);
    title(['day ' num2str( round(firstDay) )]);
    subplot(1,4,2);
    title(['day ' num2str( round(firstDay+.5*( ...
        mDelDay31_day - mDelDay32_day + ...
        mDelDay31_month - mDelDay32_month)) )]);
    subplot(1,4,3);
    title(['day ' num2str( round(firstDay + mDelDay31_day) )]);
    subplot(1,4,4);
    title(['day ' num2str( round(firstDay + mDelDay31_month) )]);
    for tiii = 1:4
        subplot(1,4,tiii); ylim([0,1]); xlim([.5,4.5]); xticks({});
        yticks(0:.25:1);
    end
    savefig(fig,['figures/' figName '.fig']);
end
```



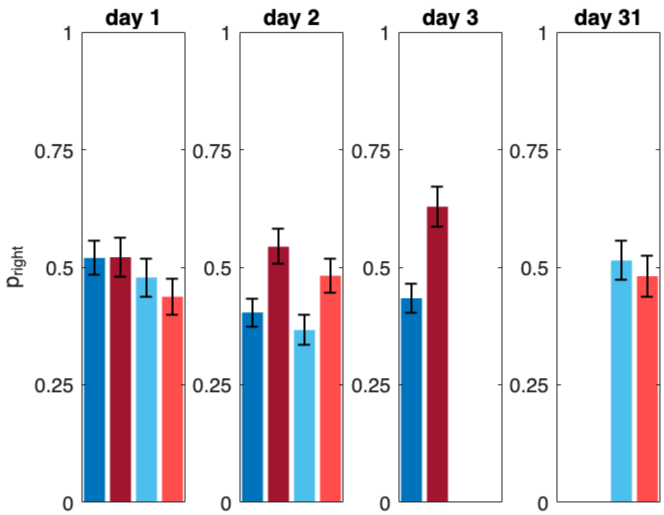


Fig. S3 & S6 - feedback - tests

Load processed data and definitions:

```
%load('behavioralDefs.mat');
%load('behavioralData.mat');
```

Compare ICB standard deviation in first session of feedback vs stability experiments:

```
relFields1.stability = 'response';
relFields1.feedback = 'oldResponse';
nSim = 1e6;
for task = 1:length(taskNames)
    taskName = taskNames{task};
    for dat = 1:length(dataNames)
        dataName = dataNames{dat};
        field = relFields1.(dataName);
        timeNames = dataTimeGroupNames.(dataName);
        pChoiceSess1Temp = [];
        for ti = 1:length(timeNames)
            timeName = timeNames{ti};
            pChoiceSess1Temp = [pChoiceSess1Temp; ...
                behav.(dataName).(taskName).(timeName).sess1.dev0.( ...
                field).mean];
        end
        pChoiceSess1.(dataName) = pChoiceSess1Temp;
    end
    % compute real diff in std:
    pStdRealDiff = std( pChoiceSess1.stability ) - std( ...
        pChoiceSess1.feedback );
    pChoiceSess1All = [pChoiceSess1.stability; pChoiceSess1.feedback];
```

```
    nStability = length( pChoiceSess1.stability );
    nFeedback = length( pChoiceSess1.feedback );
    % simulate p_std_sess1 for each dataset (stability, feedback):
    pStdSimDiff = nan(nSim,1);
    for s = 1:nSim
        stdStimStability = std( datasample( pChoiceSess1All, ...
            nStability ) );
        stdStimFeedback = std( datasample( pChoiceSess1All, nFeedback ) );
        pStdSimDiff(s) = stdStimStability - stdStimFeedback;
    end
    pVal_pStdStabilityFeedback.(taskName) = ...
        mean( pStdSimDiff >= abs(pStdRealDiff) ) + ...
        mean( pStdSimDiff <= -abs(pStdRealDiff) );
end
pVal_pStdStabilityFeedback
```

```
pVal_pStdStabilityFeedback = struct with fields:
      Vertical: 0.8329
    Horizontal: 0.5462
```

FUNCTIONS

This code uses 3 custom functions:

(1) runningWindow - see below

(2) psychometric - see below

(3) plotDiscreteViolin - see below

(3) myBinomTest - external. Reference: Matthew Nelson (2015). https://www.mathworks.com/matlabcentral/fileexchange/24813-mybinomtest-s-n-p-sided MATLAB Central File Exchange. Retrieved February 9, 2016.

psychometric

```
function [meanY,semY] = psychometric( data, xDeltaVector, flag, colVect )

% Creates a psychometric curve with mean+-SEM of the input matrix and plot
% the result by default. Element i,j is the mean of subject i in trial type
% j.
% NaN values are omitted.

% INPUT 1: data is N x M matrix, corresponding to data of N subjects,
% with M trial difficulty levels.
% INPUT 2: xDeltaVector is the difficulty level vector.
% INPUT 3 (optional): flag. 'on' (default) plots a corresponding figure.
% 'off' will not output a plot.
% INPUT 4 (optional): colVect. 1x3 color vect. The default is black.

% OUTPUT 1: meanY is the mean over subjects, for each difficulty.
% OUTPUT 2: semY is the standard error of the mean.

% compute the running window:
```

```
meanY = mean(data, 'omitnan');
semY = std(data, 'omitnan') ./ sqrt( sum(~isnan(data)) );

% plot the results:
if nargin == 2 || (nargin >= 3 && strcmp(flag,'on'))
    if nargin == 4
        col = colVect;
    else
        col = [0,0,0];
    end
    patch( [xDeltaVector, flip(xDeltaVector)], ...
        [meanY + semY, flip(meanY - semY)], ...
        col, 'EdgeColor', 'none', 'FaceAlpha', .3 );
    hold on;
    plot( xDeltaVector, meanY, 'Color', col, 'lineWidth', 1, 'Marker', '.'
);
    hold on;
end

end
```

runningWindow

```
function [meanInWin,semInWin,t] = runningWindow( data, winSize, flag, ...
    colVect )

% Creates a running window of mean+-SEM of the input matrix and plot the
% result by default, for consecutive winSize trials (e.g., 1:winSize-1,
% 2:winSize, ... M-winSize+1:M).
% NaN values are omitted.

% INPUT 1: data is N x M matrix, corresponding to data of N subjects,
% in M trials.
% INPUT 2: winSize is the window size.
% INPUT 3 (optional): flag. 'on' (default) plots a corresponding figure.
% 'off' will not output a plot.
% INPUT 4 (optional): colVect. 1x3 color vect. The default is black.

% OUTPUT 1: meanInWin is the mean in the window.
% OUTPUT 2: semInWin is the standard error of the mean in the window.
% OUTPUT 3: t is the average location of the window. Namely, the sum of the
% number of first plus last trials in the window, divided by 2.

% compute the running window:
nTrials = size(data,2);
meanInWin = nan(1,nTrials+1-winSize);
semInWin = nan(1,nTrials+1-winSize);
t = nan(1,nTrials+1-winSize);
for winStLoc = 1:(nTrials+1-winSize)
    winLocs = winStLoc:(winStLoc+winSize-1);
```

```
    winChoices = data(:,winLocs);
    p = mean( winChoices, 2, 'omitnan' );
    meanInWin(winStLoc) = mean( p, 'omitnan' );
    semInWin(winStLoc) = std( p, 'omitnan' ) / sqrt( sum(~isnan(p)) );
    t(winStLoc) = .5 * ( winLocs(1) + winLocs(end) );
end

% plot the results:
if nargin == 2 || (nargin >= 3 && strcmp(flag,'on'))
    if nargin == 4
        col = colVect;
    else
        col = [0,0,0];
    end
    patch( [t, flip(t)], ...
        [meanInWin + semInWin, flip(meanInWin - semInWin)], ...
        col, 'EdgeColor', 'none', 'FaceAlpha', .3 );
    hold on;
    plot( t, meanInWin, 'Color', col, 'lineWidth', 1, 'Marker', '.' );
    hold on;
end

end
```

plotDiscreteViolin

```
function plotDiscreteViolin(dataCell, binEdges,  xtickLabels, plotTitle,
colorMat)
    % dataCell: 1xK cell, each element is a numeric vector
    % binEdges: violin bin edges
    % xtickLabels: 1xK cell array of labels
    % plotTitle: 1x1 cell array with a single string
    % colorMat: Kx3 matrix of RGB colors (rows must match groups)

    K = length(dataCell);

    figure; hold on;

    for i = 1:K
        delta = dataCell{i};
        N = length(delta);
        n = histcounts(delta, binEdges);
        n_norm = n / N;
        color = colorMat(i, :);

        % Plot rectangles for group i at x = i
        for k = 1:length(n_norm)
            yBottom = binEdges(k);
            yTop = binEdges(k+1);
            w = n_norm(k) / 2;
```

```
            xRect = [i - w, i + w, i + w, i - w];
            yRect = [yBottom, yBottom, yTop, yTop];

            fill(xRect, yRect, color, ...
                'EdgeColor', color, 'FaceAlpha', 0.3);
        end

        % Mean ± SEM
        mu = mean(delta);
        sem = std(delta) / sqrt(N);
        errorbar(i, mu, sem, 'ko', 'MarkerFaceColor', 'k', ...
            'CapSize', 10, 'LineWidth', 1.5);
    end

    % Aesthetics
    plot([0.5, K + 0.5], mean(binEdges) * [1, 1], 'k:')
    xlim([0.5, K + 0.5])
    ylim([min(binEdges), max(binEdges)])
    xticks(1:K)
    xticklabels(xtickLabels)
    ylabel('\Delta p_c^0')
    title(plotTitle{1})
    box off
end
```

END OF DOCUMENT