Electronic Supplementary Materials

This file contains additional input and output information for the analysis conducted within the main manuscript.

Specifically, the custom MATLAB code used to organize the data, perform simple statistics and plot the results is attached. Below the code is the output from JASP (https://jasp-stats.org/) which was used to calculate the ANOVAs and follow up statistics.

Table of Contents


```
% LST and RPM analysis script for LST stats and figures, Feb 2017

clearvars
clc

%subjects in analysis
path ='/Users/uqlhear2/ownCloud/2_PhD/1_LST_behav/5_Data/Study1/';
subj = [1:33 35:42]; % two exclusions - see paper for details
N    = length(subj);
T    = 144; %trials
C    = 8; %conditions
TC   = T/C;
```

Organize data

```
%--- APM ---%
%APM.S1CorAns = [8 4 5 1 2 5 6 3 7 8 7 6]; %Correct answers
APM.S2CorAns    = [5 1 7 4 3 1 6 1 8 4 5 6 2 1 2 4 6 7 3 8 8 7 6 3 7 2
 7 5 6 5 4 8 5 1 3 2]; %Correct answers
APM.S2data      = zeros(length(subj),length(APM.S2CorAns));
APM.S2acc       = zeros(length(subj),length(APM.S2CorAns));

for j = 1:length(subj)
    % read in data
    filename        =
 [path,'Sub_',num2str(subj(j)), '_APM_Set2_results.mat'];
    tData           = load(filename);
    APM.S2data(j,:) = tData.resp; % APM set 2.
    APM.time(j)     = tData.timer.current/60; % the time it took to
 complete.
end

APM.S2acc       = APM.S2data == APM.S2CorAns;% Check accuracy
APM.S2accTotal  = sum(APM.S2acc,2);
disp(['APM: M=',num2str(mean(APM.S2accTotal)),...
    ', SD=',num2str(std(APM.S2accTotal)),...
    ', min=',num2str(min(APM.S2accTotal)),...
    ', max=',num2str(max(APM.S2accTotal)),...
    ', time taken M =',num2str(mean(APM.time)),...
    ', time taken SD =',num2str(std(APM.time))]);

%--- LST---%
```

```
for j = 1:length(subj)
    %read in data
    filename = [path,'Sub_',num2str(subj(j)), '_LST_results.mat'];
    tData = load(filename);
    LSTacc.Data(j,tData.param.trialOrder)       =
 tData.rec.Acc; %ordered by complexity (not presentation)
    LSTRT.Data(j,tData.param.trialOrder)        = tData.rec.RT;
    LSTMissedResponse(j,tData.param.trialOrder) = tData.rec.Key;
end

% Accuracy
LSTacc.Total = sum(LSTacc.Data(:,1:108),2); %the sum of correct
 answers in complexity trials
LSTacc.Cond  = squeeze(sum(reshape(LSTacc.Data,[N,TC,C]),2));
LSTacc.CondNoSteps  = squeeze(sum(reshape(LSTacc.Data,
[N,TC*2,C/2]),2));

% Reaction Time
LSTRT.Data(LSTMissedResponse == 999) = NaN;
LSTRT.Total = nanmean(LSTRT.Data(:,1:108),2);
LSTRT.Cond  = squeeze(nanmean(reshape(LSTRT.Data,[N,TC,C]),2));
LSTRT.CondNoSteps  = squeeze(nanmean(reshape(LSTRT.Data,
[N,TC*2,C/2]),2));

%--- Test-retest data ---%
path2='/Users/uqlhear2/ownCloud/2_PhD/1_LST_behav/5_Data/Study2 -
 retest/';
%only a limited sample returned to do part II.
subj2 = [1,2,7,9,16,17,18,21,24,25,28,30,31,32,33,35,36,41,42];
N2    = length(subj2);

for j = 1:length(subj2)

    filename = [path,'Sub_',num2str(subj2(j)),'_LST_results.mat'];
    tData    = load(filename);
    LSTaccRetest.S1.Data(j,tData.param.trialOrder) = tData.rec.Acc; %
 accuracy data
    LSTaccRetest.S1.Date(j,:)=tData.sub.DateTime;

    filename =
 [path2,'Sub_',num2str(subj2(j)),'_LST_RETEST_results.mat'];
    tData    = load(filename);
    LSTaccRetest.S2.Data(j,tData.param.trialOrder) = tData.rec.Acc; %
 accuracy data
    LSTaccRetest.S2.Date(j,:)=tData.sub.DateTime;
end

% Session 1 accuracy
LSTaccRetest.S1.Total = sum(LSTaccRetest.S1.Data(:,1:108),2);
LSTaccRetest.S1.Cond  = squeeze(sum(reshape(LSTaccRetest.S1.Data,
[N2,18,8]),2));

% Session 2 accuracy
LSTaccRetest.S2.Total = sum(LSTaccRetest.S2.Data(:,1:108),2);
```

```
LSTaccRetest.S2.Cond  = squeeze(sum(reshape(LSTaccRetest.S2.Data,
[N2,18,8]),2));
```

APM: M=24.9024, SD=4.5979, min=14, max=33, time taken M =30.1383, time taken SD =7.6487

STATS

export data for ANOVAs(JASP)

```
Tab = array2table(LSTacc.Cond,'VariableNames',{'BinS1','BinS2',...
                                               'TerS1','TerS2',...
                                               'QuaS1','QuaS2',...
                                               'Null1','Null2'});
writetable(Tab,'Accuracy.csv');
Tab = array2table(LSTRT.Cond,'VariableNames',{'BinS1','BinS2',...
                                               'TerS1','TerS2',...
                                               'QuaS1','QuaS2',...
                                               'Null1','Null2'});
writetable(Tab,'RT.csv');
% means and standard deviation
desTable.means = mean((LSTacc.Cond/TC*100));
desTable.stdevs = std((LSTacc.Cond/TC*100));
desTable.meansNoSteps = mean((LSTacc.CondNoSteps/36*100));
desTable.stdevsNoSteps = std((LSTacc.CondNoSteps/36*100));
desTable.meansTot = mean(LSTacc.Total/108*100);
desTable.stdevsTot = std(LSTacc.Total/108*100);

desTableRT.means = mean(LSTRT.Cond);
desTableRT.stdevs = std(LSTRT.Cond);
desTableRT.meansNoSteps = mean(LSTRT.CondNoSteps);
desTableRT.stdevsNoSteps = std(LSTRT.CondNoSteps);
desTableRT.meansTot = mean(LSTRT.Total);
desTableRT.stdevsTot = std(LSTRT.Total);

% correlation between LST and ACC
[r_tot,p_tot]=corr(LSTRT.Total,APM.S2accTotal);
disp(['Correlation between overall LST RT and APMS2, r =
 ',num2str(r_tot),' p = ',num2str(p_tot)]);
[r_tot,p_tot]=corr(LSTacc.Total,APM.S2accTotal);
disp(['Correlation between overall LST and APMS2, r =
 ',num2str(r_tot),' p = ',num2str(p_tot)]);

% internal reliability
cronbachA(1,1) = cronbachsAlpha(LSTacc.Data(:,1:108));
cronbachA(1,2) = cronbachsAlpha(LSTRT.Data(:,1:108));

idx  = 1:TC:T;
idx2 = 18:TC:T;

for i = 1:C % only interesting conditions
    cronbachA(i+1,1) = cronbachsAlpha(LSTacc.Data(:,idx(i):idx2(i)));
    cronbachA(i+1,2) = cronbachsAlpha(LSTRT.Data(:,idx(i):idx2(i)));
```

```
end

% test-retest reliability
corr_type = 'Spearman';
[rRetest,pRetest]=corr(LSTaccRetest.S1.Total,LSTaccRetest.S2.Total,'type',corr_typ

for i = 1:C % only interesting conditions
    [rRetest(i+1),pRetest(i+1)]=corr(LSTaccRetest.S1.Cond(:,i),...
        LSTaccRetest.S2.Cond(:,i),'type',corr_type);
end

%date time
LSTaccRetest.Date=(datenum(LSTaccRetest.S2.Date)-
datenum(LSTaccRetest.S1.Date))/30;
%null data comparison for review (Null is col 4).
mean(LSTRT.CondNoSteps);
```

Correlation between overall LST RT and APMS2, r = -0.40894 p =
0.007938
Correlation between overall LST and APMS2, r = 0.55737 p = 0.00015342

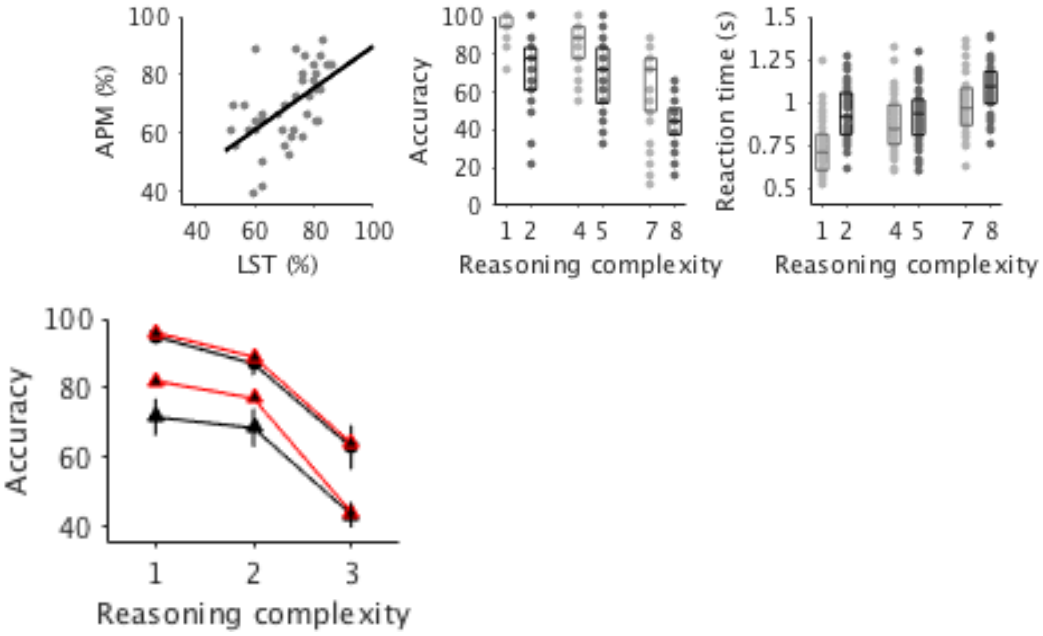
Plots

```
close all

figure('Color',[1 1 1], 'units','pixels','outerposition',[300 300 500
 200]);
hold on;
set(gcf,'color','w');

col1 = [0.7 0.7 0.7];
col2 = [0.4 0.4 0.4];
msize = 10;
subplot(1,3,1) %APM/LST correlation

scatter(LSTacc.Total/108*100,APM.S2accTotal/36*100,10,'MarkerEdgeColor',...
    [.5 .5 .5],'MarkerFaceColor',
 [.5 .5 .5] ,'LineWidth',0.5','SizeData',msize)
h = lsline;
set(h,'LineWidth',2,'Color','k');
set(gca,'FontName', 'Helvectica','FontSize',
 10,'Box','off','TickDir','out','ygrid','off','XLim',[35 100],'YLim',
[35 100]);
xlabel('LST (%)');
ylabel('APM (%)');
set(gca,'YTick',40:20:100, 'FontSize', 10);
set(gca,'XTick',40:20:100);

%--------------------
% Accuracy
subplot(1,3,2)

data=LSTacc.Cond(:,[1,3,5])/18*100;
```

```
for i=1:3
    idx = [1 4 7];
    scatter(repmat(idx(i),
[N,1]),data(:,i),'MarkerEdgeColor',col1,'MarkerFaceColor',col1,'SizeData',msize)
    median_box(data(:,i),idx(i),.25,col1-.3,1)
    hold on
end

data=LSTacc.Cond(:,[2,4,6])/18*100;
for i=1:3
    idx = [2 5 8];
    scatter(repmat(idx(i),
[N,1]),data(:,i),'MarkerEdgeColor',col2,'MarkerFaceColor',col2,'SizeData',msize)

    median_box(data(:,i),idx(i),.25,col2-.3,1)
    hold on
end

set(gca,'FontName', 'Helvectica','FontSize',
 10,'Box','off','TickDir','out','ygrid','off','XLim',[.5 8.5],'YLim',
[0 100]);
xlabel('Reasoning complexity');
ylabel('Accuracy');
set(gca,'YTick',0:20:100, 'FontSize', 10);
set(gca,'XTick',[1 2 4 5 7 8]);

%--------------------
subplot(1,3,3) % RT

data=LSTRT.Cond(:,[1,3,5]);
for i=1:3
    idx = [1 4 7];
    scatter(repmat(idx(i),
[N,1]),data(:,i),'MarkerEdgeColor',col1,'MarkerFaceColor',col1,'SizeData',msize)
    median_box(data(:,i),idx(i),.25,col1-.3,1)
    hold on
end

data=LSTRT.Cond(:,[2,4,6]);
for i=1:3
    idx = [2 5 8];
    scatter(repmat(idx(i),
[N,1]),data(:,i),'MarkerEdgeColor',col2,'MarkerFaceColor',col2,'SizeData',msize)

    median_box(data(:,i),idx(i),.25,col2-.3,1)
    hold on
end

set(gca,'FontName', 'Helvectica','FontSize',
 10,'Box','off','TickDir','out','ygrid','off','XLim',[.5 8.5],'YLim',
[0.4 1.5]);
xlabel('Reasoning complexity');
ylabel('Reaction time (s)');
set(gca,'YTick',.5:.25:2, 'FontSize', 10);
```

```
set(gca,'XTick',[1 2 4 5 7 8]);

%Comparison with Birney.
fig=figure('Color',[1 1 1], 'units','pixels','outerposition',[300 300
 (500/3) 200]);
hold on;
set(gcf,'color','w');

data=LSTacc.Cond(:,[1 3 5]);data=data/18*100;
plot(mean(data),'Color','k','LineWidth',1,'MarkerSize',5,'Marker','o','MarkerFaceC
hold on

CI(1,:)=mean(data)+(1.96*std(data)/(sqrt(length(data))));
CI(2,:)=mean(data)-(1.96*std(data)/(sqrt(length(data))));

for i=1:3
    h=line([i i],[CI(1,i),CI(2,i)]);
    set(h,'LineWidth',1,'Color','k');
    hold on
end

data=LSTacc.Cond(:,[2 4 6]);data=data/18*100;
plot(mean(data),'Color','k','LineWidth',1,'MarkerSize',5,'Marker','^','MarkerFaceC

CI(1,:)=mean(data)+(1.96*std(data)/(sqrt(length(data))));
CI(2,:)=mean(data)-(1.96*std(data)/(sqrt(length(data))));

data=[96 89 64];
plot(data,'Color','r','LineWidth',1,'MarkerSize',5,'Marker','^','MarkerFaceColor',

data=[82 77 44];
plot(data,'Color','r','LineWidth',1,'MarkerSize',5,'Marker','^','MarkerFaceColor',



for i=1:3
    h=line([i i],[CI(1,i),CI(2,i)]);
    set(h,'LineWidth',1,'Color','k');
    hold on
end

set(gca,'FontName', 'Arial','FontSize',
 12,'Box','off','TickDir','out','ygrid','off','XLim',[.5 3.5],'YLim',
[35 100]);
xlabel('Reasoning complexity');
ylabel('Accuracy');
set(gca,'YTick',0:20:100, 'FontSize', 10);
set(gca,'XTick',0:1:100);

function median_box(data,mid,width,col,lw)

% Draws a box of medians and percentiles at mid.

% Draw horizontal lines
```

```
line([mid-width mid+width],
[median(data),median(data)],'Color',col,'LineWidth',lw); hold on
line([mid-width mid+width],
[prctile(data,25),prctile(data,25)],'Color',col,'LineWidth',lw);
 hold on
line([mid-width mid+width],
[prctile(data,75),prctile(data,75)],'Color',col,'LineWidth',lw);
 hold on

% Draw vertical lines
line([mid-width mid-width],
[prctile(data,25),prctile(data,75)],'Color',col,'LineWidth',lw);
 hold on
line([mid+width mid+width],
[prctile(data,25),prctile(data,75)],'Color',col,'LineWidth',lw);
 hold on

end
```



Published with MATLAB® R2017b

Results

Repeated Measures ANOVA

Within Subjects Effects

	Sum of Squares	df	Mean Square	F	p	η²
Complexity	1363.683	2	681.841	113.251	< .001	0.739
Residual	481.650	80	6.021			
Steps	834.183	1	834.183	248.422	< .001	0.861
Residual	134.317	40	3.358			
Complexity ✻ Steps	8.366[a]	2[a]	4.183[a]	0.842[a]	0.435[a]	0.021
Residual	397.634	80	4.970			

Note. Type III Sum of Squares

[a] Mauchly's test of sphericity indicates that the assumption of sphericity is violated (p < .05).

Between Subjects Effects

	Sum of Squares	df	Mean Square	F	p	η²
Residual	761.0	40	19.02			

Note. Type III Sum of Squares

Assumption Checks

Test of Sphericity

	Mauchly's W	p	Greenhouse-Geisser ε	Huynh-Feldt ε
Complexity	0.869	0.065	0.884	0.922
Steps	1.000[a]	NaN[a]	1.000[a]	1.000[a]
Complexity ✻ Steps	0.819	0.021	0.847	0.880

[a] The repeated measure has only two levels. When the repeated measure has two levels, the assumption of sphericity is always met.

Post Hoc Tests

Post Hoc Comparisons - Complexity

		Mean Difference	SE	t	p_{bonf}
Level 1	Level 2	0.988	0.305	3.241	0.005
	Level 3	5.415	0.412	13.128	< .001
Level 2	Level 3	4.427	0.371	11.920	< .001

Post Hoc Comparisons - Steps

		Mean Difference	SE	t	p_{bonf}
Level 1	Level 2	3.683	0.268	13.72	< .001

Results

Repeated Measures ANOVA

Within Subjects Effects

	Sum of Squares	df	Mean Square	F	p	η²
Complexity	1.665	2	0.832	110.34	< .001	0.734
Residual	0.603	80	0.008			
Steps	0.775	1	0.775	79.20	< .001	0.664
Residual	0.392	40	0.010			
Complexity ✻ Steps	0.266	2	0.133	17.31	< .001	0.302
Residual	0.614	80	0.008			

Note. Type III Sum of Squares

Between Subjects Effects

	Sum of Squares	df	Mean Square	F	p	η²
Residual	4.556	40	0.114			

Note. Type III Sum of Squares

Assumption Checks

Test of Sphericity

	Mauchly's W	p	Greenhouse-Geisser ε	Huynh-Feldt ε
Complexity	0.992	0.859	0.992	1.000
Steps	1.000[a]	NaN[a]	1.000[a]	1.000[a]
Complexity ✻ Steps	0.958	0.437	0.960	1.000

[a] The repeated measure has only two levels. When the repeated measure has two levels, the assumption of sphericity is always met.

Post Hoc Tests

Post Hoc Comparisons - Complexity

		Mean Difference	SE	t	p_{bonf}
Level 1	Level 2	-0.058	0.016	-3.653	0.001
	Level 3	-0.196	0.014	-13.931	< .001
Level 2	Level 3	-0.138	0.015	-9.365	< .001

Post Hoc Comparisons - Steps

		Mean Difference	SE	t	p_{bonf}
Level 1	Level 2	-0.112	0.013	-8.625	< .001