```
% script for memory task anaysis
```

Parameter Setting

```
subject ='Group';
plot_window=[1 25 1920 1080];
home_dir = '/bigvault/Projects/seeg_pointing';
group_dir = '/bigvault/Projects/seeg_pointing/results/memory_group/';

% obj_pic = 51:165; % original [-2,3], save [-0.5,1.5], pic [0,1.15]
% seq_pic = 251:500;% original [-5,7], save [-2.5,5], pic [0,2.5]
% seq_pre = 1:200;  % original [-5,7], save [-2.5,5], pre interval [-2.5,-0.5]
% seq_after = 501:700;% original [-5,7], save [-2.5,5], pre interval [2.5,4.5]

index = [7,13,25,31,43,49];
bd_id = [index,index+18*6];
non_bd_id = [index+18*3,index+18*9];
```

RSA

1. same VS different picture RSA
2. pre vs after RSA

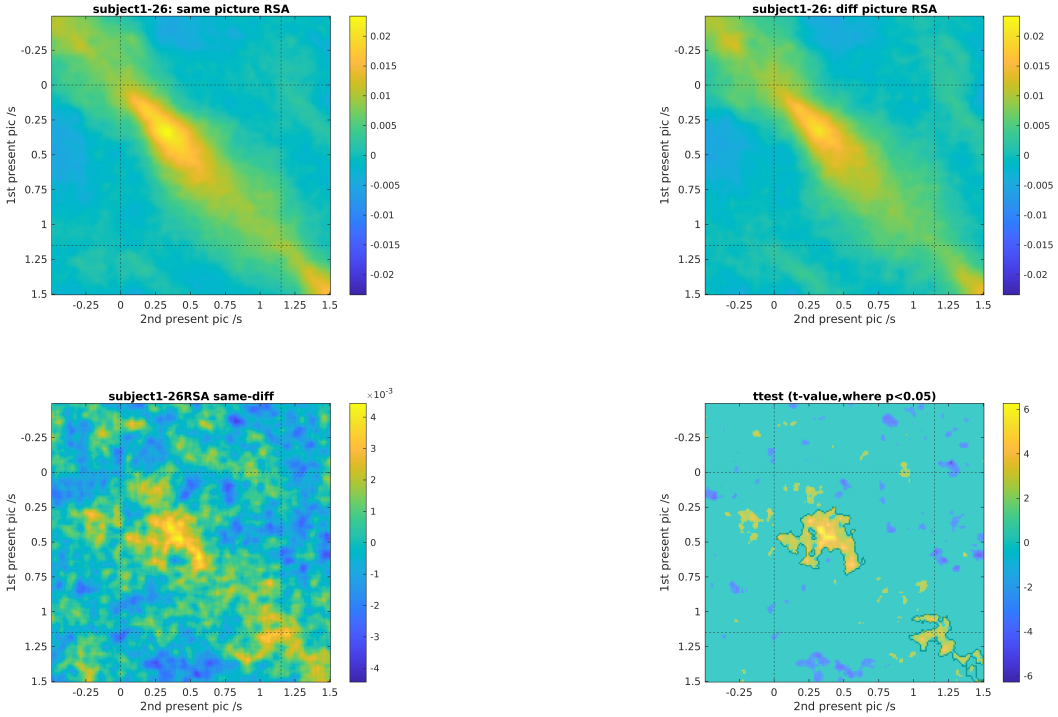
Neural Time Windows in Object Recognition Task

```
% load
load([group_dir,'rsa_obj_group.mat'], 'rsa_group')
disp(['subject: ',num2str(rsa_group.sub_id)])
```

```
subject: 1   2   3   4   7  12  15  16  17  18  19  20  21  24  25  26
```

```
subject ='subject1-26';
rsa_same= rsa_group.same;
perm_result = [];
for lag = 15
    rsa_diff = rsa_group.diff{lag};
    figure
    [cp,pp,tp,pd] =plt_rsa_sd_perm(rsa_same, rsa_diff,'obj');
    perm_result.clusters_perm{lag} =cp;
    perm_result.p_perm{lag} =pp;
    perm_result.t_sums_perm{lag} =tp;
    perm_result.permutation_distribution{lag} =pd;
    subplot(2,2,1);title([subject,': same picture RSA'])
    subplot(2,2,2);title([subject,': diff picture RSA'])
    subplot(2,2,3);title([subject,'RSA same-diff'])
    sgtitle(['lag=',num2str(lag)])
end
```

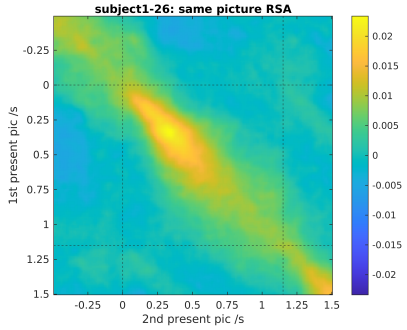
lag=15

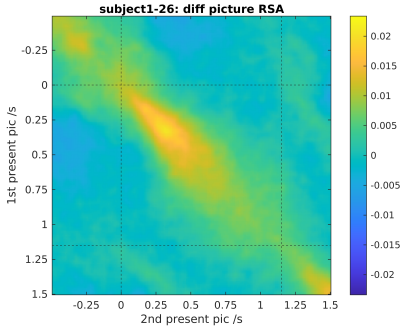


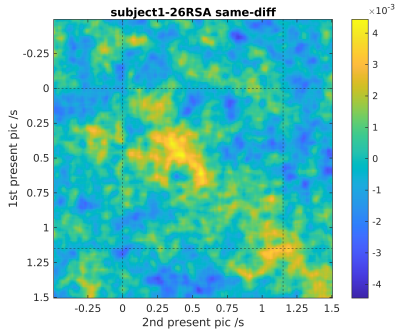
Consistency of neural activity across Object and Sequence

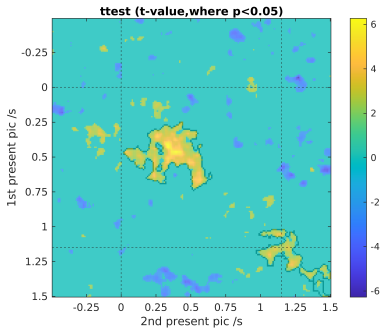
```
rsa_obj2seq_group = load_mat([group_dir,'rsa_obj2seq_group.mat']);
rsa_same = rsa_obj2seq_group.same;
rsa_diff = rsa_obj2seq_group.diff;
method = 'ttest';

% 4. obj2seq same difff
plt_rsa_sd(rsa_same,rsa_diff,'obj2seq');
```

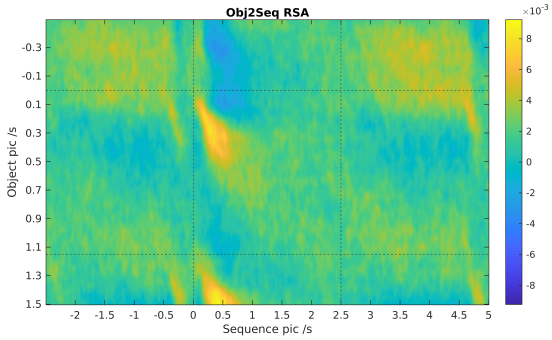
lag=15

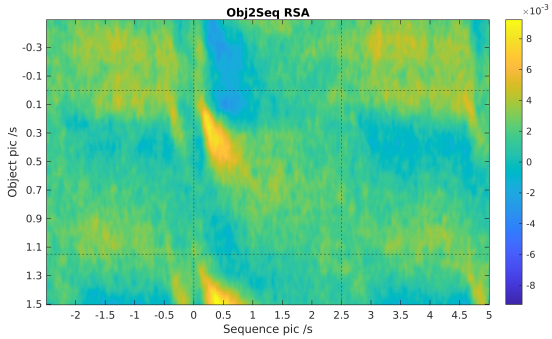


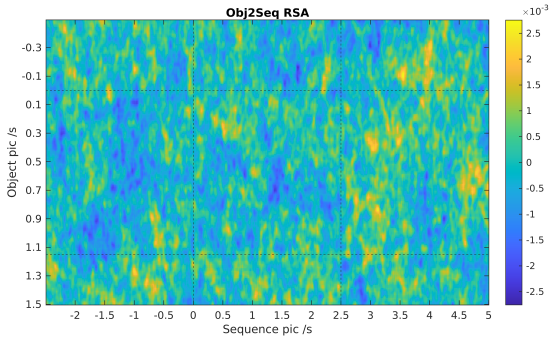


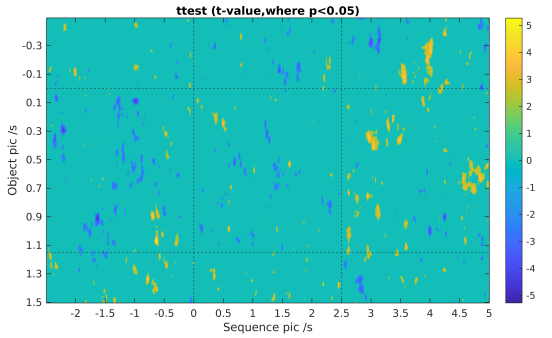






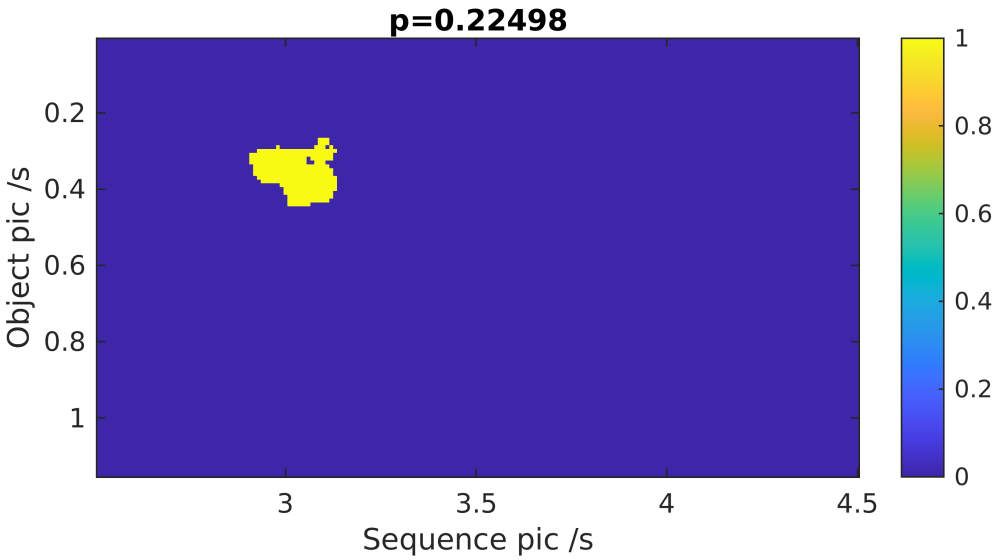




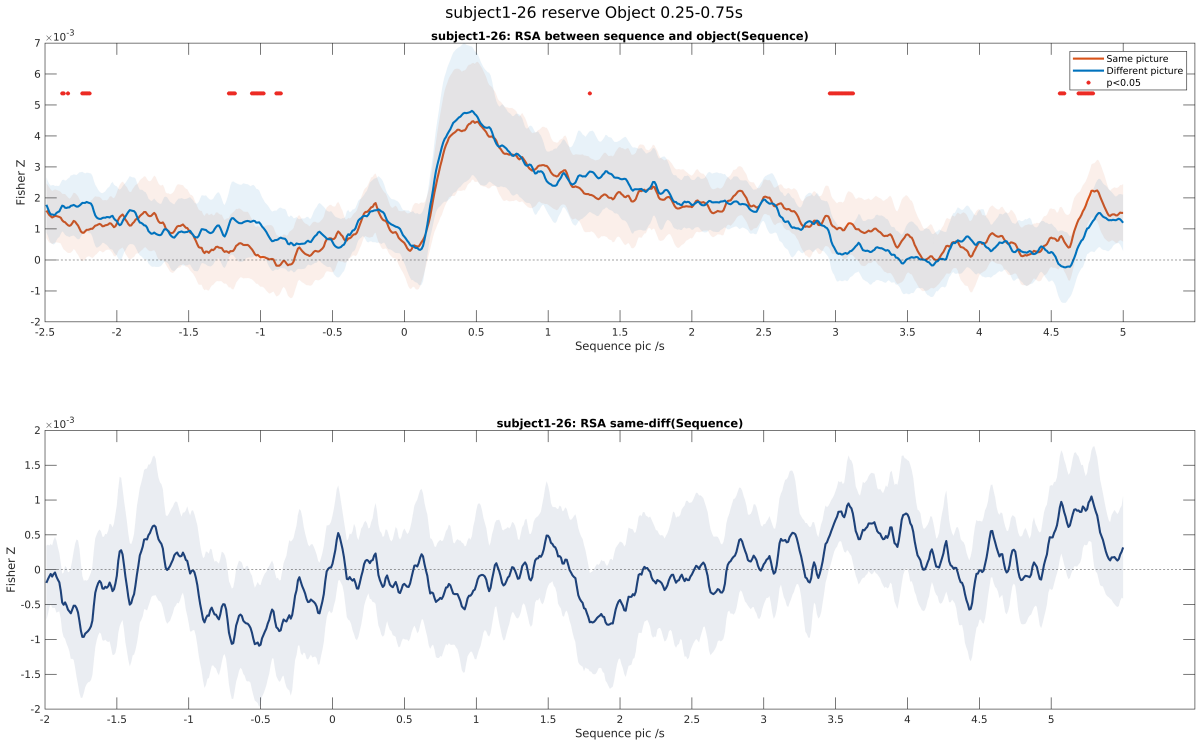



```
% permutation time[501:750]
obj2seq_same = rsa_same(51:165,501:700,:);
obj2seq_diff = rsa_diff(51:165,501:700,:);
```

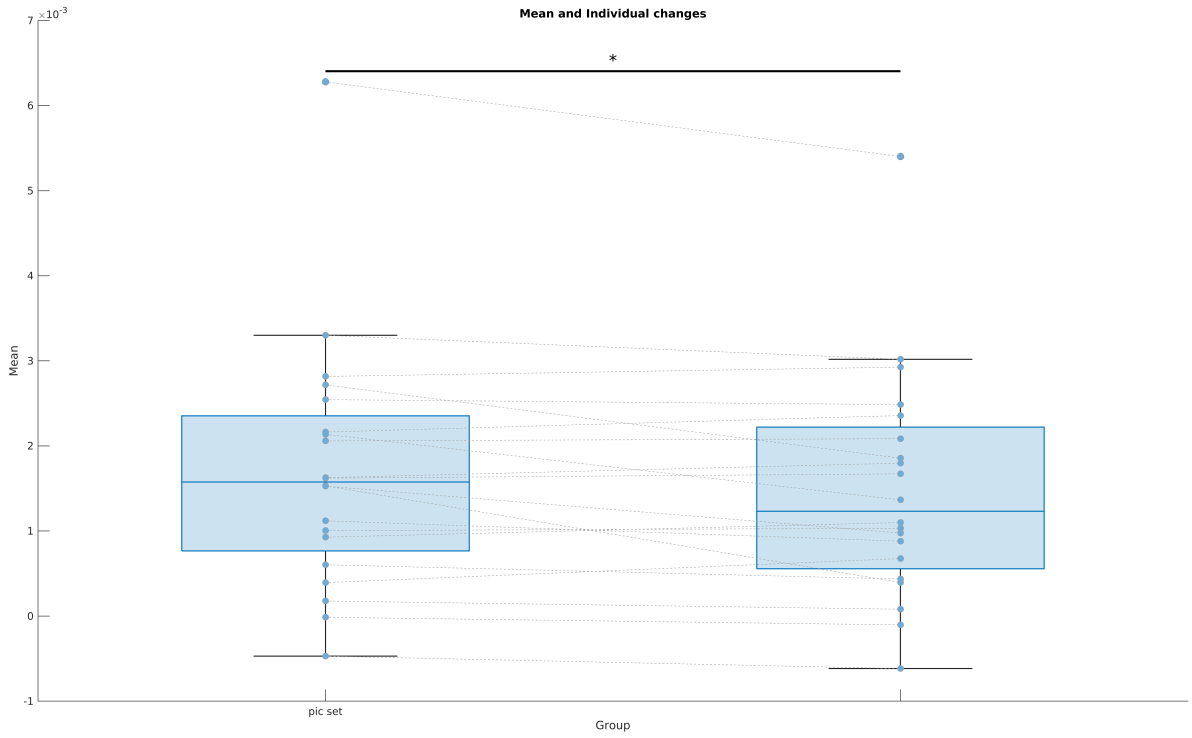
```
[clusters_perm, p_perm,~,~] = permutest(obj2seq_same,obj2seq_diff);

figure
i=1;
mask = zeros(size(obj2seq_same(:,:,1)));
mask(clusters_perm{1, i}) = 1;
plt_imagesc(mask,'obj2seq_s');
xticks(0:50:250);
xticklabels([250:50:500]/100);
caxis([0,1])
daspect([1 1 1])
title(['p=',num2str(p_perm(i))])
```




```
% Object 0.25-0.75s
plt_rsa_obj2seq_flatten(rsa_same(76:125,:,:), rsa_diff(76:125,:,:), 1, subject, plot_wi
sgtitle([subject,' reserve Object 0.25-0.75s'])
```




```
% plot box
data_same = squeeze(mean(rsa_same(51:166,501:750,:),[1,2]));
data_diff = squeeze(mean(rsa_diff(51:166,501:750,:),[1,2]));
figure
plt_box_line([data_same,data_diff],'pic set')
```

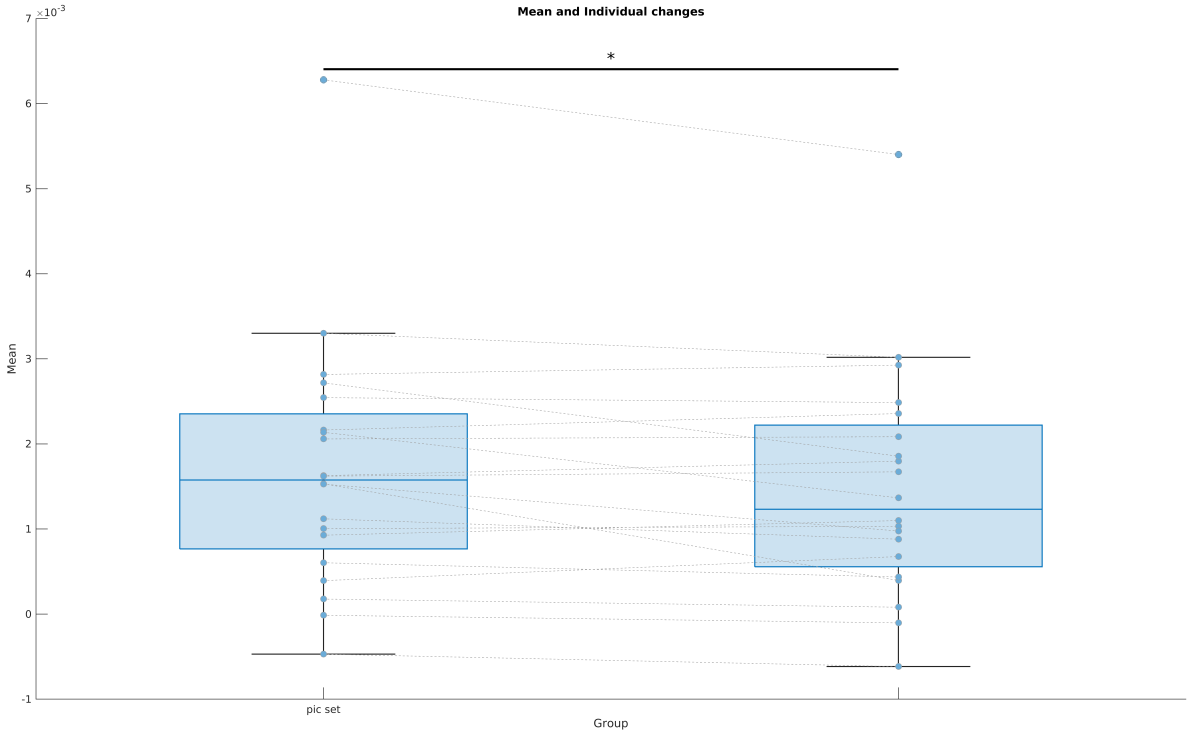


Boundary effect RSA?

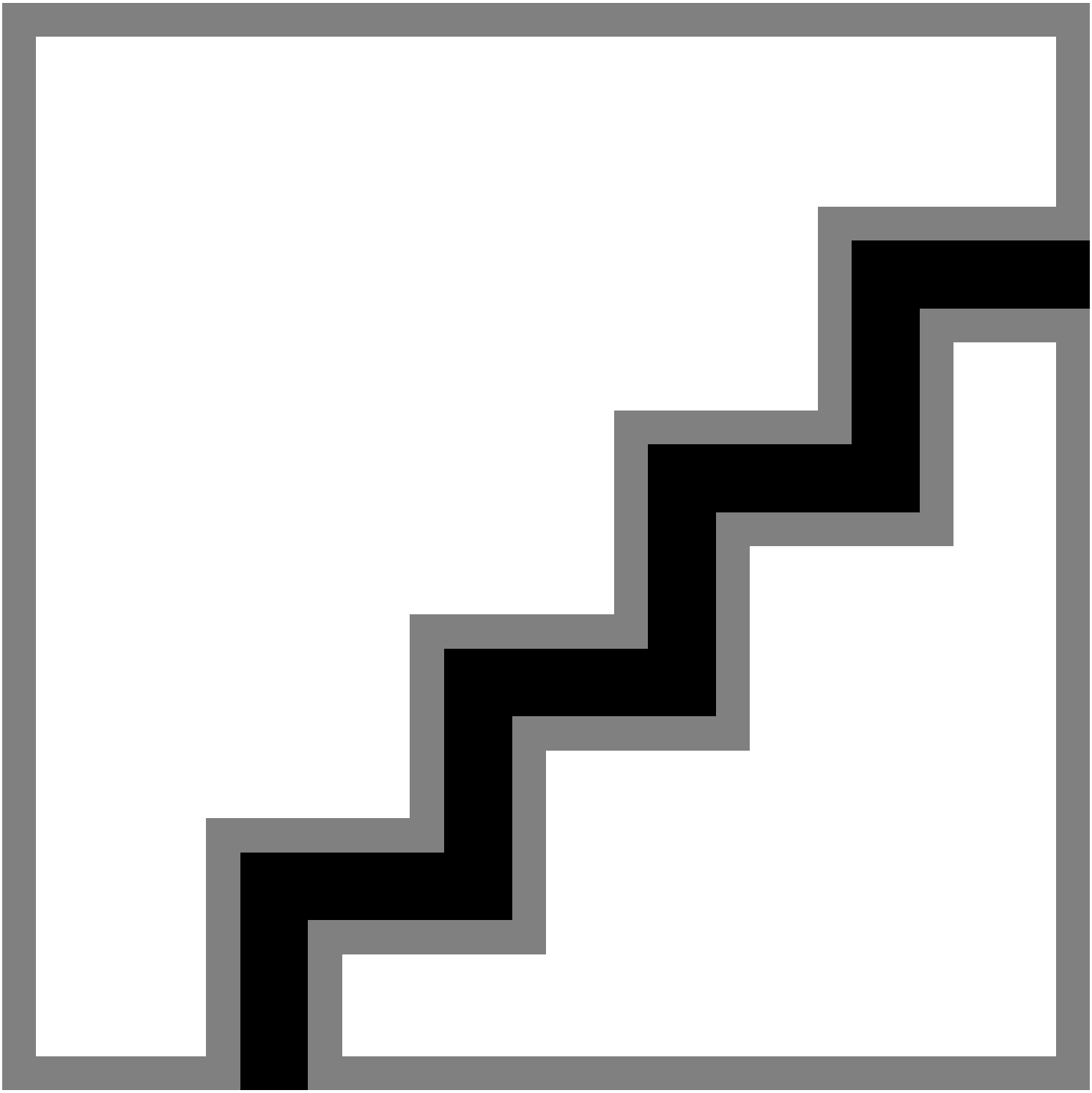
obj2sequence: boundary vs boundary

```
% load data
load(([group_dir,'rsa_obj2seq_bd.mat']))
% condition
obj2seq_bd_all = squeeze(mean(cell2matrix(cellmerge(rsa_group.bd,2)),3));
obj2seq_non_bd_all = squeeze(mean(cell2matrix(cellmerge(rsa_group.non_bd,2)),3));
% position
obj2seq_bd = squeeze(mean(cell2matrix(cellmerge(rsa_group.bd(:,[7,13]),2)),3));
obj2seq_non_bd = squeeze(mean(cell2matrix(cellmerge(rsa_group.non_bd(:,[7,13]),2)),3));
obj2seq_bd_pre = squeeze(mean(cell2matrix(cellmerge(rsa_group.bd(:,[6,12]),2)),3));
obj2seq_non_bd_pre = squeeze(mean(cell2matrix(cellmerge(rsa_group.non_bd(:,[6,12]),2)),
```

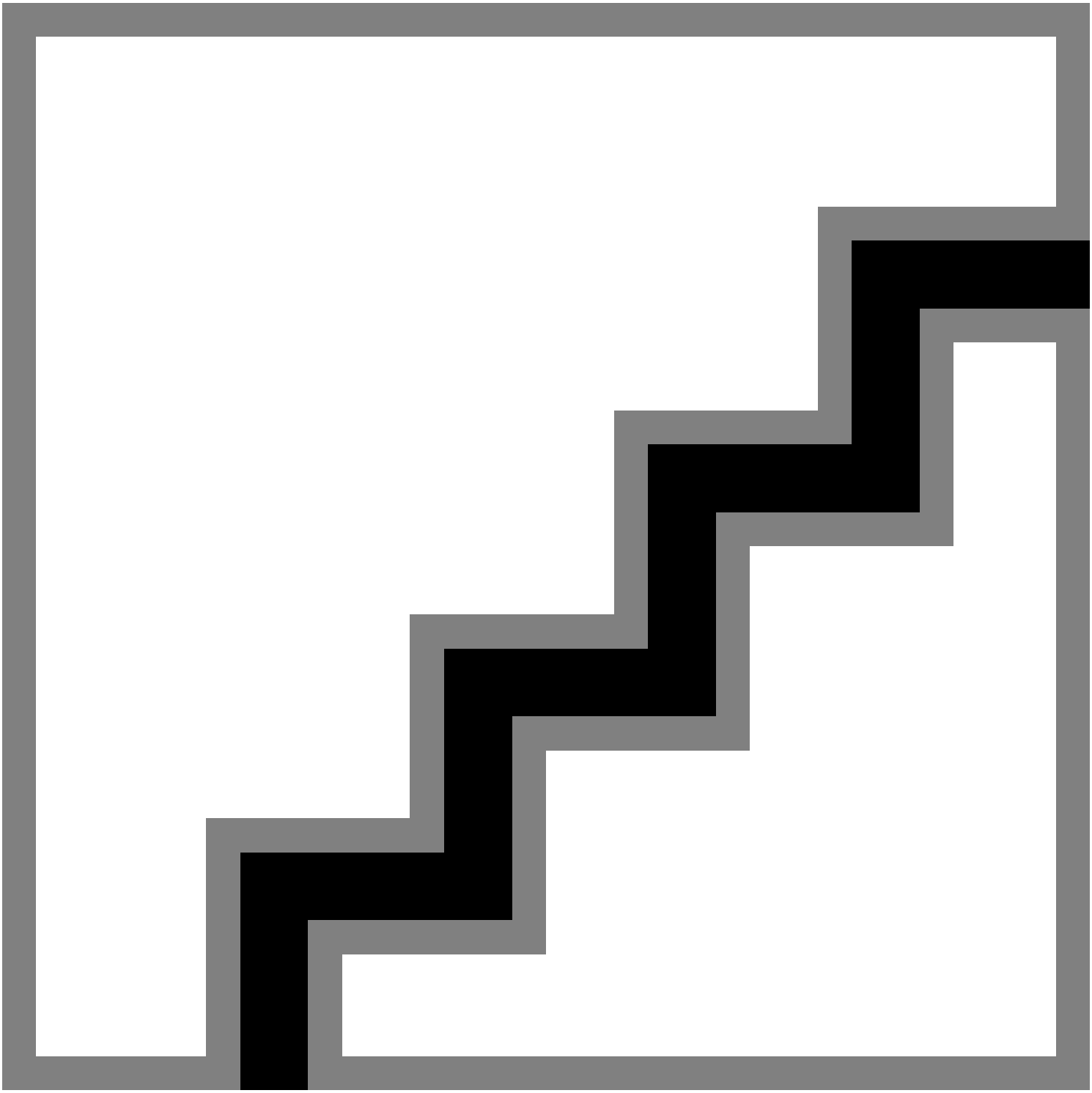
```
% plot obj2seq RSA in Boundary-non Boundary condition
plt_rsa_sd(obj2seq_bd_all,obj2seq_non_bd_all,'obj2seq')
```



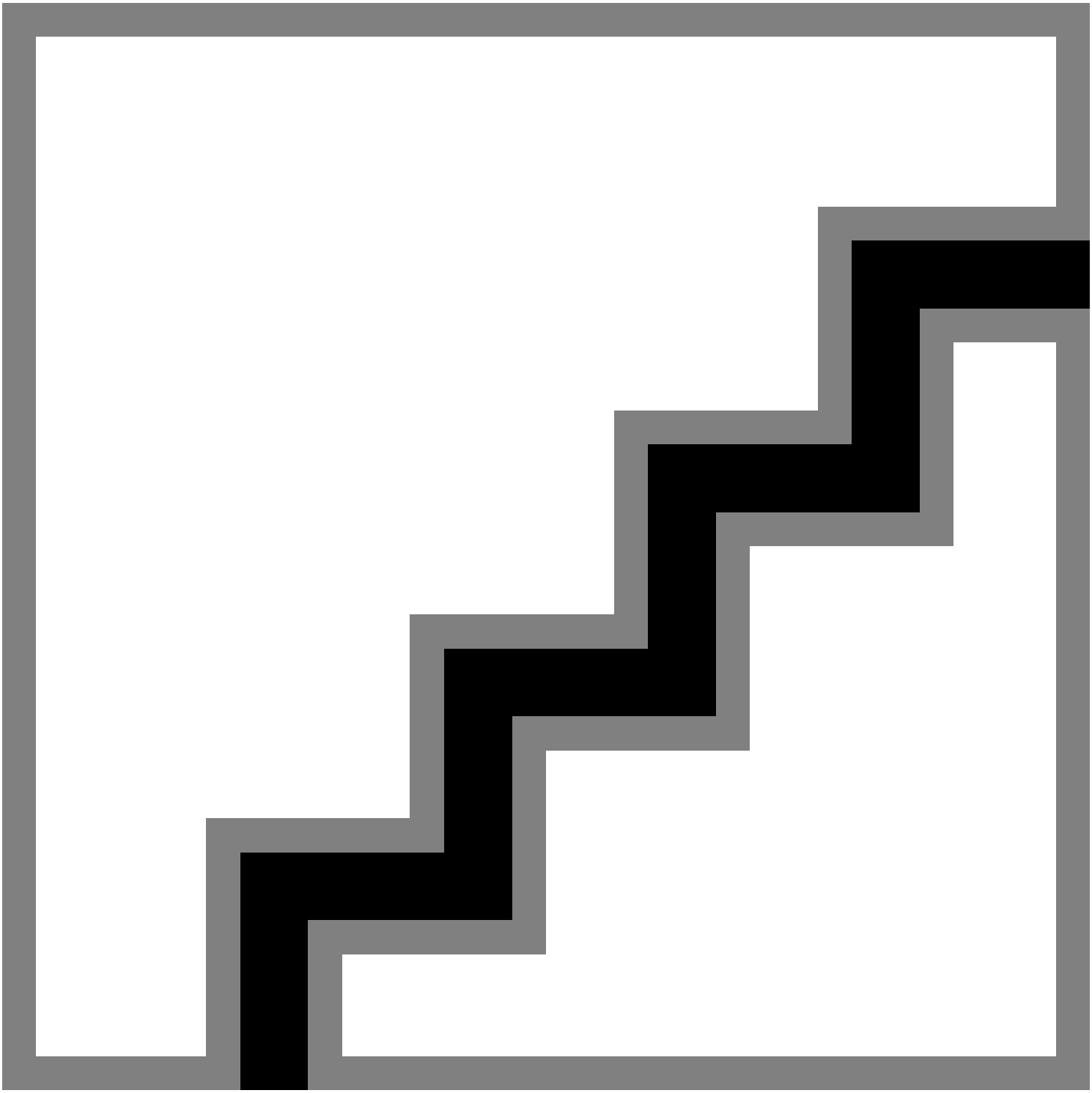

```
subplot(2,2,1);title([subject,': Boundary RSA'])
subplot(2,2,2);title([subject,': non Boundary RSA'])
subplot(2,2,3);title([subject,': Boundary - non Boundary RSA'])
sgtitle('obj2seq RSA (all 18)')
```



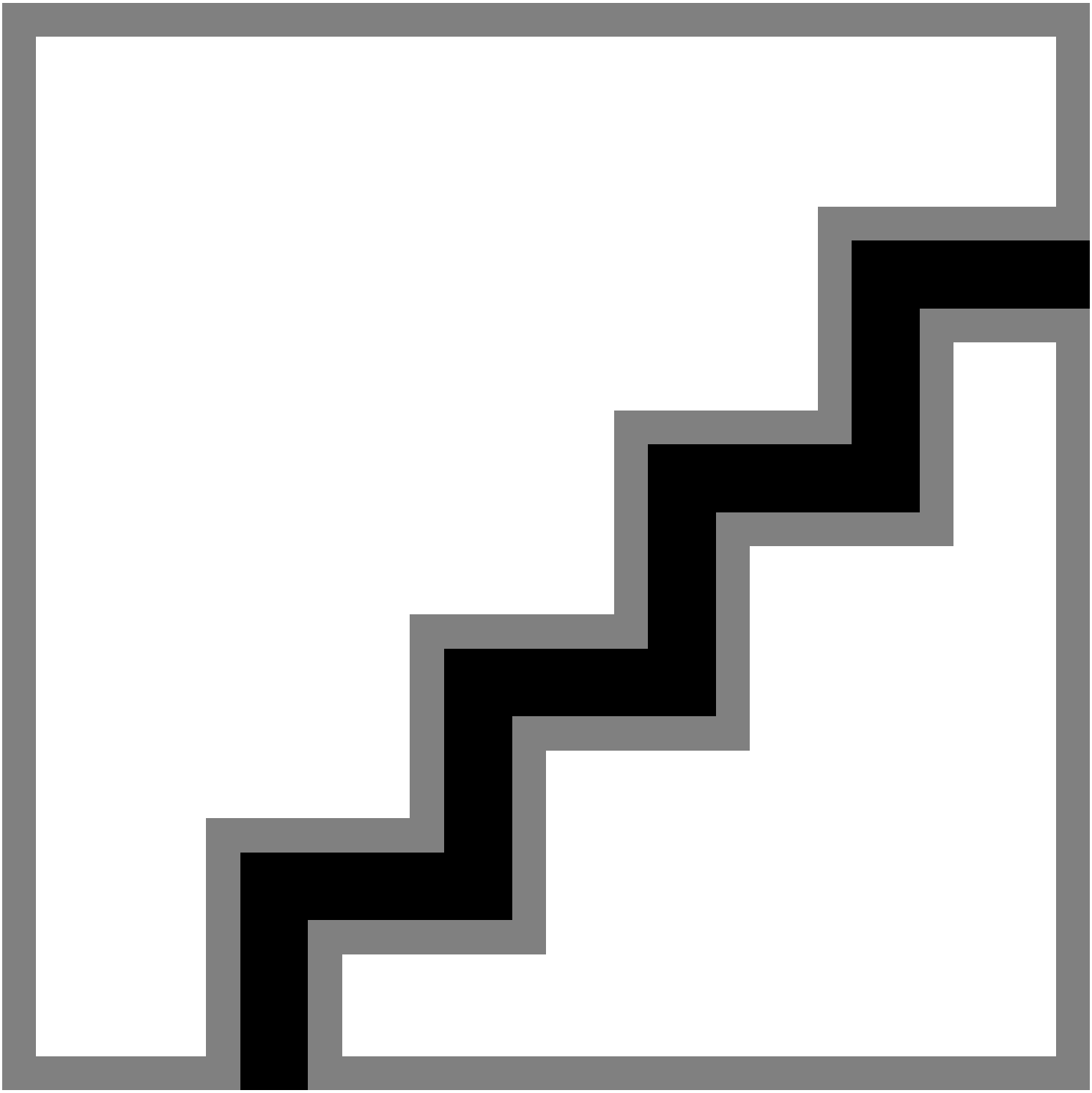
```
% plot obj2seq RSA in Boundary-non Boundary position
plt_rsa_sd_perm(obj2seq_bd,obj2seq_non_bd,'obj2seq');
```



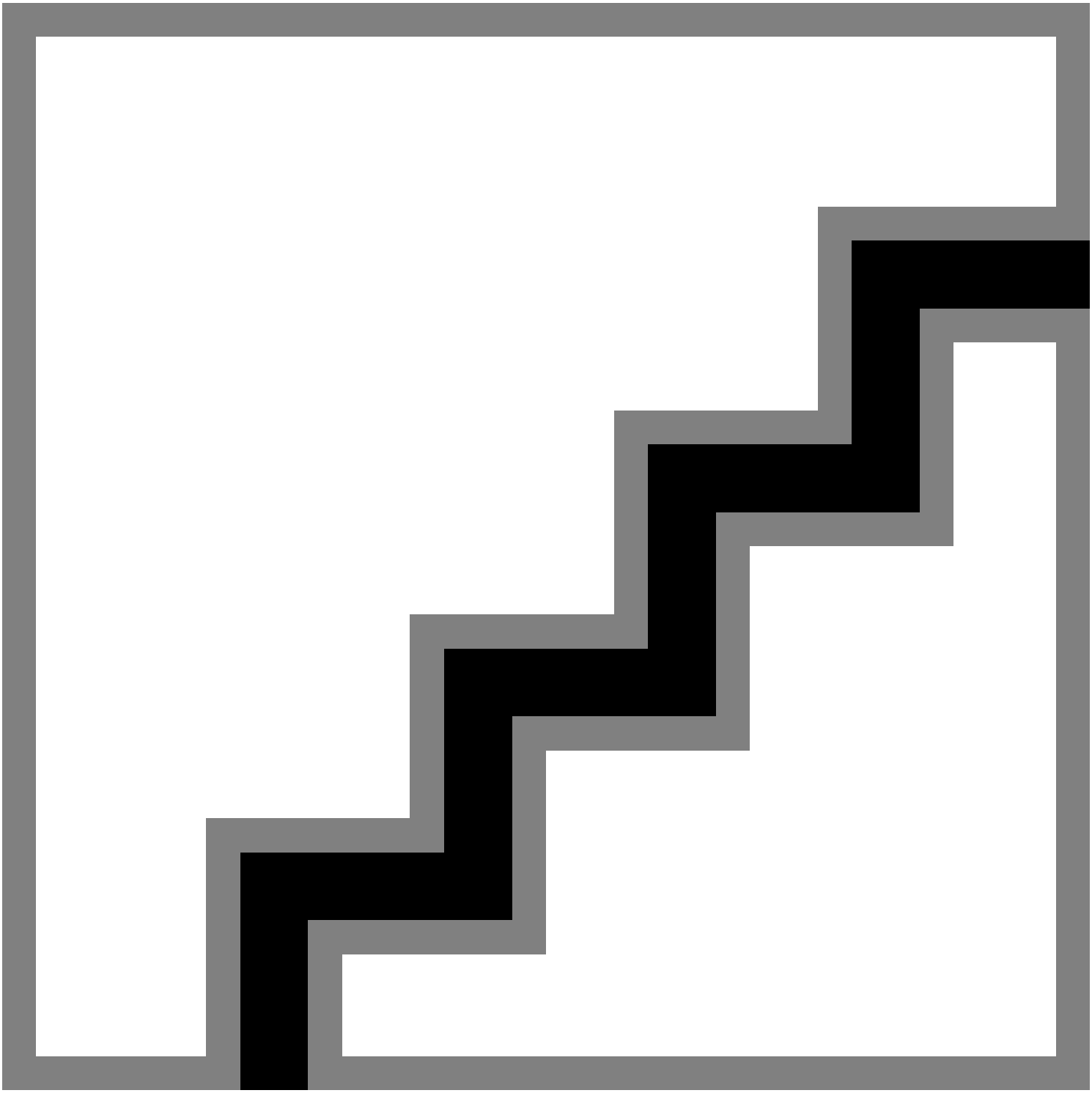
```
subplot(2,2,1);title([subject,': Boundary RSA'])
subplot(2,2,2);title([subject,': non Boundary RSA'])
subplot(2,2,3);title([subject,': Boundary - non Boundary RSA'])
sgtitle('obj2seq RSA (position)')
```



```
% plot obj2seq RSA in Boundary-non Boundary position
[clusters_perm,p_perm,~,~] = plt_rsa_sd_perm(obj2seq_bd(51:165,501:700,:),obj2seq_non_b
```



```
subplot(2,2,1);title([subject,': Boundary RSA'])
subplot(2,2,2);title([subject,': non Boundary RSA'])
subplot(2,2,3);title([subject,': Boundary - non Boundary RSA'])
sgtitle('obj2seq RSA (position)')
```

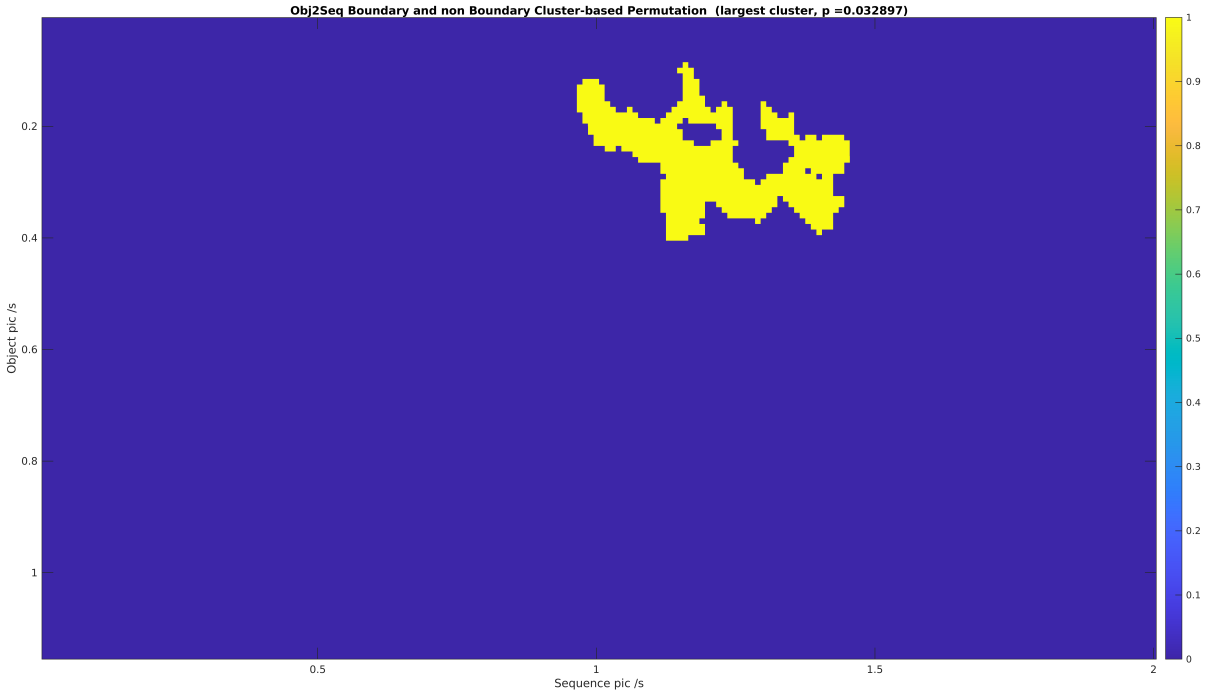


```
% permutest p=0.05
mask = NaN(size(obj2seq_bd(51:165,501:700,1)));
mask(clusters_perm{1, 1}) = 1;
figure;plt_imagesc(mask,'obj2seq_s')
```

```
ans = 2
```

```
xticks(0:50:500);
xticklabels([0:50:500]/100);
```

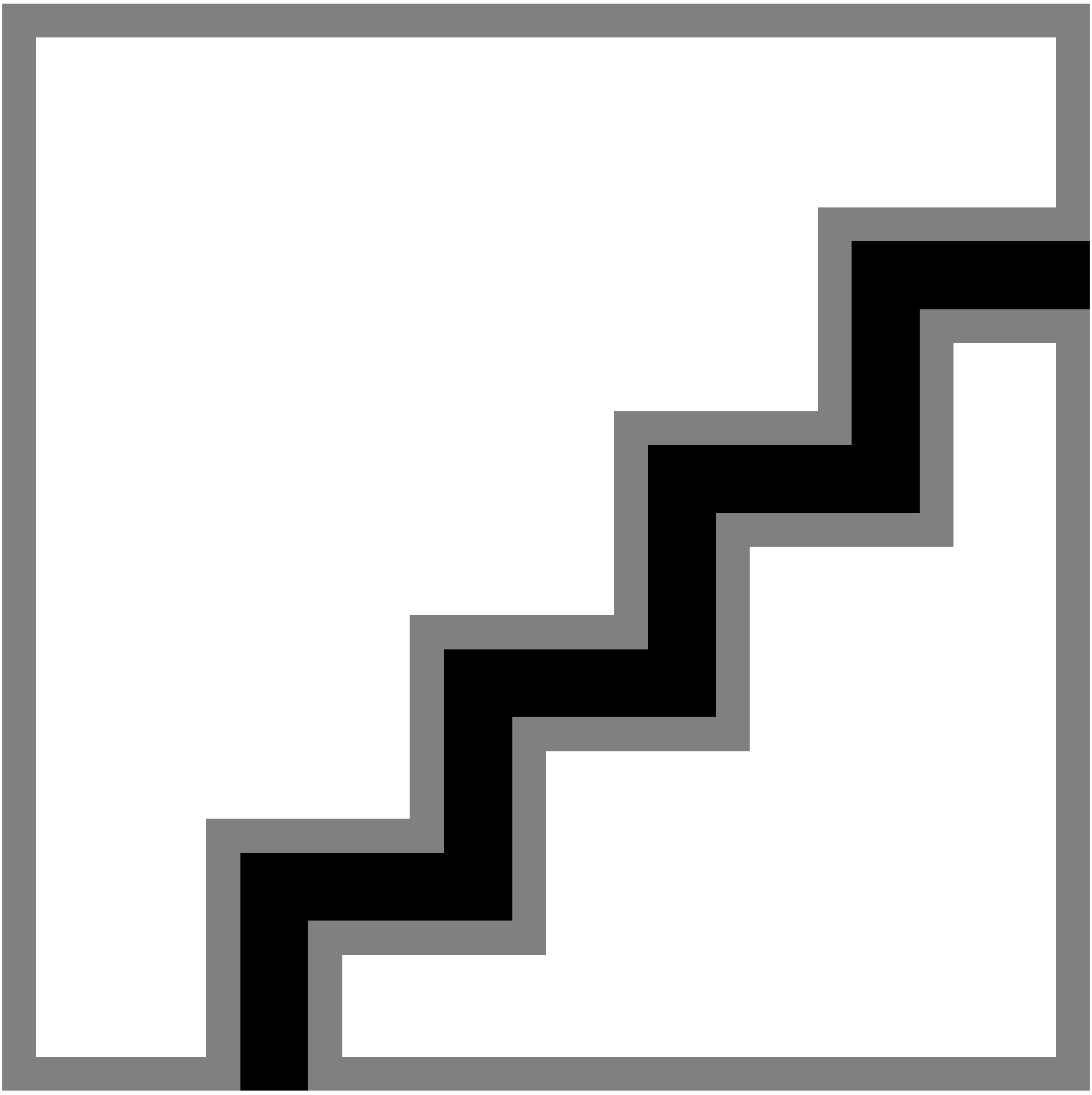
```
caxis([0,1])
daspect([1 1 1])
title(['Obj2Seq Boundary and non Boundary Cluster-based Permutation  (largest cluster,
set(gcf, 'Position', [1 25 1920 1080]);
```




```
mask_perm = [NaN(115,500),mask,NaN(115,50)];
mask_perm = [NaN(50,750);mask_perm;NaN(35,750)];
```

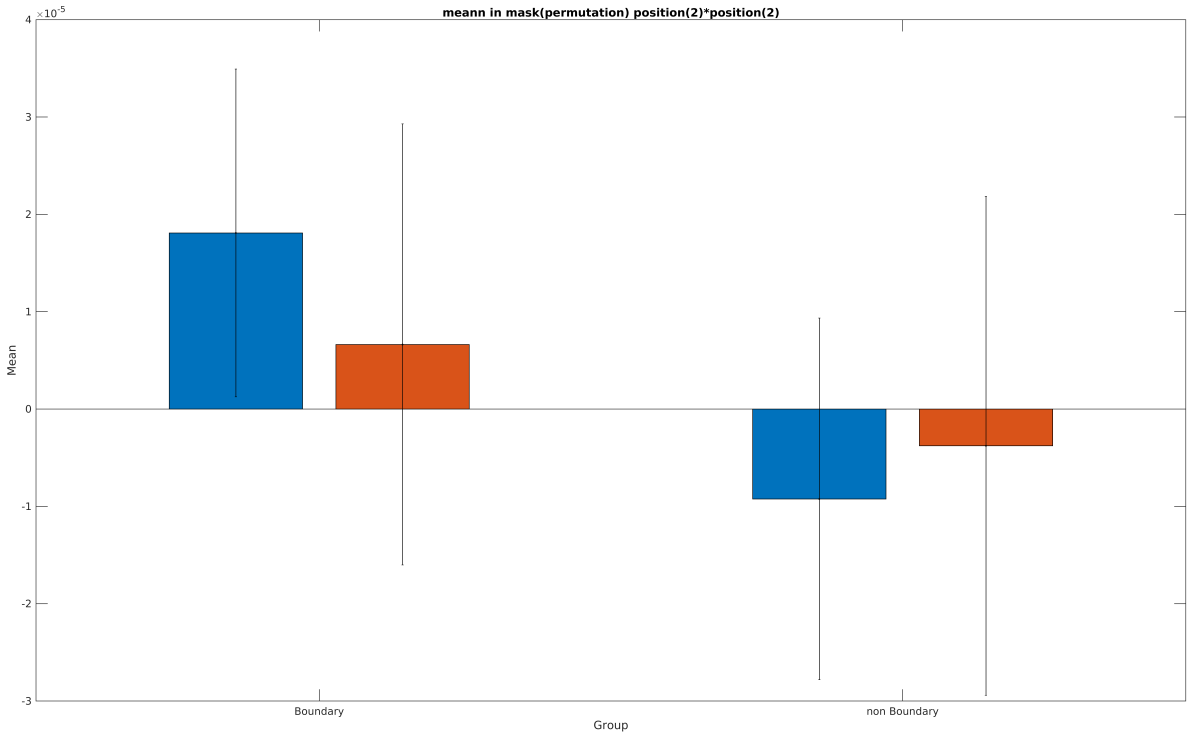
```
% plot mean value in each mask  condition permutation
obj2seq_bd_mask = obj2seq_bd.*mask_perm;
obj2seq_non_bd_mask = obj2seq_non_bd.*mask_perm;
mask_bd = squeeze(mean(obj2seq_bd_mask, [1 2], 'omitnan'));
mask_non_bd = squeeze(mean(obj2seq_non_bd_mask, [1 2], 'omitnan'));
figure
clim = [-0.008,0.008];
subplot(2,2,1)
imagesc(mean(obj2seq_bd_mask(60:100,590:650,:),3))
title('Boundary in mask')
caxis(clim)
colorbar()
subplot(2,2,2)
imagesc(mean(obj2seq_non_bd_mask (60:100,590:650,:),3))
title('non Boundary in mask')
caxis(clim)
colorbar()
subplot(2,2,3)
plt_box_line([mask_bd,mask_non_bd],{'boundary','non boundary'})
title('Mask')
```

```
subplot(2,2,4)
mask_perm(isnan(mask_perm))=0;
BW_perm = bwperim(mask_perm);
plt_imagesc(mean(obj2seq_bd-obj2seq_non_bd,3)+BW_perm*0.01,'obj2seq');
title('Mask')
sgtitle('obj2seq mask')
```

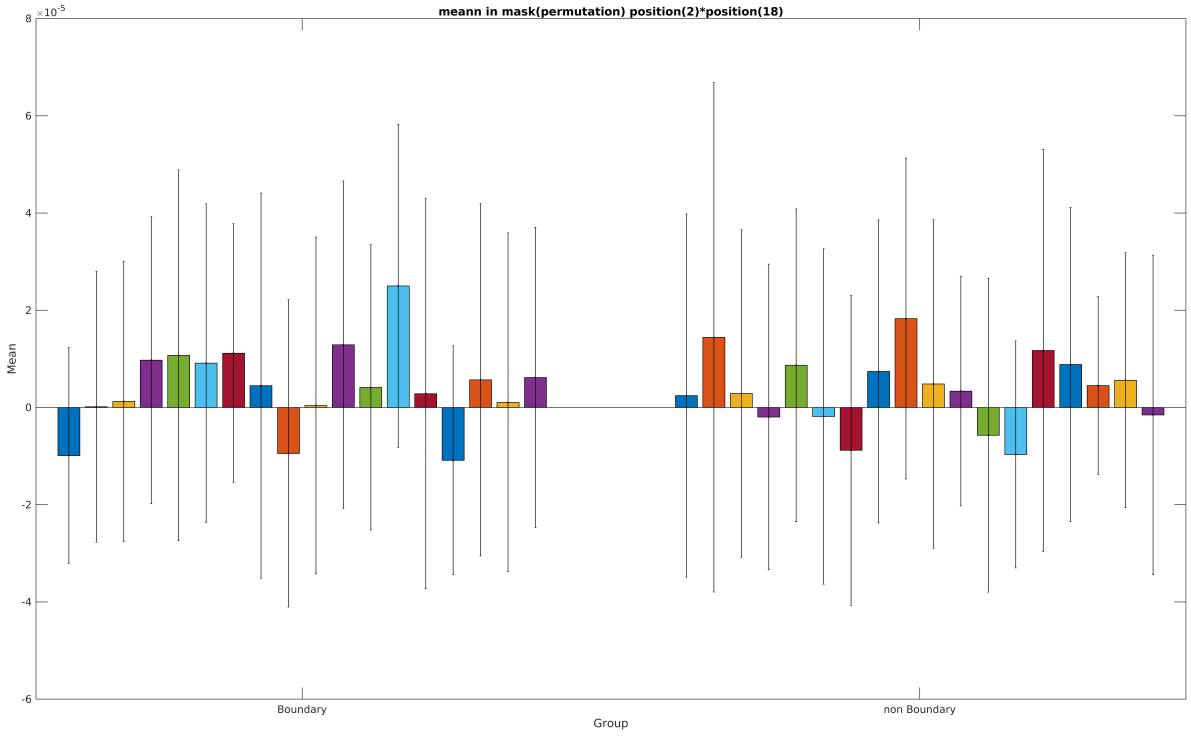


```
% plot anova result condition(anova 2*2, mask ttest)
data = [];
```

```
data(1,1,:) = squeeze(mean(mean(obj2seq_bd.*mask_perm,1),2));
data(1,2,:) = squeeze(mean(mean(obj2seq_bd_pre.*mask_perm,1),2));
data(2,1,:) = squeeze(mean(mean(obj2seq_non_bd.*mask_perm,1),2));
data(2,2,:) = squeeze(mean(mean(obj2seq_non_bd_pre.*mask_perm,1),2));
figure
plt_bar_group(data,{'Boundary','non Boundary'}) % no ttest for each bins
title('meann in mask(permutation) position(2)*position(2)')
```




```
% plot anova result condition(anova 2*18, mask ttest)
data = [];
for pici=1:18
    data(1,pici,:) = squeeze(mean(mean(cell2matrix(rsa_group.bd(:,pici)).*mask_perm,1),
    data(2,pici,:) = squeeze(mean(mean(cell2matrix(rsa_group.non_bd(:,pici)).*mask_perm
end
figure
plt_bar_group(data,{'Boundary','non Boundary'}) % no ttest for each bins
title('meann in mask(permutation) position(2)*position(18)')
```



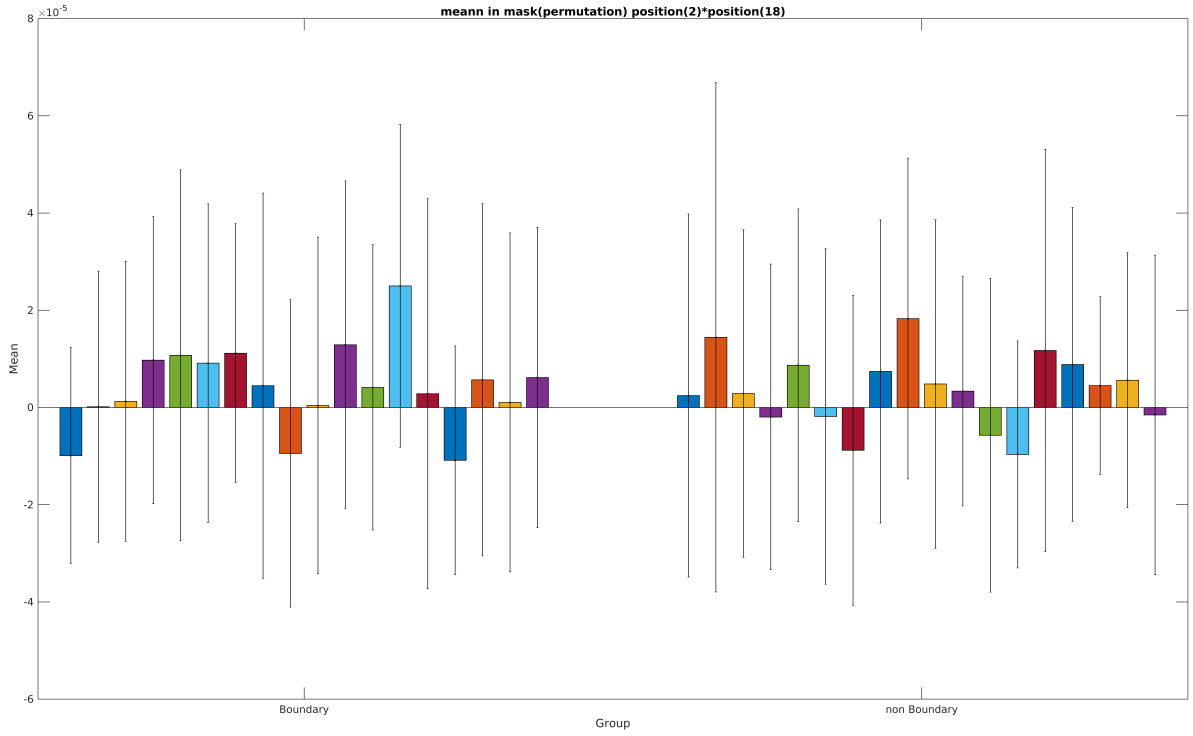
Hippocampus

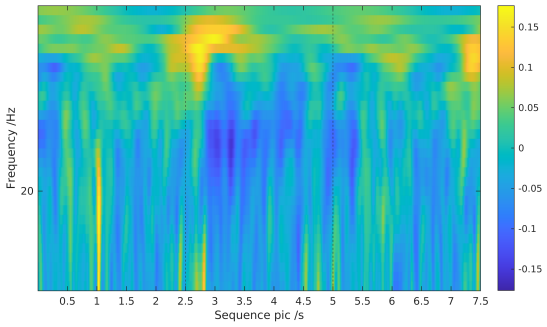
```
% load wavlet data for subject
load([group_dir,'Hippocampus_wavelet_subject.mat']);
```

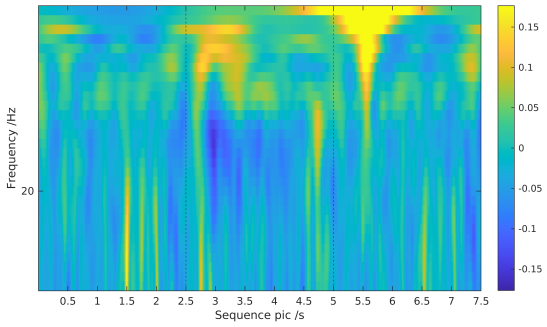
Boundary turns vs nonBoundary turns

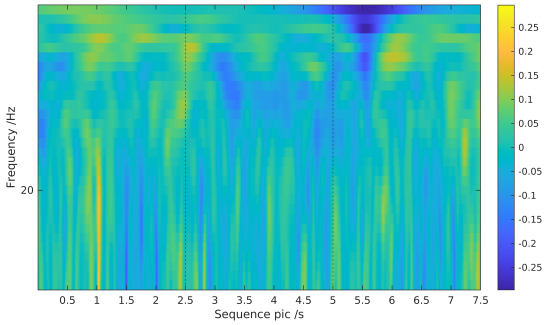
total

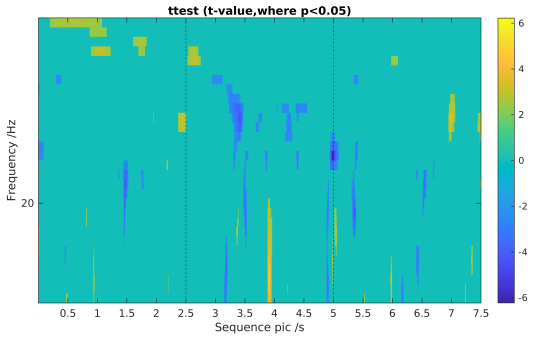
```
subject='subject1-27 (2turns)';
data_bd = [];
data_non_bd = [];
subjects =wavelet_subject.subjects;
for subi=1:length(subjects)
    data_bd(:,:,subi) = mean(cell2matrix(wavelet_subject.data_bd(subjects(subi),7:18)),
    data_non_bd(:,:,subi) = mean(cell2matrix(wavelet_subject.data_non_bd(subjects(subi)
end
wavelet_bd = data_bd(1:30,:,:);
wavelet_non_bd = data_non_bd(1:30,:,:);
plt_rsa_sd(wavelet_bd, wavelet_non_bd, 'wavelet')
```


meann in mask(permutation) position(2)*position(18)
×10^-5
Mean
Boundary
non Boundary
Group


Frequency /Hz
Sequence pic /s


Frequency /Hz
Sequence pic /s


Frequency /Hz
Sequence pic /s

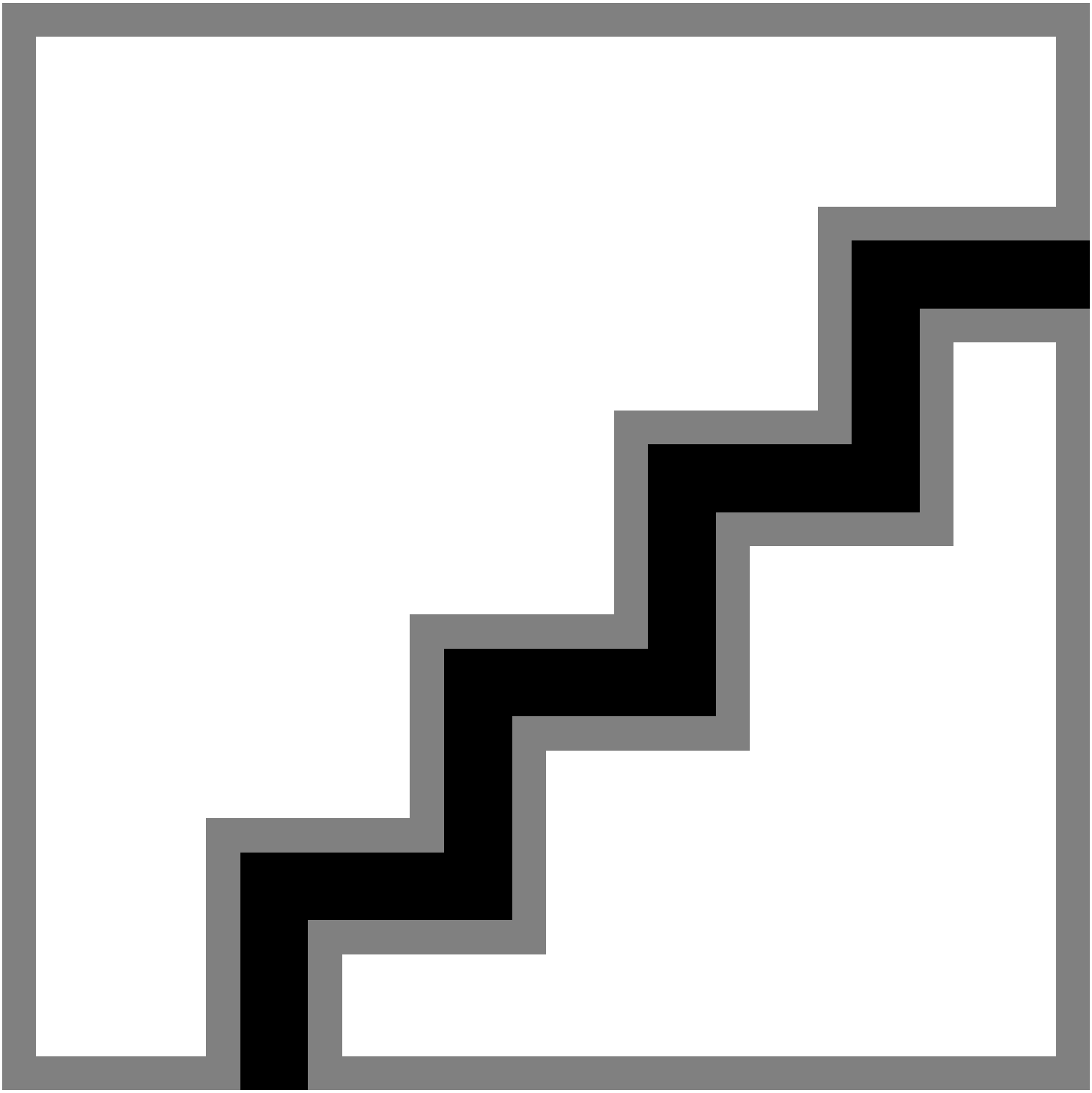

ttest (t-value,where p<0.05)
Frequency /Hz
Sequence pic /s

2 turns

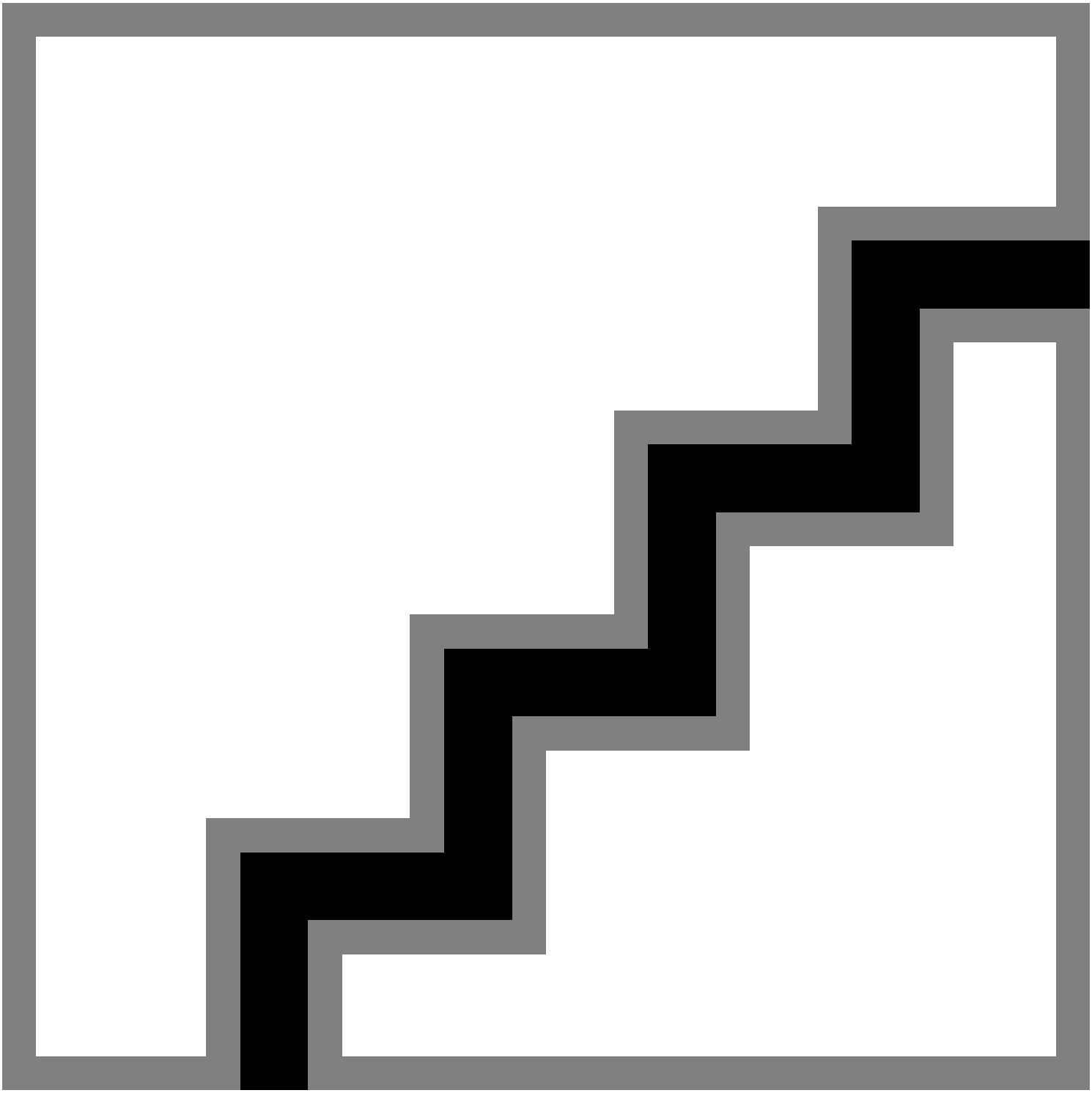
```
% zoom in 1-25Hz
subject='subject1-27 (2turn)'
```

```
subject =
'subject1-27 (2turn)'
```

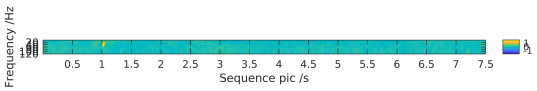
```
data_bd = [];
data_non_bd = [];
subjects =wavelet_subject.subjects;
for subi=1:length(subjects)
    for seqi=1:6
    data_bd{subi,seqi} = mean(cell2matrix(wavelet_subject.data_bd(subjects(subi),seqi+6
    data_non_bd{subi,seqi} = mean(cell2matrix(wavelet_subject.data_non_bd(subjects(subi
    end
end
plt_wavelet_sd(data_bd, data_non_bd, subject, plot_window)
```

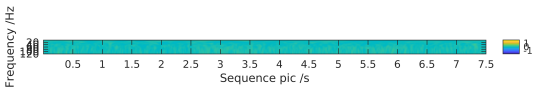


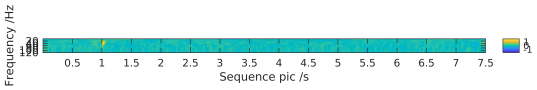
```
% permutest position
wavelet1 = cell2matrix(data_bd(:,1));
wavelet2 = cell2matrix(data_non_bd(:,1));
tic
[clusters_perm, p_perm,~,~] = plt_rsa_sd_perm(wavelet1,wavelet2,'wavelet');
```

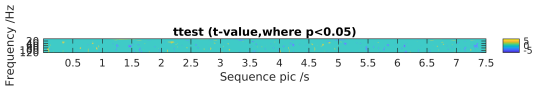


Warning: With 10 paired trials, only 1024 permutations are possible. Using this value instead of 10000.










```
toc
```

```
Elapsed time is 226.163018 seconds.
```

Theta (anova)

```
% anovan
wavelet_bd = (cell2matrix(wavelet_subject.data_bd(:,7))+cell2matrix(wavelet_subject.dat
wavelet_pre_bd = (cell2matrix(wavelet_subject.data_bd(:,6))+cell2matrix(wavelet_subject
wavelet_non_bd = (cell2matrix(wavelet_subject.data_non_bd(:,7))+cell2matrix(wavelet_sub
wavelet_pre_non_bd = (cell2matrix(wavelet_subject.data_non_bd(:,6))+cell2matrix(wavelet

wavelet = cat(3, wavelet_bd,wavelet_pre_bd,wavelet_non_bd,wavelet_pre_non_bd);
condition  = reshape(repmat([1,1,2,2], 10, 1),[],1);
position  = reshape(repmat([1,2,1,2], 10, 1),[],1);
p2=[];
for i = 1:size(wavelet,1)
    for j=1:size(wavelet,2)
        p2(i,j,:) = anovan(squeeze(wavelet(i,j,:)),{condition position},'model','intera
    end
end
```

```
% ttest
data_bd = [];
data_non_bd = [];
subjects =wavelet_subject.subjects;
for subi=1:length(subjects)
```

```
    wavelet_bd(:,:,subi) = mean(cell2matrix(wavelet_subject.data_bd(subjects(subi),[7,1
    wavelet_non_bd(:,:,subi) = mean(cell2matrix(wavelet_subject.data_non_bd(subjects(su
end

figure
subplot(1,2,1)
imagesc(mean(wavelet_bd,3))
caxis([-0.4,0.4])
yticks(0:20:120);
        yticklabels([0:20:120]);
        ylabel('Frequency /Hz');
        xticks(0:256:7.5*512);
        xticklabels([0:256:7.5*512]/512);
        xlabel('Sequence pic /s')
        xline(2.5*512,'--')
        xline(5*512,'--')
        colorbar()
colorbar()
subplot(1,2,2)
imagesc(mean(wavelet_non_bd,3))
caxis([-0.4,0.4])
yticks(0:20:120);
        yticklabels([0:20:120]);
        ylabel('Frequency /Hz');
        xticks(0:256:7.5*512);
        xticklabels([0:256:7.5*512]/512);
        xlabel('Sequence pic /s')
        xline(2.5*512,'--')
        xline(5*512,'--')
        colorbar()
colorbar()
plt_rsa_sd(wavelet_bd,wavelet_non_bd,'wavelet')
```

```
% mask combain  and anova
p=p2;
a = p; a(a<0.05)=-1; a(a>=0.05)=0; a=abs(a);
anova_condition = a(:,:,1);
CC = bwconncomp(anova_condition);
cc_size=[];
for i=1:length(CC.PixelIdxList)
    cc_size(i)=length(CC.PixelIdxList{1, i});
end
[cc_sort,cc_idx] = sort(cc_size,'descend');
mask = zeros(size(anova_condition));
mask(CC.PixelIdxList{1, cc_idx(1)}) = 1;
figure;imagesc(mask)
title('mask(anovan)')
mask_anova2 = mask;
```

```
p=p2;
a = p; a(a<0.05)=-1; a(a>=0.05)=0; a=abs(a);
anovan_name = {'condition','position','condition*position'};
```

```
figure
for i= 1:3
    subplot(2,2,i)
    if i<4
        imagesc(a(:,:,i))
        title(['anovan: ',anovan_name{i}])
    else
        imagesc(pic_corr_h)
        title('Mask')
    end
    yticks(0:20:120);
    yticklabels([0:20:120]);
    ylabel('Object pic /s')
    xticks(0:256:7.5*512);
    xticklabels([0:256:7.5*512]/512);
    xlabel('Sequence pic /s')
    xline(2.5*512,'--')
    xline(5*512,'--')
    colorbar()
end
set(gcf, 'Position', [1 25 1920 1080]);
```

```
% plot anova result condition(anova 2*2, mask ttest)
mask_anova=mask_anova2;
data = [];
data(1,1,:) = squeeze(mean(mean(wavelet_bd.*mask_anova,1),2));
data(1,2,:) = squeeze(mean(mean(wavelet_pre_bd.*mask_anova,1),2));
data(2,1,:) = squeeze(mean(mean(wavelet_non_bd.*mask_anova,1),2));
data(2,2,:) = squeeze(mean(mean(wavelet_pre_non_bd.*mask_anova,1),2));

figure
clim = [-0.5,0.5];
subplot(2,3,1)
temp = wavelet_bd.*mask_anova;
imagesc(mean(temp(1:14,1490:1810),3))
title('Boundary in mask')
caxis(clim)
colorbar()
subplot(2,3,2)
temp = wavelet_non_bd.*mask_anova;
imagesc(mean(temp(1:14,1490:1810),3))
title('non Boundary in mask')
caxis(clim)
colorbar()
subplot(2,3,3)
temp = wavelet_pre_bd.*mask_anova;
imagesc(mean(temp(1:14,1490:1810),3))
title('pre Boundary in mask')
caxis(clim)
colorbar()
subplot(2,3,4)
temp = wavelet_pre_non_bd.*mask_anova;
imagesc(mean(temp(1:14,1490:1810),3))
```

```
title('pre non Boundary in mask')
caxis(clim)
colorbar()
subplot(2,3,5)
plt_bar_group(data,{'Boundary','non Boundary'}) % no ttest for each bins
title('meann in mask(ttest) position(2)*position(6)')
subplot(2,3,6)
imagesc(mask_anova)
title('Mask')
yticks(0:20:120);
yticklabels([0:20:120]);
ylabel('Object pic /s')
xticks(0:256:7.5*512);
xticklabels([0:256:7.5*512]/512);
xlabel('Sequence pic /s')
xline(2.5*512,'--')
xline(5*512,'--')
colorbar()
sgtitle('obj2seq mask')
```

```
% permutest all 18 picture


% permutation only 1000 times
tic
[clusters_perm, p_perm, t_sums_perm, permutation_distribution ] = permutest(wavelet_bd,
toc
```

```
Elapsed time is 135.599272 seconds.
```

```
% permutest p=0.05
i=1;
mask = NaN(size(data_bd(:,:,1)));
mask(clusters_perm{1, i}) = 1;
figure;plt_imagesc(mask,'wavelet')
```

```
ans = 1
```

```
title(['wavelet Boundary and non Boundary Cluster-based Permutation  (largest cluster,
set(gcf, 'Position', [1 25 1920 1080]);
```

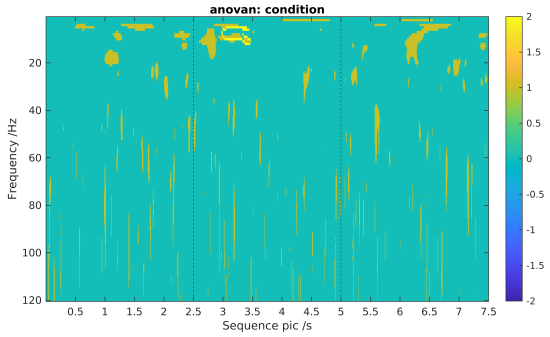
```
Warning: Some output might be missing due to a network interruption. To get the missing output,
rerun the script.
```

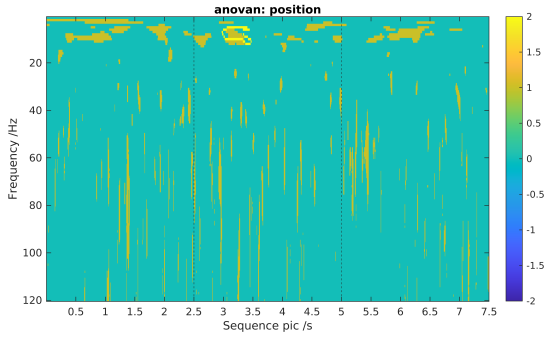
```
% anova   position(2,[boundary, non_boundary])*position(6,[1:6])
wavelet=[];
for pici =1:6
wavelet = cat(3, wavelet,cell2matrix(wavelet_subject.data_bd(:,[pici,pici+6,pici+12])))
end
for pici =1:6
wavelet = cat(3, wavelet,cell2matrix(wavelet_subject.data_non_bd(:,[pici,pici+6,pici+12
```

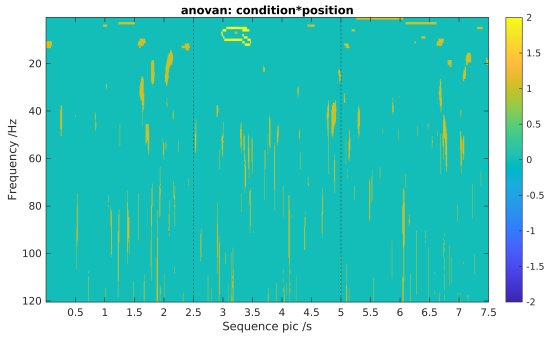
```
end
condition  = reshape(repmat([1,2], 10*6, 1),[],1);
position  = reshape(repmat([1:6,1:6], 10, 1),[],1);
p6=[];
for i = 1:size(wavelet,1)
    for j=1:size(wavelet,2)
        p6(i,j,:) = anovan(squeeze(wavelet(i,j,:)),{condition position},'model','intera
    end
end
```

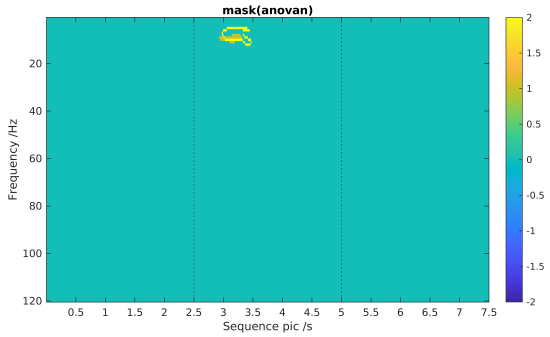
```
% compare anova mask in 2*2 and 2*6
p=p6;
a = p; a(a<0.05)=-1; a(a>=0.05)=0; a=abs(a);
anova_condition = a(:,:,1);
BW_anova = bwperim(mask_anova2);
CC = bwconncomp(anova_condition);
cc_size=[];
for i=1:length(CC.PixelIdxList)
    cc_size(i)=length(CC.PixelIdxList{1, i});
end
[cc_sort,cc_idx] = sort(cc_size,'descend');
mask = zeros(size(anova_condition));
mask(CC.PixelIdxList{1, cc_idx(6)}) = 1;
figure;imagesc(max(mask,BW_anova*2))
title('mask(anovan)')
mask_anova6 = mask;
```

```
p=p6;
a = p; a(a<0.05)=-1; a(a>=0.05)=0; a=abs(a);
anovan_name = {'condition','position','condition*position'};
figure
for i= 1:4
    subplot(2,2,i)
    if i<4
          plt_imagesc(max(a(:,:,i),BW_anova*2),'wavelet');
          title(['anovan: ',anovan_name{i}])
    else
        plt_imagesc(max(mask_anova6,BW_anova*2),'wavelet');
        title('mask(anovan)')
    end
end
set(gcf, 'Position', [1 25 1920 1080]);
```

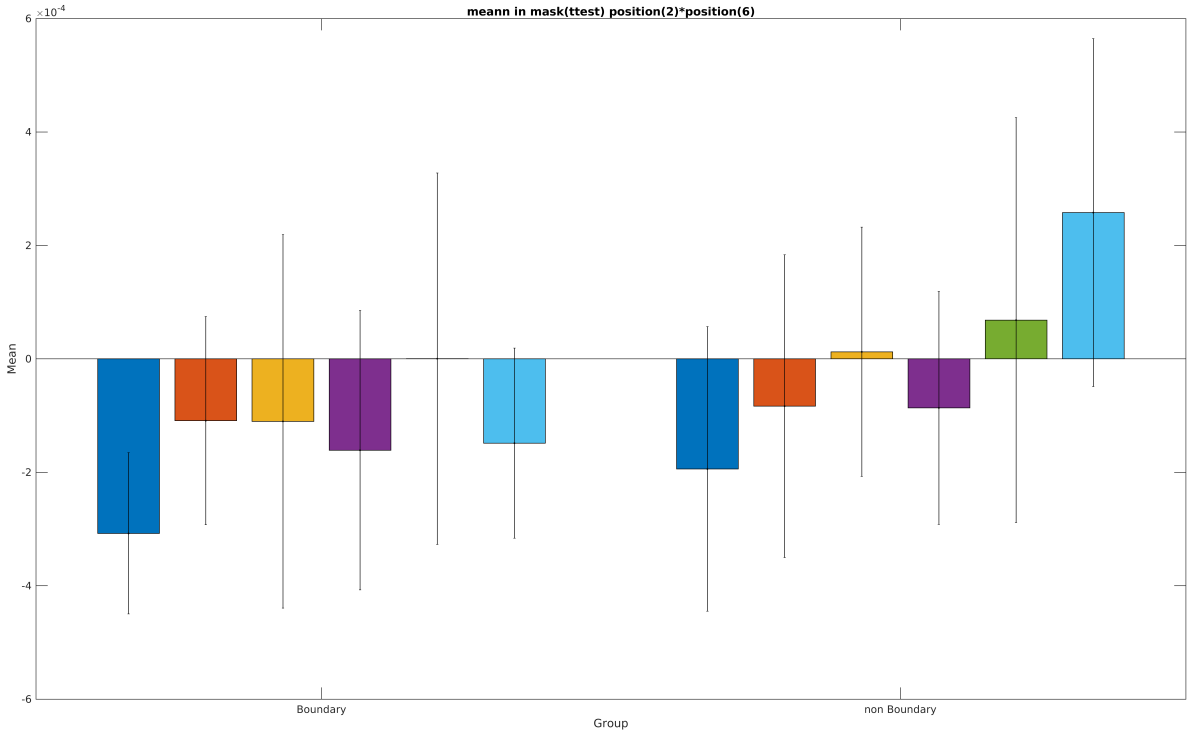









```
% plot anova result condition(anova 2*6, mask ttest)
data = [];
for pici=1:6
    data(1,pici,:) = squeeze(mean(mean(cell2matrix(wavelet_subject.data_bd(:,[pici,pici
    data(2,pici,:) = squeeze(mean(mean(cell2matrix(wavelet_subject.data_non_bd(:,[pici,
end
figure
plt_bar_group(data,{'Boundary','non Boundary'}) % no ttest for each bins
title('meann in mask(ttest) position(2)*position(6)')
```


meann in mask(ttest) position(2)*position(6)
×10^-4
6
4
2
0
-2
-4
-6
Mean
Boundary
non Boundary
Group