Table of Contents


```
clear all
```

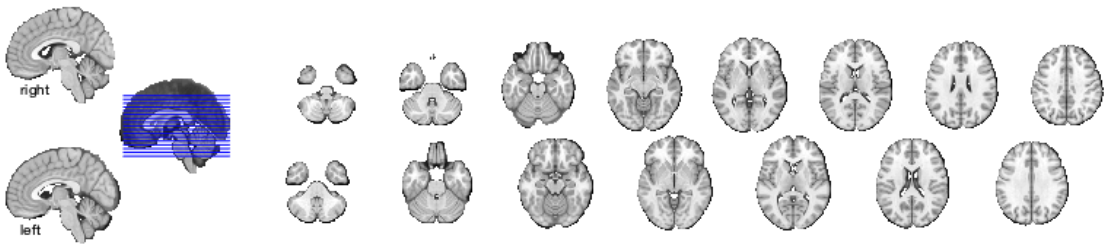
load data and other set up

```
repodir = '/Users/yoni/Repositories/effects_of_CM_on_brain';
outdir = fullfile(repodir, 'results', 'group_level');
cd(repodir);

doplot=1;

time1 = fmri_data(filenames(fullfile('data', 'subject
 level', 'relisten_time1', '*', 'con_0003.img')));
time2 = fmri_data(filenames(fullfile('data', 'subject
 level', 'relisten_time2', '*', 'con_0007.img')));

gm_mask = fmri_data(which('gray_matter_mask.img'));
%gm_mask =
 fmri_data(which('dartel_spm12_mni152_gray_matter_mask.img'));
gm_mask.dat = gm_mask.dat > .25; % tighter gm mask. increase val to
 make tighter

time1 = apply_mask(time1, gm_mask);
time2 = apply_mask(time2, gm_mask);

load(fullfile(repodir, 'data', 'CM_data_included_Ss_only.mat'), 'CM')


% drop P who misunderstood donation instructions
```

```
wh = get_var(CM, 'deltadon') > -45 | get_var(CM, 'deltadon') < -46 ;

time1 = get_wh_image(time1, wh);
time2 = get_wh_image(time2, wh);
delta_relisten = image_math(time2, time1, 'minus');

grp = get_var(CM, 'Group',wh);
grp_cc(:,1) = (grp == 1) + -1*(grp ~= 1);
grp_cc(:,2) = (grp == 2) + -1*(grp == 3);

% get deltadon/deltaFAS and mean center within group
deltadon_mcgrp = get_var(CM,'deltadon', wh);
don1_mcgrp = get_var(CM,'don1', wh);
don2_mcgrp = get_var(CM,'don2', wh);
deltaFAS_mcgrp = get_var(CM,'deltaFAS', wh);

for i=1:3
    deltadon_mcgrp(grp==i) = scale(deltadon_mcgrp(grp==i), 1);
    don1_mcgrp(grp==i) = scale(don1_mcgrp(grp==i), 1);
    don2_mcgrp(grp==i) = scale(don2_mcgrp(grp==i), 1);
    deltaFAS_mcgrp(grp==i) = scale(deltaFAS_mcgrp(grp==i), 1);
end

% create a don2 orthogonalized wrt to don1
mdl = fitglm(don1_mcgrp, don2_mcgrp);
don2_mcgrp_orth = mdl.Residuals.Raw;

if doplot
    figure;
    obj =
 canlab_results_fmridisplay('compact2', 'overlay', 'icbm152_2009_symmetric_for_und
 );
end
```

```
Using default mask: /Users/yoni/Repositories/CanlabCore/CanlabCore/
canlab_canonical_brains/Canonical_brains_surfaces/brainmask.nii
Direct calls to spm_defauts are deprecated.
Please use spm('Defaults',modality) or spm_get_defaults instead.
Defaults settings have been modified by file(s):
  /Users/yoni/Documents/MATLAB/spm_my_defaults.m
Modified fields: stats mask
Defaults settings have been modified by file(s):
  /Users/yoni/Documents/MATLAB/spm_my_defaults.m
Modified fields: stats mask
loading mask. mapping volumes.
checking that dimensions and voxel sizes of volumes are the same.
Pre-allocating data array. Needed: 74965944 bytes
Loading image number:    57
Elapsed time is 3.020614 seconds.
fmri_data.create: Converting 671382 NaNs to 0s.Image names entered,
 but fullpath attribute is empty. Getting path info.
Using default mask: /Users/yoni/Repositories/CanlabCore/CanlabCore/
canlab_canonical_brains/Canonical_brains_surfaces/brainmask.nii
Defaults settings have been modified by file(s):
```

```
  /Users/yoni/Documents/MATLAB/spm_my_defaults.m
Modified fields: stats mask
Defaults settings have been modified by file(s):
  /Users/yoni/Documents/MATLAB/spm_my_defaults.m
Modified fields: stats mask
loading mask. mapping volumes.
checking that dimensions and voxel sizes of volumes are the same.
Pre-allocating data array. Needed: 74965944 bytes
Loading image number:    57
Elapsed time is 2.892706 seconds.
fmri_data.create: Converting 671382 NaNs to 0s.Image names entered,
 but fullpath attribute is empty. Getting path info.
Using default mask: /Users/yoni/Repositories/CanlabCore/CanlabCore/
canlab_canonical_brains/Canonical_brains_surfaces/brainmask.nii
Defaults settings have been modified by file(s):
  /Users/yoni/Documents/MATLAB/spm_my_defaults.m
Modified fields: stats mask
Defaults settings have been modified by file(s):
  /Users/yoni/Documents/MATLAB/spm_my_defaults.m
Modified fields: stats mask
loading mask. mapping volumes.
checking that dimensions and voxel sizes of volumes are the same.
Pre-allocating data array. Needed: 1409312 bytes
Loading image number:     1
Elapsed time is 0.021778 seconds.
Image names entered, but fullpath attribute is empty. Getting path
 info.
Warning: Missing variable type for variable Group. Type assumed to be
 numeric.
Setting up fmridisplay objects
This takes a lot of memory, and can hang if you have too little.
```



robust regression: CM vs. Faml and CM vs. OxyPla comparisons, with DeltaDon and DeltaFAS mean centered within group

deltadon and deltaFAS only share 3.5% of variance after mean-centering within group, so OK include in same model. Also with robust corr, not a strong relationship between the two vars (

```
dat = delta_relisten;

% build design matrix.
% Make CM the reference group (intercept), and add dummy regressors
 for Faml and OxyPla
dm = zeros(size(delta_relisten.dat, 2), 2);
dm( grp==2, 1) = -1;
dm( grp==3, 2) = -1;

% add deltadon/fas mean centered within grp, or don1/2
dm(:,3) = deltadon_mcgrp;
%dm(:,3) = don1_mcgrp;
%dm(:,4) = don2_mcgrp_orth;

%figure; imagesc([dm ones(length(dm), 1)]); colorbar
dat.X = dm; % regs are, in order: Oxy vs CM, Faml vs CM, abs change in
 CM

% estimate model
out2 = regress(dat, .001, 'unc', 'k', 10); % automatically adds
 intercept as last column --> CM
%save(fullfile(outdir, 'cm_vs_oxy_faml_deltadonfas_robust.mat'),
 'out2')

Analysis:
---------------------------------
Design matrix warnings:
---------------------------------
No intercept detected, adding intercept to last column of design
 matrix
Warning:  Predictors are not centered -- intercept is not
 interpretable as stats for average subject

---------------------------------
Running regression: 195616 voxels. Design:  56 obs,   4 regressors,
 intercept is last

Predicting exogenous variable(s) in dat.X using brain data as
 predictors, mass univariate
Running in OLS Mode
Model run in 0 minutes and 0.52 seconds

Image   1
  2 contig. clusters, sizes   4 to  41
```

```
Positive effect:  45 voxels, min p-value: 0.00027871
Negative effect:   0 voxels, min p-value: 0.00102639

Image   2
  2 contig. clusters, sizes   4 to  41
Positive effect:  42 voxels, min p-value: 0.00016963
Negative effect:   2 voxels, min p-value: 0.00089777

Image   3
  2 contig. clusters, sizes   4 to  41
Positive effect:   1 voxels, min p-value: 0.00085616
Negative effect: 475 voxels, min p-value: 0.00001478

Image   4
  2 contig. clusters, sizes   4 to  41
Positive effect: 117 voxels, min p-value: 0.00005102
Negative effect:   8 voxels, min p-value: 0.00072241

SPM12: spm_check_registration (v6245)             12:55:34 -
 05/08/2019
========================================================================
Display <a href="matlab:spm_image('display','/
Users/yoni/Repositories/CanlabCore/CanlabCore/
canlab_canonical_brains/Canonical_brains_surfaces/
keuken_2014_enhanced_for_underlay.img,1');">/Users/yoni/
Repositories/CanlabCore/CanlabCore/canlab_canonical_brains/
Canonical_brains_surfaces/keuken_2014_enhanced_for_underlay.img,1</a>
 (<a href="matlab:spm_check_registration('/Users/yoni/
Repositories/CanlabCore/CanlabCore/canlab_canonical_brains/
Canonical_brains_surfaces/keuken_2014_enhanced_for_underlay.img,1','/
Users/yoni/Repositories/CanlabCore/CanlabCore/canlab_canonical_brains/
Canonical_brains_surfaces/keuken_2014_enhanced_for_underlay.img,1','/
Users/yoni/Repositories/CanlabCore/CanlabCore/canlab_canonical_brains/
Canonical_brains_surfaces/keuken_2014_enhanced_for_underlay.img,1','/
Users/yoni/Repositories/CanlabCore/CanlabCore/
canlab_canonical_brains/Canonical_brains_surfaces/
keuken_2014_enhanced_for_underlay.img,1');">all</
a>)  <a href="matlab:spm_image('display','/
Users/yoni/Repositories/CanlabCore/CanlabCore/
canlab_canonical_brains/Canonical_brains_surfaces/
keuken_2014_enhanced_for_underlay.img,1');">/Users/yoni/
Repositories/CanlabCore/CanlabCore/canlab_canonical_brains/
Canonical_brains_surfaces/keuken_2014_enhanced_for_underlay.img,1</a>
        <a href="matlab:spm_image('display','/
Users/yoni/Repositories/CanlabCore/CanlabCore/
canlab_canonical_brains/Canonical_brains_surfaces/
keuken_2014_enhanced_for_underlay.img,1');">/Users/yoni/
Repositories/CanlabCore/CanlabCore/canlab_canonical_brains/
Canonical_brains_surfaces/keuken_2014_enhanced_for_underlay.img,1</a>
        <a href="matlab:spm_image('display','/
Users/yoni/Repositories/CanlabCore/CanlabCore/
canlab_canonical_brains/Canonical_brains_surfaces/
keuken_2014_enhanced_for_underlay.img,1');">/Users/yoni/
```

```
Repositories/CanlabCore/CanlabCore/canlab_canonical_brains/
Canonical_brains_surfaces/keuken_2014_enhanced_for_underlay.img,1</a>
Defaults settings have been modified by file(s):
  /Users/yoni/Documents/MATLAB/spm_my_defaults.m
Modified fields: stats mask
Defaults settings have been modified by file(s):
  /Users/yoni/Documents/MATLAB/spm_my_defaults.m
Modified fields: stats mask
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  /Users/yoni/Documents/MATLAB/spm_my_defaults.m
Modified fields: stats mask
Defaults settings have been modified by file(s):
  /Users/yoni/Documents/MATLAB/spm_my_defaults.m
Modified fields: stats mask
```
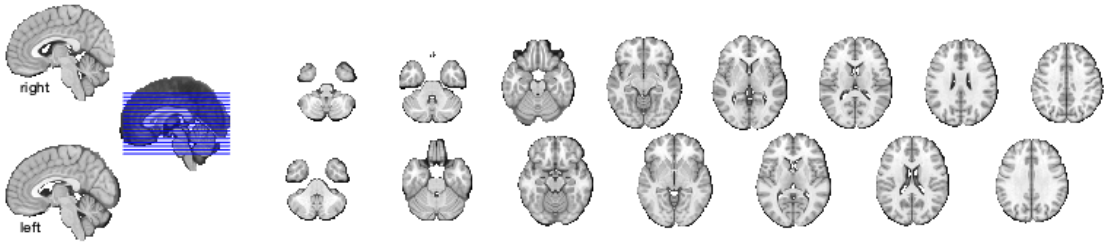
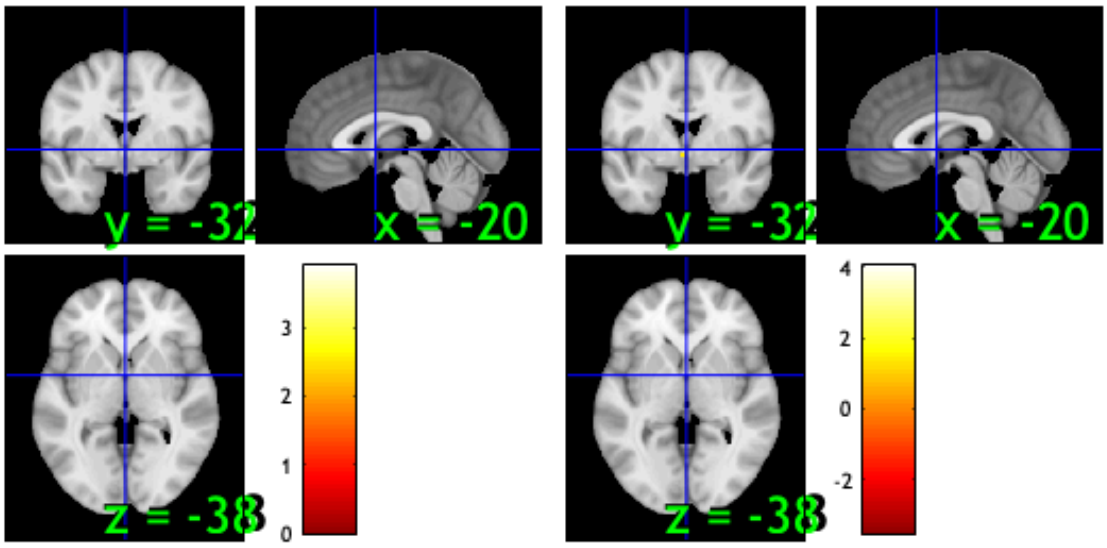
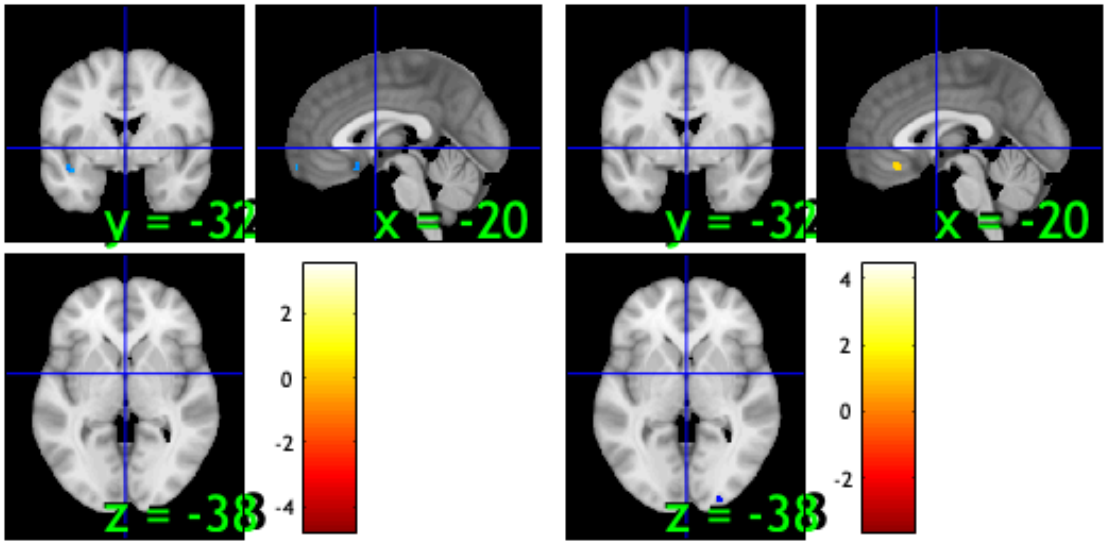
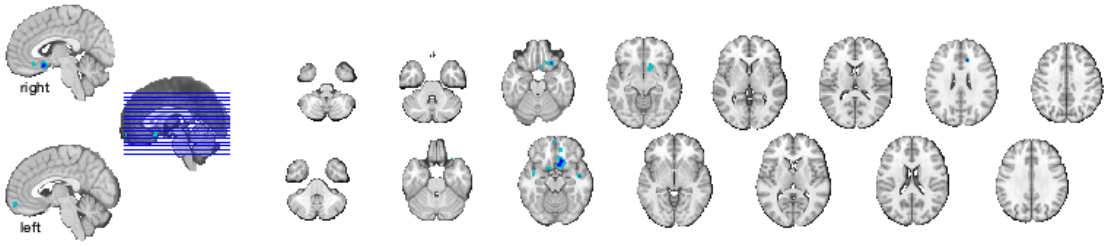




y = -32
x = -20
z = -38
3
2
1
0
y = -32
x = -20
z = -38
4
2
0
-2


y = -32
x = -20
z = -38
2
0
-2
-4
y = -32
x = -20
z = -38
4
2
0
-2

which region survive for deltadon? L NAc, pOFC, others

```
if doplot
    print_header('Delta donation predicting delta brain');
    toshow = get_wh_image(out2.t,3);
    obj = removeblobs(obj);
    obj = addblobs(obj, region(toshow));
    snapnow
end

table(region(get_wh_image(out2.t, 3)));

=========================================================================
=
                =
= Delta donation predicting delta brain
                =
=
                =
=========================================================================
Grouping contiguous voxels:  13 regions
sagittal montage:   6 voxels displayed, 470 not displayed on these
 slices
sagittal montage:  24 voxels displayed, 452 not displayed on these
 slices
sagittal montage:   6 voxels displayed, 470 not displayed on these
 slices
axial montage:  96 voxels displayed, 380 not displayed on these slices
axial montage:  49 voxels displayed, 427 not displayed on these slices
```



Grouping contiguous voxels: 13 regions

Positive Effects
Defaults settings have been modified by file(s):
/Users/yoni/Documents/MATLAB/spm_my_defaults.m
Modified fields: stats mask
Defaults settings have been modified by file(s):
/Users/yoni/Documents/MATLAB/spm_my_defaults.m
Modified fields: stats mask

Region	Volume	XYZ			maxZ	modal_label_descriptions	Perc_covered_by_label	Atlas_regions_covered	region_index
'No label'	64	26	-46	18	3.334	'No description'	0	0	1

Negative Effects

Region	Volume	XYZ			maxZ	modal_label_descriptions	Perc_covered_by_label	Atlas_regions_covered	region_index

```
   'NAC_L'              320     -16      8    -14    -3.5423
'Basal_ganglia'                             68                        0
                 8
   'Cblm_CrusI_R'       160      38    -82    -30    -3.4446
'Cerebellum'                               100                       0
                 2
   'Ctx_10r_R'          272       8     42    -14    -3.4005
'Cortex_Default_ModeA'                      24                        0
                10
   'Ctx_8Av_L'          304     -34     12     60    -3.5574
'Cortex_Default_ModeB'                      84                        0
                13
   'Ctx_pOFC_R'        5576      12     18    -14    -4.3319
'Cortex_Limbic'                             16                        4
                 3
   'Ctx_PI_L'           512     -42     -2    -16    -3.7991
'Cortex_Limbic'                             53                        1
                 6
   'Ctx_10v_L'          432      -2     60    -14    -3.5234
'Cortex_Limbic'                             52                        0
                 7
   'Ctx_STSda_R'        680      46     -8    -14    -3.9107
'Cortex_Temporal_Parietal'                  39                        0
                 5
   'Ctx_AAIC_L'         192     -28     10    -16    -3.5426
'Cortex_Ventral_AttentionB'                 63                        0
                 9
   'Ctx_AVI_L'           64     -36     26    -10    -3.3359
'Cortex_Ventral_AttentionB'                 50                        0
                11
   'Ctx_a32pr_R'        560      12     28     26    -4.0088
'Cortex_Ventral_AttentionB'                 46                        0
                12
   'No label'            64     -12      8    -24    -3.3128    'No
 description'                              0                        0
             4
```

Regions labeled by reference atlas CANlab_2018_combined

Volume: Volume of contiguous region in cubic mm.
MaxZ: Signed max over Z-score for each voxel.
Atlas_regions_covered: Number of reference atlas regions covered at least 25% by the region. This relates to whether the region covers multiple reference atlas regions

Region: Best reference atlas label, defined as reference region with highest number of in-region voxels. Regions covering >25% of >5 regions labeled as "Multiple regions"

Perc_covered_by_label: Percentage of the region covered by the label.
Ref_region_perc: Percentage of the label region within the target region.

modal_atlas_index: Index number of label region in reference atlas
all_regions_covered: All regions covered >5% in descending order of importance

For example, if a region is labeled 'TE1a' and Perc_covered_by_label = 8, Ref_region_perc = 38, and Atlas_regions_covered = 17, this means that 8% of the region's voxels are labeled TE1a, which is the highest percentage among reference label regions. 38% of the region TE1a is covered by the region. However, the region covers at least 25% of 17 distinct labeled reference regions.

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Note: Region object r(i).title contains full list of reference atlas regions covered by each cluster.

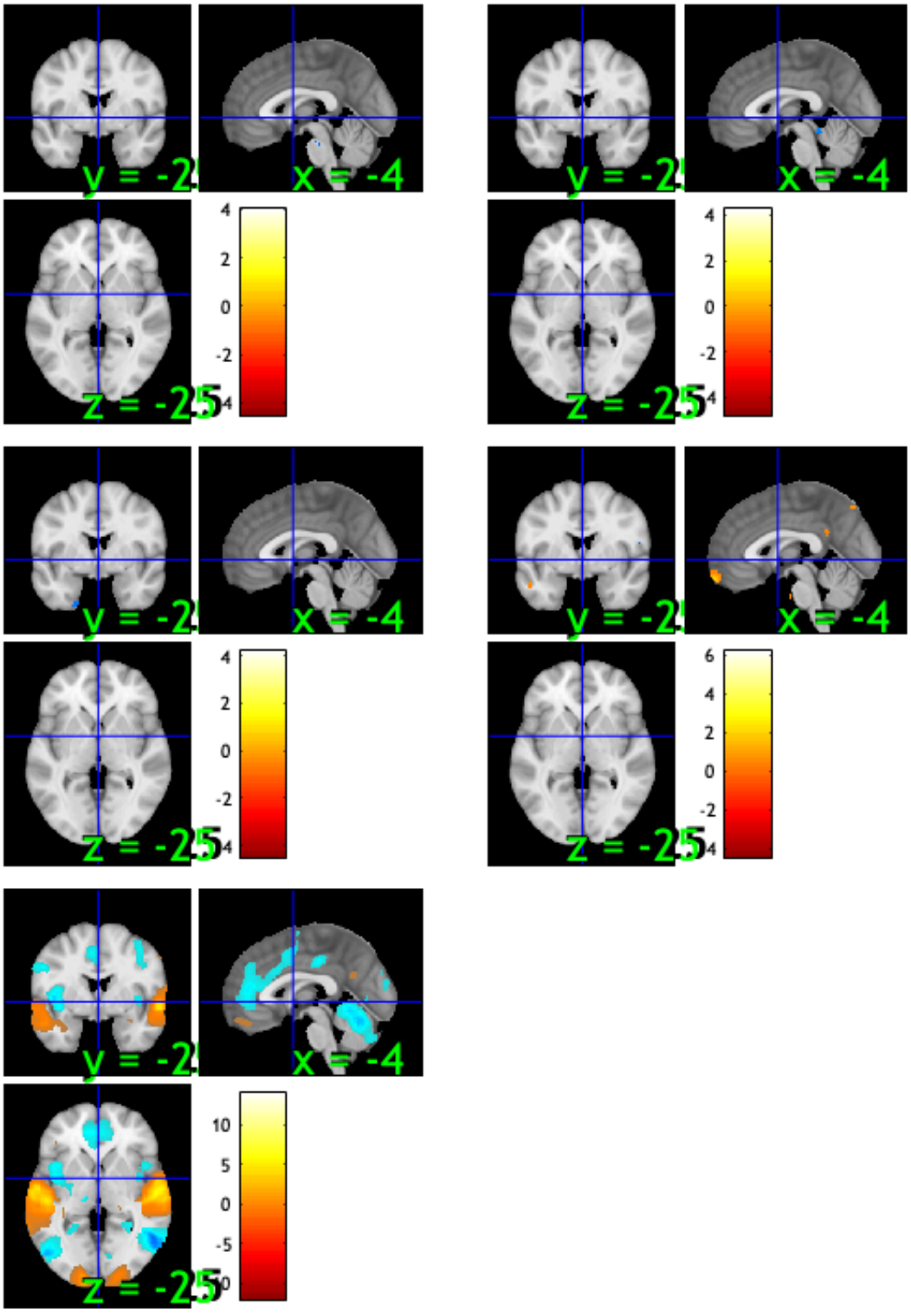
So, no regions positively relate to delta don cntrolling for group, while a number of mOFC/ NAc regions negatively relate to delta don. Let us explore this further by decomposing "delta brain" and deltadon into Time1 and Time2 variables.

Predict Time1 brain from Don1 + Don2 orthogonalized wrt to Don1 + group

```
dat = time1;

% build design matrix.
% Make CM the reference group (intercept), and add dummy regressors
 for Faml and OxyPla
dm = zeros(size(delta_relisten.dat, 2), 2);
dm( grp==2, 1) = -1;
dm( grp==3, 2) = -1;

% add deltadon/fas mean centered within grp, or don1/2
dm(:,3) = don1_mcgrp;
dm(:,4) = don2_mcgrp_orth;

%figure; imagesc([dm ones(length(dm), 1)]); colorbar
dat.X = dm; % regs are, in order: Oxy vs CM, Faml vs CM, abs change in
 CM

% estimate model
out2 = regress(dat, .001, 'unc', 'k', 10); % automatically adds
 intercept as last column --> CM
%save(fullfile(outdir, 'cm_vs_oxy_faml_deltadonfas_robust.mat'),
 'out2')

Analysis:
---------------------------------
Design matrix warnings:
---------------------------------
No intercept detected, adding intercept to last column of design
 matrix
Warning:  Predictors are not centered -- intercept is not
 interpretable as stats for average subject

---------------------------------
Running regression: 195616 voxels. Design:  56 obs,   5 regressors,
 intercept is last
```

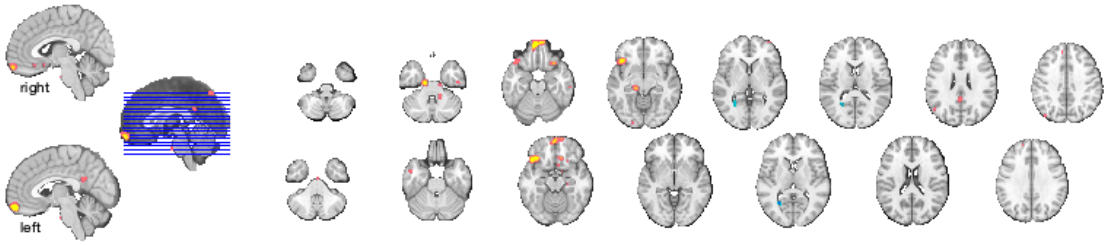
```
Predicting exogenous variable(s) in dat.X using brain data as
 predictors, mass univariate
Running in OLS Mode
Model run in 0 minutes and 0.56 seconds

Image   1
 15 contig. clusters, sizes   1 to  65
Positive effect:   4 voxels, min p-value: 0.00017893
Negative effect: 195 voxels, min p-value: 0.00003779

Image   2
 15 contig. clusters, sizes   1 to  65
Positive effect: 288 voxels, min p-value: 0.00008404
Negative effect: 210 voxels, min p-value: 0.00001514

Image   3
 15 contig. clusters, sizes   1 to  65
Positive effect:  34 voxels, min p-value: 0.00010610
Negative effect:  94 voxels, min p-value: 0.00003779

Image   4
 15 contig. clusters, sizes   1 to  65
Positive effect: 1273 voxels, min p-value: 0.00000012
Negative effect:  57 voxels, min p-value: 0.00004399

Image   5
 15 contig. clusters, sizes   1 to  65
Positive effect: 17973 voxels, min p-value: 0.00000000
Negative effect: 25413 voxels, min p-value: 0.00000000

SPM12: spm_check_registration (v6245)            12:55:59 -
 05/08/2019
========================================================================
Display <a href="matlab:spm_image('display','/
Users/yoni/Repositories/CanlabCore/CanlabCore/
canlab_canonical_brains/Canonical_brains_surfaces/
keuken_2014_enhanced_for_underlay.img,1');">/Users/yoni/
Repositories/CanlabCore/CanlabCore/canlab_canonical_brains/
Canonical_brains_surfaces/keuken_2014_enhanced_for_underlay.img,1</a>
 (<a href="matlab:spm_check_registration('/Users/yoni/
Repositories/CanlabCore/CanlabCore/canlab_canonical_brains/
Canonical_brains_surfaces/keuken_2014_enhanced_for_underlay.img,1','/
Users/yoni/Repositories/CanlabCore/CanlabCore/canlab_canonical_brains/
Canonical_brains_surfaces/keuken_2014_enhanced_for_underlay.img,1','/
Users/yoni/Repositories/CanlabCore/CanlabCore/canlab_canonical_brains/
Canonical_brains_surfaces/keuken_2014_enhanced_for_underlay.img,1','/
Users/yoni/Repositories/CanlabCore/CanlabCore/canlab_canonical_brains/
Canonical_brains_surfaces/keuken_2014_enhanced_for_underlay.img,1','/
Users/yoni/Repositories/CanlabCore/CanlabCore/
canlab_canonical_brains/Canonical_brains_surfaces/
keuken_2014_enhanced_for_underlay.img,1');">all</
a>)  <a href="matlab:spm_image('display','/
Users/yoni/Repositories/CanlabCore/CanlabCore/
canlab_canonical_brains/Canonical_brains_surfaces/
```

```
keuken_2014_enhanced_for_underlay.img,1');">/Users/yoni/
Repositories/CanlabCore/CanlabCore/canlab_canonical_brains/
Canonical_brains_surfaces/keuken_2014_enhanced_for_underlay.img,1</a>
        <a href="matlab:spm_image('display','/
Users/yoni/Repositories/CanlabCore/CanlabCore/
canlab_canonical_brains/Canonical_brains_surfaces/
keuken_2014_enhanced_for_underlay.img,1');">/Users/yoni/
Repositories/CanlabCore/CanlabCore/canlab_canonical_brains/
Canonical_brains_surfaces/keuken_2014_enhanced_for_underlay.img,1</a>
        <a href="matlab:spm_image('display','/
Users/yoni/Repositories/CanlabCore/CanlabCore/
canlab_canonical_brains/Canonical_brains_surfaces/
keuken_2014_enhanced_for_underlay.img,1');">/Users/yoni/
Repositories/CanlabCore/CanlabCore/canlab_canonical_brains/
Canonical_brains_surfaces/keuken_2014_enhanced_for_underlay.img,1</a>
        <a href="matlab:spm_image('display','/
Users/yoni/Repositories/CanlabCore/CanlabCore/
canlab_canonical_brains/Canonical_brains_surfaces/
keuken_2014_enhanced_for_underlay.img,1');">/Users/yoni/
Repositories/CanlabCore/CanlabCore/canlab_canonical_brains/
Canonical_brains_surfaces/keuken_2014_enhanced_for_underlay.img,1</a>
Defaults settings have been modified by file(s):
  /Users/yoni/Documents/MATLAB/spm_my_defaults.m
Modified fields: stats mask
Defaults settings have been modified by file(s):
  /Users/yoni/Documents/MATLAB/spm_my_defaults.m
Modified fields: stats mask
Defaults settings have been modified by file(s):
  /Users/yoni/Documents/MATLAB/spm_my_defaults.m
Modified fields: stats mask
Defaults settings have been modified by file(s):
  /Users/yoni/Documents/MATLAB/spm_my_defaults.m
Modified fields: stats mask
Defaults settings have been modified by file(s):
  /Users/yoni/Documents/MATLAB/spm_my_defaults.m
Modified fields: stats mask
```


y = -2
x = -4
z = -25
4
2
0
-2
y = -2
x = -4
z = -25
4
2
0
-2
y = -2
x = -4
z = -25
4
2
0
-2
y = -2
x = -4
z = -25
6
4
2
0
-2
y = -2
x = -4
z = -25
10
5
0
-5

Strongest results are for Don2 (orthogonalized wrt to Don1) predicting brain response at Time1

```
if doplot
    print_header('Don2 (orthogonalized wrt to Don1) predicting Time 1
 brain');
    toshow = get_wh_image(out2.t,4);
    obj = removeblobs(obj);
    obj = addblobs(obj, region(toshow));
    snapnow
end

table(region(get_wh_image(out2.t, 4)));

=============================================================================
=
                =
= Don2 (orthogonalized wrt to Don1) predicting Time 1 brain
                =
=
                =
=============================================================================
Grouping contiguous voxels:  37 regions
sagittal montage:  47 voxels displayed, 1283 not displayed on these
 slices
sagittal montage:  26 voxels displayed, 1304 not displayed on these
 slices
sagittal montage:  41 voxels displayed, 1289 not displayed on these
 slices
axial montage: 166 voxels displayed, 1164 not displayed on these
 slices
axial montage: 266 voxels displayed, 1064 not displayed on these
 slices
```




```
Grouping contiguous voxels:  37 regions

_____________________________________________________________________________
Positive Effects
Defaults settings have been modified by file(s):
  /Users/yoni/Documents/MATLAB/spm_my_defaults.m
Modified fields: stats mask
Defaults settings have been modified by file(s):
  /Users/yoni/Documents/MATLAB/spm_my_defaults.m
Modified fields: stats mask
         Region          Volume           XYZ             maxZ
      modal_label_descriptions      Perc_covered_by_label
 Atlas_regions_covered    region_index
    _________________    _______    __________________    _______
    ____________________________    ____________________

 ________________________    _____________

    'NAC_R'                   64       12        2     -14     3.2949
 'Basal_ganglia'                                 50                     0
                  13
    'Bstem_Pons_L'          2232      -14      -16     -34     4.6148
 'Brainstem'                                     40                     0
                   1
    'Bstem_Pons_R'           320       14      -20     -32     3.5016
 'Brainstem'                                     80                     0
                   4
    'Bstem_Ponscd'          1112      -16      -26      -8     3.8351
 'Brainstem'                                     32                     0
                  16
```

```
   'Cblm_Dentate_R'      656      14     -44     -34     3.9158
'Cerebellum'                                 34                    0
                2
   'Ctx_d23ab_L'         728      -2     -48      26     3.6359
'Cortex_Default_ModeA'                       49                    0
               20
   'Ctx_PGs_L'           616     -50     -68      28      3.654
'Cortex_Default_ModeA'                       65                    0
               21
   'Ctx_PGs_L'           208     -42     -78      40     3.5148
'Cortex_Default_ModeA'                       81                    0
               24
   'Ctx_8Ad_L'           824     -18      38      46     3.8279
'Cortex_Default_ModeA'                       37                    0
               26
   'Ctx_PGs_L'           688     -30     -74      50     3.8179
'Cortex_Default_ModeA'                       31                    0
               29
   'Ctx_TGd_L'           344     -52       2     -24       3.64
'Cortex_Default_ModeB'                       63                    0
                5
   'Ctx_47s_R'          1232      28      22     -20     3.9859
'Cortex_Default_ModeB'                       58                    1
                6
   'Ctx_47l_L'          4200     -42      26     -12     4.6086
'Cortex_Default_ModeB'                       35                    2
                9
   'Ctx_9a_L'            320     -18      52      32     3.4197
'Cortex_Default_ModeB'                       57                    0
               22
   'Ctx_9p_L'            160     -10      44      38     3.4642
'Cortex_Default_ModeB'                       15                    0
               25
   'Ctx_55b_L'           176     -40       4      44     3.4784
'Cortex_Default_ModeB'                       95                    0
               28
   'Ctx_55b_L'           376     -52       6      48     3.6088
'Cortex_Default_ModeB'                       53                    0
               30
   'Ctx_8Av_L'           192     -34      14      56     3.4032
'Cortex_Default_ModeB'                       83                    0
               33
   'Ctx_TE1m_R'          368      62     -26     -18     3.7583
'Cortex_Fronto_ParietalB'                   100                    0
                8
   'Ctx_p10p_L'           64     -20      70       6     3.3252
'Cortex_Fronto_ParietalB'                    50                    0
               19
   'Ctx_8BM_L'           192     -12      20      48     3.3356
'Cortex_Fronto_ParietalB'                    17                    0
               31
   'Ctx_7Pm_L'           416      -2     -74      50     3.6465
'Cortex_Fronto_ParietalC'                    38                    0
               32
```

```
   'Ctx_TE2a_R'          344      48    -16    -32    3.5148
'Cortex_Limbic'                                67                      0
                3
   'Ctx_10pp_R'         5736      -2     58    -18    5.2947
'Cortex_Limbic'                                26                      3
                7
   'Ctx_OFC_R'           936      10     28    -16    3.8032
'Cortex_Limbic'                                41                      0
               10
   'Ctx_pOFC_R'          224       6     14    -14    3.4636
'Cortex_Limbic'                                43                      0
               12
   'Ctx_pOFC_L'          144     -12     16    -12    3.3361
'Cortex_Limbic'                                44                      0
               15
   'Ctx_6mp_R'           128      18    -14     70     3.426
'Cortex_SomatomotorA'                         100                      0
               34
   'Ctx_p32pr_L'          64     -10     20     34    3.3783
'Cortex_Ventral_AttentionA'                    50                      0
               23
   'Ctx_PF_L'             64     -62    -38     44    3.3286
'Cortex_Ventral_AttentionA'                   100                      0
               27
   'Ctx_MT_L'             64     -46    -74      6    3.3351
'Cortex_Visual_Central'                       100                      0
               18
   'Ctx_PreS_R'          160      22    -24    -14     3.406
'Cortex_Visual_Peripheral'                     65                      0
               11
   'Ctx_V1_L'            360     -24    -94    -10    3.4559
'Cortex_Visual_Peripheral'                     33                      0
               14
   'No label'            160      36     62      4    3.4814    'No
description'                              0                       0
           17


Negative Effects
      Region       Volume           XYZ             maxZ
    modal_label_descriptions     Perc_covered_by_label
Atlas_regions_covered    region_index
   ____________    ______    ________________    _______
   ____________________________    ______________________
_____________________    ____________

   'Ctx_43_R'        144      56     -2     16    -3.3745
'Cortex_SomatomotorB'                    33                      0
               37
   'Ctx_ProS_L'     1168     -28    -58      8    -4.0855
'Cortex_Visual_Peripheral'                 23                      0
               35
```

'No label'	280	26	-46	16	-3.8665	'No description'
			0			0
						36

Regions labeled by reference atlas CANlab_2018_combined

Volume: Volume of contiguous region in cubic mm.
MaxZ: Signed max over Z-score for each voxel.
Atlas_regions_covered: Number of reference atlas regions covered at least 25% by the region. This relates to whether the region covers multiple reference atlas regions

Region: Best reference atlas label, defined as reference region with highest number of in-region voxels. Regions covering >25% of >5 regions labeled as "Multiple regions"

Perc_covered_by_label: Percentage of the region covered by the label.
Ref_region_perc: Percentage of the label region within the target region.
modal_atlas_index: Index number of label region in reference atlas
all_regions_covered: All regions covered >5% in descending order of importance

For example, if a region is labeled 'TE1a' and Perc_covered_by_label = 8, Ref_region_perc = 38, and Atlas_regions_covered = 17, this means that 8% of the region's voxels are labeled TE1a, which is the highest percentage among reference label regions. 38% of the region TE1a is covered by the region. However, the region covers at least 25% of 17 distinct labeled reference regions.

References for atlases:

Beliveau, Vincent, Claus Svarer, Vibe G. Frokjaer, Gitte M. Knudsen, Douglas N. Greve, and Patrick M. Fisher. 2015. “Functional Connectivity of the Dorsal and Median Raphe Nuclei at Rest.” NeuroImage 116 (August): 187–95.
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Glasser, Matthew F., Timothy S. Coalson, Emma C. Robinson, Carl D. Hacker, John Harwell, Essa Yacoub, Kamil Ugurbil, et al. 2016. A
Multi-Modal Parcellation of Human Cerebral Cortex. Nature 536 (7615): 171?78.
Keren, Noam I., Carl T. Lozar, Kelly C. Harris, Paul S. Morgan, and Mark A. Eckert. 2009. “In Vivo Mapping of the Human Locus Coeruleus.”
NeuroImage 47 (4): 1261–67.

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multiple histological data. Neuroimage. 2010 Feb 1;49(3):2053-62.
Jakab A, Blanc R, Berényi EL, Székely G. (2012) Generation of

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2110-2116, doi: 10.3174/ajnr.A3140

Nash, Paul G., Vaughan G. Macefield, Iven J. Klineberg, Greg M. Murray, and Luke A. Henderson. 2009. ?Differential Activation of the Human
Trigeminal Nuclear Complex by Noxious and Non-Noxious Orofacial Stimulation.? Human Brain Mapping 30 (11):3772?82.

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Pauli, Wolfgang M., Amanda N. Nili, and J. Michael Tyszka. 2018. ?
A High-Resolution Probabilistic in Vivo Atlas of Human Subcortical Brain
Nuclei.? Scientific Data 5 (April): 180063.

Pauli, Wolfgang M., Randall C. O?Reilly, Tal Yarkoni, and Tor D. Wager. 2016. ?Regional Specialization within the Human Striatum for
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Sclocco, Roberta, Florian Beissner, Gaelle Desbordes, Jonathan R. Polimeni, Lawrence L. Wald, Norman W. Kettner, Jieun Kim, et al. 2016.
?Neuroimaging Brainstem Circuitry Supporting Cardiovagal Response to Pain: A Combined Heart Rate Variability/ultrahigh-Field (7 T)
Functional Magnetic Resonance Imaging Study.? Philosophical Transactions. Series A, Mathematical, Physical, and Engineering Sciences 374
(2067). rsta.royalsocietypublishing.org. https://doi.org/10.1098/
rsta.2015.0189.

Shen, X., F. Tokoglu, X. Papademetris, and R. T. Constable. 2013. "Groupwise Whole-Brain Parcellation from Resting-State fMRI Data for Network Node Identification." NeuroImage 82 (November): 403–15.

Zambreanu, L., R. G. Wise, J. C. W. Brooks, G. D. Iannetti, and I. Tracey. 2005. ?A Role for the Brainstem in Central Sensitisation in Humans. Evidence from Functional Magnetic Resonance Imaging.? Pain 114 (3):397?407.

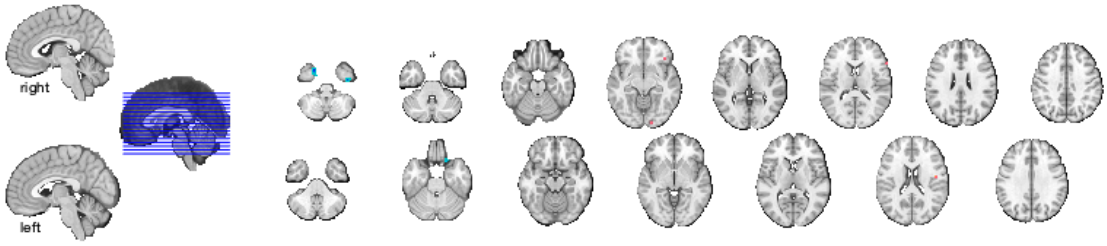
Note: Region object r(i).title contains full list of reference atlas regions covered by each cluster.

Don1 is not strongly related to any brain responses at Time1, though

```
if doplot
    print_header('Don1 predicting Time 1 brain');
    toshow = get_wh_image(out2.t,3);
    obj = removeblobs(obj);
    obj = addblobs(obj, region(toshow));
    snapnow
end

table(region(get_wh_image(out2.t, 3)));
```

```
=========================================================================
=
                =
= Don1 predicting Time 1 brain
                =
=
                =
=========================================================================
Grouping contiguous voxels:   7 regions
sagittal montage:   0 voxels displayed, 128 not displayed on these
 slices
sagittal montage:   0 voxels displayed, 128 not displayed on these
 slices
sagittal montage:   0 voxels displayed, 128 not displayed on these
 slices
axial montage:  11 voxels displayed, 117 not displayed on these slices
axial montage:  45 voxels displayed,  83 not displayed on these slices
```




```
Grouping contiguous voxels:   7 regions

_____________________________________________________________________________
Positive Effects
Defaults settings have been modified by file(s):
  /Users/yoni/Documents/MATLAB/spm_my_defaults.m
Modified fields: stats mask
Defaults settings have been modified by file(s):
  /Users/yoni/Documents/MATLAB/spm_my_defaults.m
Modified fields: stats mask
      Region       Volume          XYZ             maxZ
    modal_label_descriptions    Perc_covered_by_label
 Atlas_regions_covered    region_index
    ___________    ______    _______________    ______
    ________________________    ________________________
 ________________________    ____________

    'Ctx_47l_R'     176      38     32    -10    3.4256
 'Cortex_Default_ModeB'                36                          0
              2
    'Ctx_44_R'      304      60     20     14    3.5549
 'Cortex_Default_ModeB'                32                          0
              3
    'Ctx_OP4_R'     376      46     -8     18    3.8762
 'Cortex_SomatomotorB'                 17                          0
              4
    'Ctx_V2_R'      248      12    -94    -10    3.4714
 'Cortex_Visual_Central'               55                          0
              1
```

Negative Effects

Region	Volume	XYZ		maxZ	
modal_label_descriptions	Perc_covered_by_label				
Atlas_regions_covered	region_index				
'Ctx_TGd_L'	1080	-24	6	-42	-3.9409
'Cortex_Default_ModeB'			36		0
6					
'Ctx_TGv_R'	408	40	-10	-44	-3.6162
'Cortex_Limbic'			92		0
5					
'Ctx_13l_R'	568	18	22	-26	-4.1206
'Cortex_Limbic'			39		0
7					

Regions labeled by reference atlas CANlab_2018_combined

Volume: Volume of contiguous region in cubic mm.
MaxZ: Signed max over Z-score for each voxel.
Atlas_regions_covered: Number of reference atlas regions covered at least 25% by the region. This relates to whether the region covers multiple reference atlas regions

Region: Best reference atlas label, defined as reference region with highest number of in-region voxels. Regions covering >25% of >5 regions labeled as "Multiple regions"

Perc_covered_by_label: Percentage of the region covered by the label.
Ref_region_perc: Percentage of the label region within the target region.
modal_atlas_index: Index number of label region in reference atlas
all_regions_covered: All regions covered >5% in descending order of importance

For example, if a region is labeled 'TE1a' and Perc_covered_by_label = 8, Ref_region_perc = 38, and Atlas_regions_covered = 17, this means that 8% of the region's voxels are labeled TE1a, which is the highest percentage among reference label regions. 38% of the region TE1a is covered by the region. However, the region covers at least 25% of 17 distinct labeled reference regions.

References for atlases:

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Bär, Karl-Jürgen, Feliberto de la Cruz, Andy Schumann, Stefanie Koehler, Heinrich Sauer, Hugo Critchley, and Gerd Wagner. 2016. ? Functional Connectivity and Network Analysis of Midbrain and Brainstem Nuclei.? NeuroImage 134 (July):53?63.

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Keuken, M. C., P-L Bazin, L. Crown, J. Hootsmans, A. Laufer, C. Müller-Axt, R. Sier, et al. 2014. "Quantifying Inter-Individual Anatomical Variability in the Subcortex Using 7 T Structural MRI." NeuroImage 94 (July): 40–46.
Krauth A, Blanc R, Poveda A, Jeanmonod D, Morel A, Székely G. (2010) A mean three-dimensional atlas of the human thalamus: generation from multiple histological data. Neuroimage. 2010 Feb 1;49(3):2053-62. Jakab A, Blanc R, Berényi EL, Székely G. (2012) Generation of

Individualized Thalamus Target Maps by Using Statistical Shape Models and Thalamocortical Tractography. AJNR Am J Neuroradiol. 33: 2110-2116, doi: 10.3174/ajnr.A3140

Nash, Paul G., Vaughan G. Macefield, Iven J. Klineberg, Greg M. Murray, and Luke A. Henderson. 2009. ?Differential Activation of the Human Trigeminal Nuclear Complex by Noxious and Non-Noxious Orofacial Stimulation.? Human Brain Mapping 30 (11):3772?82.

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Sclocco, Roberta, Florian Beissner, Gaelle Desbordes, Jonathan R. Polimeni, Lawrence L. Wald, Norman W. Kettner, Jieun Kim, et al. 2016.
?Neuroimaging Brainstem Circuitry Supporting Cardiovagal Response to Pain: A Combined Heart Rate Variability/ultrahigh-Field (7 T) Functional Magnetic Resonance Imaging Study.? Philosophical Transactions. Series A, Mathematical, Physical, and Engineering Sciences 374
(2067). rsta.royalsocietypublishing.org. https://doi.org/10.1098/rsta.2015.0189.

Shen, X., F. Tokoglu, X. Papademetris, and R. T. Constable. 2013. "Groupwise Whole-Brain Parcellation from Resting-State fMRI Data for Network Node Identification." NeuroImage 82 (November): 403–15.

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Note: Region object r(i).title contains full list of reference atlas regions covered by each cluster.

Brain activity at Time1 in mOFC/NAc regions prospectively predicts who will increase or decrease in donation, across groups. Like a prognostic marker of natural history of donation change

Is this prognostic finding driven by a particular group? Test this w/ a group * Don2 interaction term in the model

Interactions terms are between the two group contrast codes (CM vs. cntrls, OxyPla vs. Faml) and Don2 orthogonalized wrt to Don1.

```
% build design matrix.
% Make CM the reference group (intercept), and add dummy regressors
 for Faml and OxyPla
dm = grp_cc;

% add deltadon/fas mean centered within grp, or don1/2
```

```
dm(:,3) = don1_mcgrp;
dm(:,4) = don2_mcgrp_orth;

dm(:,5) = don2_mcgrp_orth .* dm(:,1);
dm(:,6) = don2_mcgrp_orth .* dm(:,2);

%figure; imagesc([dm ones(length(dm), 1)]); colorbar
dat.X = dm; % regs are, in order: Oxy vs CM, Faml vs CM, abs change in
 CM

% estimate model
out2 = regress(dat, .001, 'unc', 'k', 10); % automatically adds
 intercept as last column --> CM
%save(fullfile(outdir, 'cm_vs_oxy_faml_deltadonfas_robust.mat'),
 'out2')

Analysis:
---------------------------------
Design matrix warnings:
---------------------------------
No intercept detected, adding intercept to last column of design
 matrix
Warning:  Group sizes are unequal for effects-coded [1 -1] variable.


---------------------------------
Running regression: 195616 voxels. Design:  56 obs,   7 regressors,
 intercept is last

Predicting exogenous variable(s) in dat.X using brain data as
 predictors, mass univariate
Running in OLS Mode
Model run in 0 minutes and 0.77 seconds

Image   1
 11 contig. clusters, sizes   1 to 307
Positive effect:  60 voxels, min p-value: 0.00010884
Negative effect: 375 voxels, min p-value: 0.00001681

Image   2
 11 contig. clusters, sizes   1 to 307
Positive effect: 1572 voxels, min p-value: 0.00000572
Negative effect:   0 voxels, min p-value: 0.00313663

Image   3
 11 contig. clusters, sizes   1 to 307
Positive effect:  37 voxels, min p-value: 0.00007117
Negative effect:  98 voxels, min p-value: 0.00004399

Image   4
 11 contig. clusters, sizes   1 to 307
Positive effect: 267 voxels, min p-value: 0.00001621
Negative effect: 324 voxels, min p-value: 0.00000036
```

```
Image   5
 11 contig. clusters, sizes   1 to 307
Positive effect:  62 voxels, min p-value: 0.00002956
Negative effect: 818 voxels, min p-value: 0.00000262

Image   6
 11 contig. clusters, sizes   1 to 307
Positive effect: 822 voxels, min p-value: 0.00000024
Negative effect:  19 voxels, min p-value: 0.00010872

Image   7
 11 contig. clusters, sizes   1 to 307
Positive effect: 31200 voxels, min p-value: 0.00000000
Negative effect: 53007 voxels, min p-value: 0.00000000

SPM12: spm_check_registration (v6245)            12:56:22 -
 05/08/2019
========================================================================
Display <a href="matlab:spm_image('display','/
Users/yoni/Repositories/CanlabCore/CanlabCore/
canlab_canonical_brains/Canonical_brains_surfaces/
keuken_2014_enhanced_for_underlay.img,1');">/Users/yoni/
Repositories/CanlabCore/CanlabCore/canlab_canonical_brains/
Canonical_brains_surfaces/keuken_2014_enhanced_for_underlay.img,1</a>
 (<a href="matlab:spm_check_registration('/Users/yoni/
Repositories/CanlabCore/CanlabCore/canlab_canonical_brains/
Canonical_brains_surfaces/keuken_2014_enhanced_for_underlay.img,1','/
Users/yoni/Repositories/CanlabCore/CanlabCore/canlab_canonical_brains/
Canonical_brains_surfaces/keuken_2014_enhanced_for_underlay.img,1','/
Users/yoni/Repositories/CanlabCore/CanlabCore/canlab_canonical_brains/
Canonical_brains_surfaces/keuken_2014_enhanced_for_underlay.img,1','/
Users/yoni/Repositories/CanlabCore/CanlabCore/canlab_canonical_brains/
Canonical_brains_surfaces/keuken_2014_enhanced_for_underlay.img,1','/
Users/yoni/Repositories/CanlabCore/CanlabCore/canlab_canonical_brains/
Canonical_brains_surfaces/keuken_2014_enhanced_for_underlay.img,1','/
Users/yoni/Repositories/CanlabCore/CanlabCore/canlab_canonical_brains/
Canonical_brains_surfaces/keuken_2014_enhanced_for_underlay.img,1','/
Users/yoni/Repositories/CanlabCore/CanlabCore/
canlab_canonical_brains/Canonical_brains_surfaces/
keuken_2014_enhanced_for_underlay.img,1');">all</
a>)  <a href="matlab:spm_image('display','/
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canlab_canonical_brains/Canonical_brains_surfaces/
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Repositories/CanlabCore/CanlabCore/canlab_canonical_brains/
Canonical_brains_surfaces/keuken_2014_enhanced_for_underlay.img,1</a>
Defaults settings have been modified by file(s):
  /Users/yoni/Documents/MATLAB/spm_my_defaults.m
Modified fields: stats mask
Defaults settings have been modified by file(s):
  /Users/yoni/Documents/MATLAB/spm_my_defaults.m
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Defaults settings have been modified by file(s):
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Modified fields: stats mask
Defaults settings have been modified by file(s):
  /Users/yoni/Documents/MATLAB/spm_my_defaults.m
Modified fields: stats mask
```

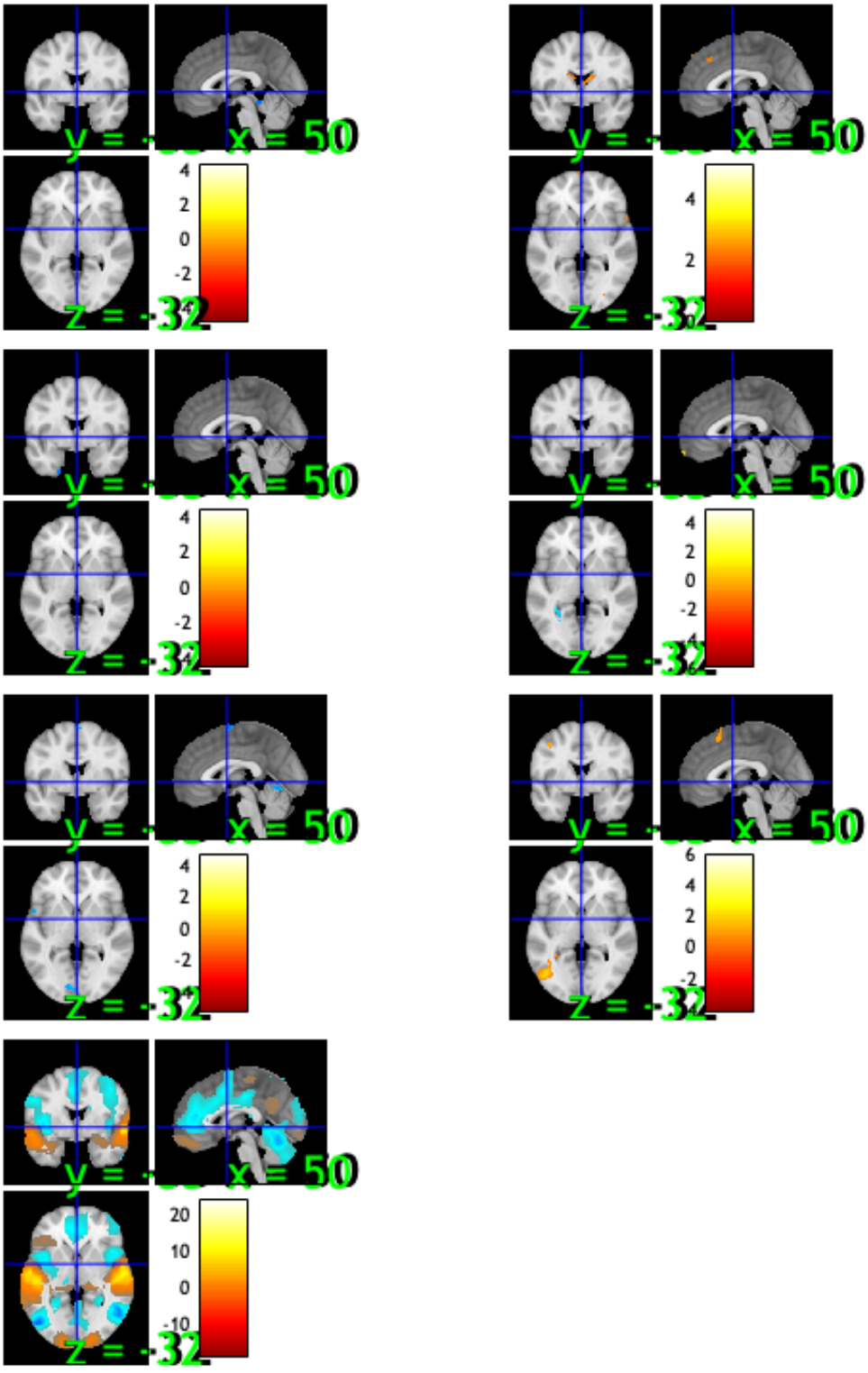
x = 50
z = -32
4
2
0
-2
20
10
0
-10
6

Results: When these interaction terms are included in the model, much less survives threshold. This suggests that mOFC/NAC predicts Don2 across groups

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