Divergent Neural Processing of Self-Referential Stimuli in Orbitofrontal and Ventromedial Cortex Populations

```
% -*- UFT -*-
% Author: behira
% behzadiravani@gmail.com
% loading the data
clc
clear
data = readtable('data\stimlock.tsv', FileType='text'); % reading that tabular data
```

Subject and Experimental Condition

```
% create report object
report = stat_report(data, 'data\BHV.json', 'data\FrontalEcogvsSeeg.json'); % stat_report insta
% print some info
Uniq_id = report.report("num_indiv");
```

```
The total number of pt is: 22
```

```
report.report("number_total_elec"); % statistical summary of number of electrodes
```

```
The total number of elec is: 253, in total patients 22
 mean (std) # elec: 11.50(10.60), range =  [1,38]
```

Behavioral Data

Finding out how many trails per conditions have been performed on average.

```
report.report("number_trials"); % statistical summary of number of trials per condition
```

```
EP # trails: mean (std): 24 (1.2)
SJ # trails: mean (std): 24 (1.9)
MTH # trails: mean (std): 39 (1.7)
```

```
report.report("number_true_false") % statistical summary of number of trials responded with tru
```

```
EP true # trails replied with true: mean (std): 9 (4), range = [4,22]
EP false # trails replied with true: mean (std): 15 (4), range = [4,21]
SJ true # trails replied with true: mean (std): 16 (3), range = [8,23]
SJ false # trails replied with true: mean (std): 8 (3), range = [3,14]
MTH true # trails replied with true: mean (std): 21 (4), range = [15,31]
MTH false # trails replied with true: mean (std): 16 (3), range = [9,20]
ans = struct with fields:
     true: {[9 4 4 22]  [16 3 8 23]  [21 4 15 31]}
    false: {[15 4 4 21]  [8 3 3 14]  [16 3 9 20]}
```

```
report.report("reaction_time") % statistical summary of RT responded with true and false
```

```
EP true RT replied with true: mean (std): 3.67 (1.40), range = [1.35,6.48]
EP false RT replied with true: mean (std): 3.62 (1.40), range = [1.38,6.45]
SJ true RT replied with true: mean (std): 3.06 (1.33), range = [0.96,5.49]
```

```
SJ false RT replied with true: mean (std): 3.56 (1.27), range = [1.16,5.86]
MTH true RT replied with true: mean (std): 4.65 (1.84), range = [1.22,8.32]
MTH false RT replied with true: mean (std): 5.37 (2.04), range = [1.34,9.47]
ans = struct with fields:
     true: {[3.6700 1.4000 1.3500 6.4800]  [3.0600 1.3300 0.9600 5.4900]  [4.6500 1.8400 1.2200 8.3200]}
    false: {[3.6200 1.4000 1.3800 6.4500]  [3.5600 1.2700 1.1600 5.8600]  [5.3700 2.0400 1.3400 9.4700]}
```

```
report.report("veridicality") % statistical summary of response veridicality.
```

```
EP true veridicality replied with true: mean (std): 0.47 (0.15), range = [0.24,0.82]
EP false veridicality replied with true: mean (std): 0.70 (0.21), range = [0.11,0.96]
MTH true veridicality replied with true: mean (std): 0.87 (0.11), range = [0.60,1.00]
MTH false veridicality replied with true: mean (std): 0.79 (0.20), range = [0.29,1.00]
ans = struct with fields:
     true: {[0.4700 0.1500 0.2400 0.8200]  [0.8700 0.1100 0.6000 1]}
    false: {[0.7000 0.2100 0.1100 0.9600]  [0.7900 0.2000 0.2900 1]}
```

Self-Referential Neuronal Population Activity in the OFC and vmPFC

```
report.report("ECoGSEEG") % statisitcal summary of number of ECoG and SEEG electrodes as well a
```

```
S01 -- electype: ECOG
S02 -- electype: ECOG
S03 -- electype: ECOG
S04 -- electype: ECOG
S05 -- electype: ECOG
S06 -- electype: ECOG
S07 -- electype: ECOG
S08 -- electype: ECOG
S09 -- electype: ECOG
S10 -- electype: ECOG
S11 -- electype: ECOG
S12 -- electype: ECOG
S13 -- electype: ECOG
S14 -- electype: ECOG
S15 -- electype: ECOG
S16 -- electype: ECOG
S17 -- electype: SEEG
S18 -- electype: ECOG
S19 -- electype: SEEG
S20 -- electype: ECOG
S21 -- electype: SEEG
S22 -- electype: SEEG
ECOG = 13 +/- 11, [2, 38]
OFC = 0.76 +/- 0.33
MPFC = 0.24 +/- 0.33
SEEG = 6 +/- 6, [1, 13]
OFC = 0.50 +/- 0.58
MPFC = 0.50 +/- 0.58
```

Assessing the spatial distribution of self-referntial- and math-activated electrodes on the cortex. The significance has been determined by 5000 permutations Monte Carlo test and stored in Pval_LOC in the data table.

```
R = resultiEEG(data, 'data\BHV.json', 'data\FrontalEcogvsSeeg.json'); % cerate an instance of r
% define the colors for electrode activity in hex
col = ["#0065C1",... blue for self-referential
        "#A63838" ]; % red for math
R.LocalizeSelfMath(col);
```

```
Warning: indxing statrs at zero adding 1 to faces
```

```
Starting parallel pool (parpool) using the 'local' profile ...
Warning: Removing "C:\MatlabToolboxes\spm12\spm12\external\fieldtrip\compat\matlablt2012a" from your path.
See http://www.fieldtriptoolbox.org/faq/should_i_add_fieldtrip_with_all_subdirectories_to_my_matlab_path/
Connected to the parallel pool (number of workers: 8).
observation 1 of 107
observation 14 of 107
observation 13 of 107
observation 12 of 107
observation 11 of 107
observation 10 of 107
observation 9 of 107
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observation 20 of 107
observation 19 of 107
observation 18 of 107
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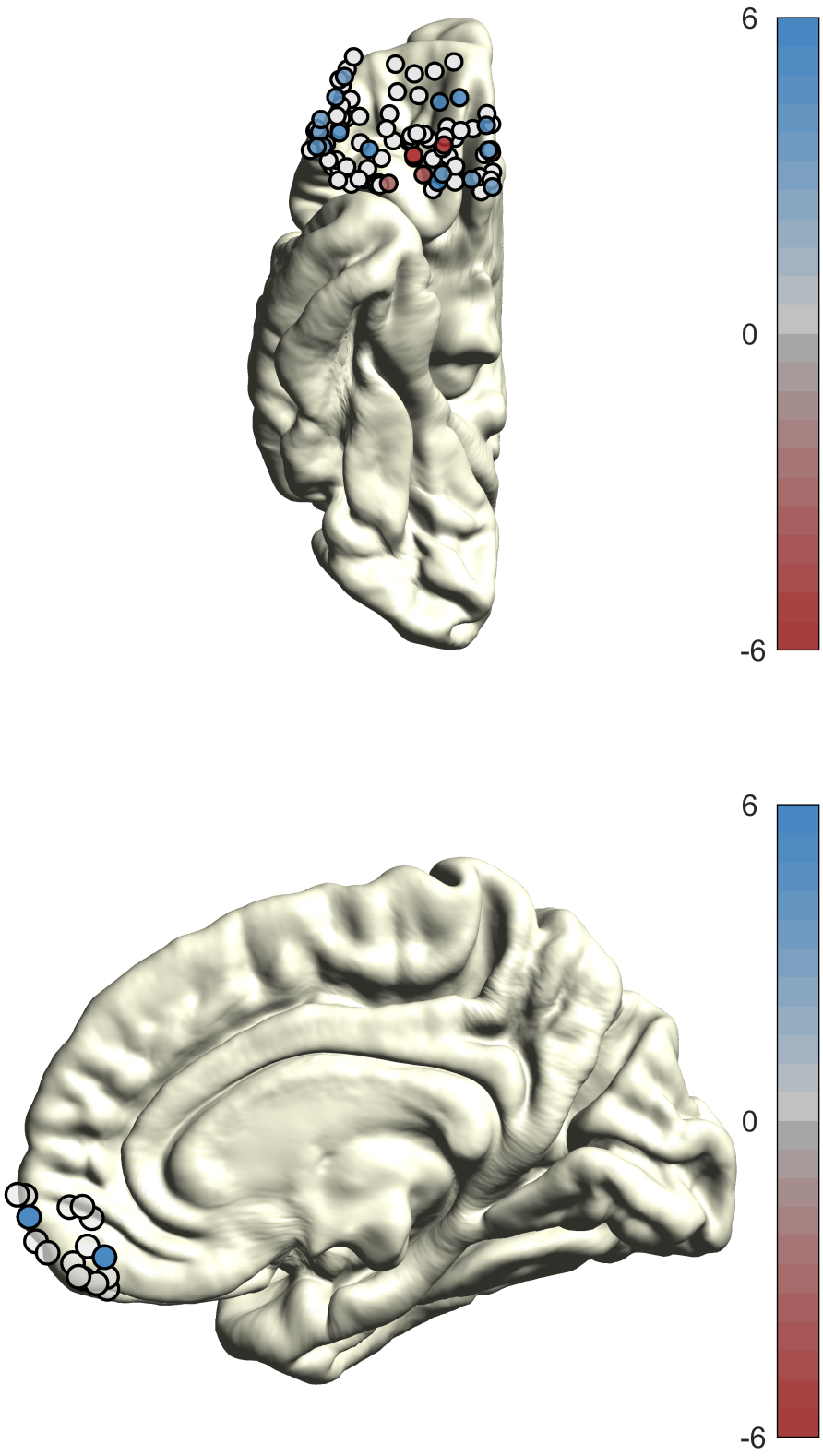


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Warning: indxing statrs at zero adding 1 to faces
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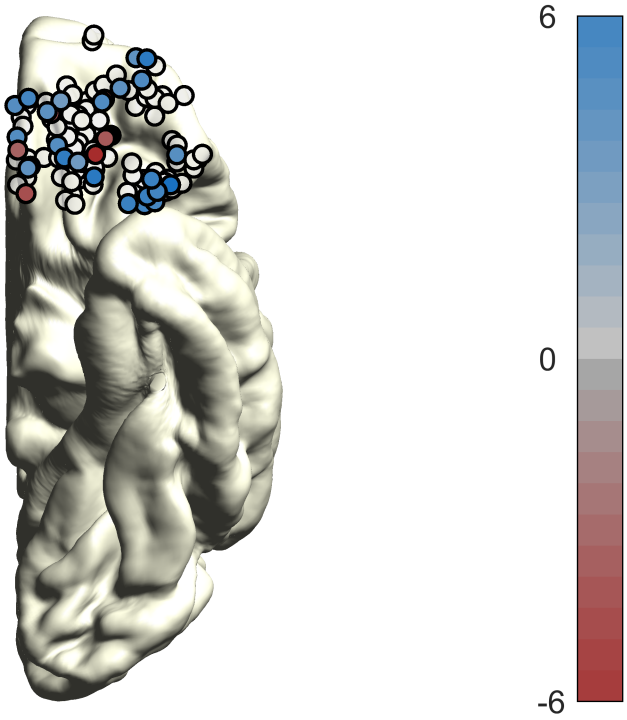
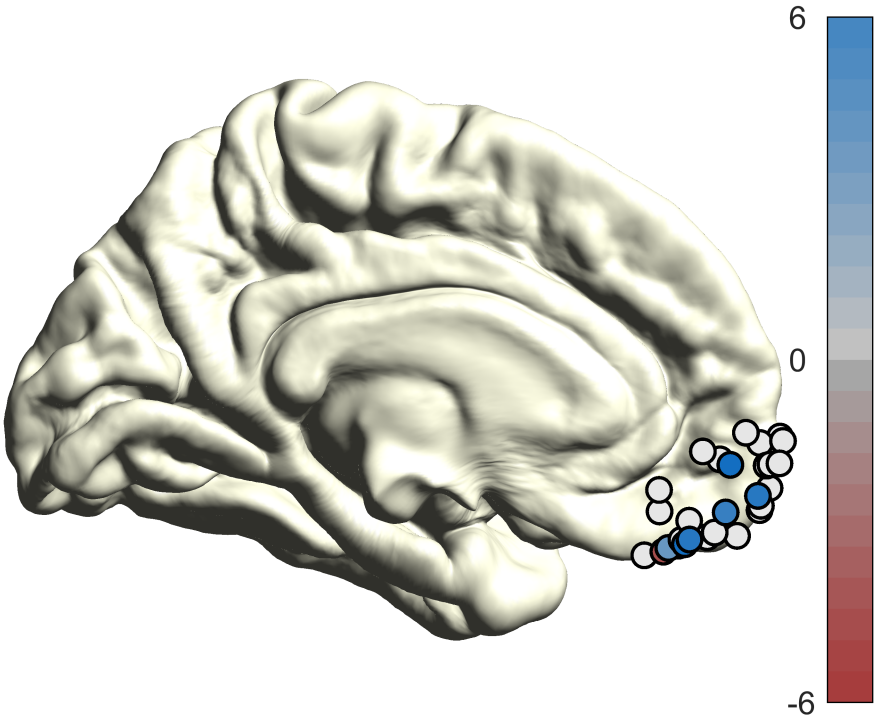
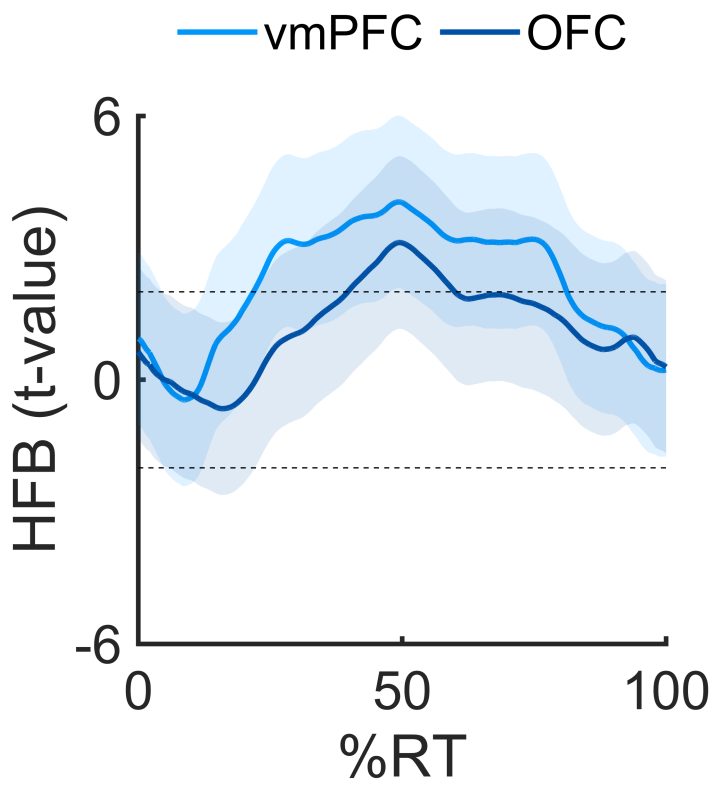





```
% read the time warped HFB envelope
HFB_tw.data  = R.getTimeWarppedHFB('data\Stimlock-TimeWarped_ieeg.dat');
% read labels
HFB_tw.label = readtable('data\Stimlock-TimeWarped.tsv', FileType = 'text');
% trials were warped to 0:100% of RT
HFB_tw.time  = (0:size(HFB_tw.data,2)-1)./512 - .5; % pre = 500ms, fsamp = 512
% define colors
col = ["#0097FB", "#0051A6"]; % light and dark blue
R.plot_HFB(HFB_tw, .1, col) % smoothing .1s
```




```
{
  "Anatomy": [
    "MPFC",
    "OFC"
  ],
  "time": [
    22,
    40
  ],
  "tvalue": [
    2.0582317462587456,
    2.0515793356025762
  ],
  "dof": [
    38,
    207
  ],
  "pvalue": [
    0.046473355236149594,
    0.041469574463316672
  ],
  "CI": [
    [
      -0.052999750339447149,
      0.067882795654500033
    ],
    [
      -0.11636782753021721,
      0.131640396275843
    ]
  ]
}
```

Testing if in the same brain a pattern similar to gourp level can be found. Therefore, we need to first find individuals with electrode implanted both in OFC and vmPFC.

```
[SE, SJ] = R.find_sameBrain(HFB_tw.label, HFB_tw.data, HFB_tw.time); % finds data from same bra
t2p = time2peak(SE, SJ) % create time2peak object
```

```
t2p =
  time2peak with properties:

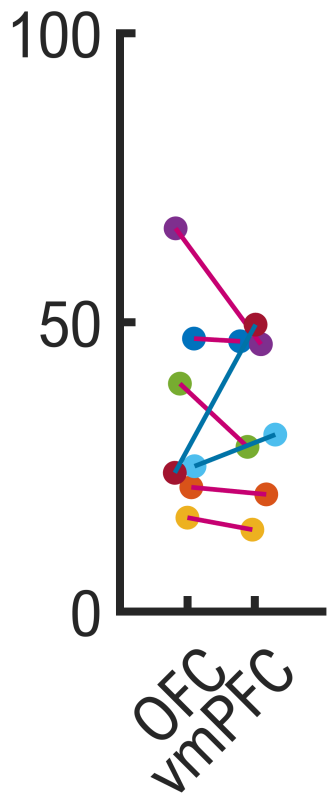
                      SE: [14×18 table]
                      SJ: [14×18 table]
    HFB_response_latencey: [1×1 struct]
```

Peaks were identified using matlab *findpeaks*, the first peak identifed as the peak that had an amplitude larger than 75th percentil and the latency larger 10% of RT.

```
t2p.HFB_response_latencey % caluclates the response latency for HFB in same brain
```

```
ans = struct with fields:
     OFC: [47.2058 21.5072 16.2574 66.2574 39.4157 25.1482 24.0051]
    MPFC: [46.7401 20.2794 14.1829 46.2320 28.4928 30.6097 49.6190]
```

```
% ploting the results (fig1c)
figure
t2p.plot()
```



Now we assess how many percentages of the electrodes were activated during self-referential vs. math.

```
out = report.report("active_total"); % how many electrodes were activated per each condition: s
fprintf('total of %1.0f(%1.0f)%% self-activated\n', mean(cellfun(@(x) x.self, out))*1e2, std(ce
```

```
total of 13(15)% self-activated
```

```
fprintf('total of %1.0f(%1.0f)%% math\n', mean(cellfun(@(x) x.math, out))*1e2, std(cellfun(@(x)
```

```
total of 4(5)% math
```

Performing a paried t-test to assess if the difference between the percentage of self- vs. math-activated electrodes are statistically meaningful.

```
% calculate two-ways, paired ttest to compare the percentages of self- vs. math-activated elect
[~, p, CI, stats ] = ttest(cellfun(@(x) x.self, out), cellfun(@(x) x.math, out));
fprintf('self > math: t(%d) = %1.2f, p < %1.2f, CI = [%1.2f, %1.2f]', stats.df, stats.tstat, p,
```

```
self > math: t(21) = 2.80, p < 0.01, CI = [0.02, 0.16]
```

We further assess if the self-episodic and self-judgment electrodes within the self-referentally activated populations overlaps.

```
out = report.report("percentage");
fprintf('total of %1.0f(%1.0f)%% within self-referental populations weer activated both in EP(S
```

```
total of 3(7)% within self-referental populations weer activated both in EP(SE) and SJ
```

A little anatomical overlap found betweem self-episodic and self-judgment within self-referentailly activated populations.

Performing a linear-mixed effect model (LMM) to follow up if HFB differes for SE and SJ

```
% create a LMM object for SE and SJ
LMM = stat.LMMSESJ(R.data, 'Tval ~ -1 + task:JPAnatomy + (1|subj) + (1|Density)')
```

```
LMM =
preprocssing the input table...
finding self-referentially activated electrodes for this analysis.
removing non-self-referentially activated electrodes
done!
  LMMSESJ with properties:

         coeff: []
        coeffl: []
        coeffh: []
    prediction: []
         index: []
      preprocT: [180×19 table]
          data: [1265×15 table]
         model: "Tval ~ -1 + task:JPAnatomy + (1|subj) + (1|Density)"
           mdl: []
```

```
% running bootstarping
LMM = LMM.bootstramp(LMM.preprocT)
```

```
preprocssing the input table...
finding self-referentially activated electrodes for this analysis.
```

```
removing non-self-referentially activated electrodes
done!
Bootraping, please wait...
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done!
LMM =
preprocssing the input table...
finding self-referentially activated electrodes for this analysis.
removing non-self-referentially activated electrodes
done!
  LMMSESJ with properties:

         coeff: []
        coeffl: []
        coeffh: []
    prediction: []
         index: []
      preprocT: [180×19 table]
          data: [1265×15 table]
         model: "Tval ~ -1 + task:JPAnatomy + (1|subj) + (1|Density)"
           mdl: [1000×1 struct]
```

ploting the LMM results for SE and SJ among those that showed more activity than distractor condition:

```
LMM.bars
```

```
task_EP:JPAnatomy_MPFC
task_SJ:JPAnatomy_MPFC
task_EP:JPAnatomy_OFC
task_SJ:JPAnatomy_OFC
```