Analysis Dataset 1: Evoked Response Potential (ERP) of affective picture (IAPS)

The following script shows how dataset 1 was analyzed using the time-GAL toolbox. EEG data can be retrieved from the OSF repository (https://osf.io/q56ns/) and found in folder "Dataset1_IAPS_ERP".

Import/group data

The time-GAL toolbox needs data to be formated in a specific way: One 3D (matrix channels, time, trials) and one vector indicating subject's id of each trial. These matrix and vector are needed for each condition. Here, we show the example with pleasant vs. unpleasant figures:

```
[Data_Condition_Pleasant, List_Condition_Pleasant] = groupCondition('./
Dataset1_IAPS_ERP/', 'Data_Pleasant', 'Data', 'FileName', 'Condition_Pleasant');
```

A total of 39 files were found with tag: Data_Pleasant Data: [129×601×32 double]

```
Reading file: Data_Pleasant_subject_1.mat | File 1 out of 39
Reading file: Data Pleasant subject 10.mat | File 2 out of 39
Reading file: Data Pleasant subject 11.mat | File 3 out of 39
Reading file: Data_Pleasant_subject_12.mat | File 4 out of 39
Reading file: Data Pleasant subject 13.mat | File 5 out of 39
Reading file: Data_Pleasant_subject_14.mat | File 6 out of 39
Reading file: Data Pleasant subject 15.mat | File 7 out of 39
Reading file: Data_Pleasant_subject_16.mat | File 8 out of 39
Reading file: Data_Pleasant_subject_17.mat | File 9 out of 39
Reading file: Data_Pleasant_subject_18.mat | File 10 out of 39
Reading file: Data_Pleasant_subject_19.mat | File 11 out of 39
Reading file: Data_Pleasant_subject_2.mat | File 12 out of 39
Reading file: Data_Pleasant_subject_20.mat | File 13 out of 39
Reading file: Data_Pleasant_subject_21.mat | File 14 out of 39
Reading file: Data Pleasant subject 22.mat | File 15 out of 39
Reading file: Data_Pleasant_subject_23.mat | File 16 out of 39
Reading file: Data Pleasant subject 24.mat | File 17 out of 39
Reading file: Data_Pleasant_subject_25.mat | File 18 out of 39
Reading file: Data_Pleasant_subject_26.mat | File 19 out of 39
Reading file: Data_Pleasant_subject_27.mat | File 20 out of 39
Reading file: Data_Pleasant_subject_28.mat | File 21 out of 39
Reading file: Data_Pleasant_subject_29.mat | File 22 out of 39
Reading file: Data_Pleasant_subject_3.mat | File 23 out of 39
Reading file: Data_Pleasant_subject_30.mat | File 24 out of 39
Reading file: Data Pleasant subject 31.mat | File 25 out of 39
Reading file: Data_Pleasant_subject_32.mat | File 26 out of 39
Reading file: Data_Pleasant_subject_33.mat | File 27 out of 39
Reading file: Data_Pleasant_subject_34.mat | File 28 out of 39
Reading file: Data_Pleasant_subject_35.mat | File 29 out of 39
Reading file: Data_Pleasant_subject_36.mat | File 30 out of 39
Reading file: Data_Pleasant_subject_37.mat | File 31 out of 39
Reading file: Data_Pleasant_subject_38.mat | File 32 out of 39
Reading file: Data_Pleasant_subject_39.mat | File 33 out of 39
Reading file: Data_Pleasant_subject_4.mat | File 34 out of 39
Reading file: Data Pleasant subject 5.mat | File 35 out of 39
Reading file: Data_Pleasant_subject_6.mat | File 36 out of 39
Reading file: Data Pleasant subject 7.mat | File 37 out of 39
Reading file: Data_Pleasant_subject_8.mat | File 38 out of 39
```

```
Reading file: Data_Pleasant_subject_9.mat | File 39 out of 39
```

Saving conditionData matrix and listSubjects vector as file: Condition Pleasant

```
[Data_Condition_Unpleasant, List_Condition_Unpleasant] = groupCondition('./
Dataset1_IAPS_ERP/', 'Data_Unpleasant', 'Data', 'FileName', 'Condition_Unpleasant');
```

A total of 39 files were found with tag: Data Unpleasant Data: [129×601×26 double]

```
Reading file: Data Unpleasant subject 1.mat | File 1 out of 39
Reading file: Data_Unpleasant_subject_10.mat | File 2 out of 39
Reading file: Data Unpleasant subject 11.mat
                                             | File 3 out of 39
Reading file: Data_Unpleasant_subject_12.mat | File 4 out of 39
Reading file: Data_Unpleasant_subject_13.mat | File 5 out of 39
Reading file: Data_Unpleasant_subject_14.mat
                                               File 6 out of 39
Reading file: Data_Unpleasant_subject_15.mat
                                               File 7 out of 39
Reading file: Data_Unpleasant_subject_16.mat
                                               File 8 out of 39
Reading file: Data_Unpleasant_subject_17.mat
                                               File 9 out of 39
Reading file: Data_Unpleasant_subject_18.mat | File 10 out of 39
Reading file: Data Unpleasant subject 19.mat | File 11 out of 39
Reading file: Data_Unpleasant_subject_2.mat | File 12 out of 39
Reading file: Data_Unpleasant_subject_20.mat | File 13 out of 39
Reading file: Data_Unpleasant_subject_21.mat | File 14 out of 39
Reading file: Data_Unpleasant_subject_22.mat | File 15 out of 39
Reading file: Data_Unpleasant_subject_23.mat |
                                               File 16 out of 39
Reading file: Data_Unpleasant_subject_24.mat | File 17 out of 39
Reading file: Data_Unpleasant_subject_25.mat |
                                               File 18 out of 39
Reading file: Data_Unpleasant_subject_26.mat | File 19 out of 39
Reading file: Data_Unpleasant_subject_27.mat | File 20 out of 39
Reading file: Data Unpleasant subject 28.mat | File 21 out of 39
Reading file: Data Unpleasant subject 29.mat | File 22 out of 39
Reading file: Data Unpleasant subject 3.mat | File 23 out of 39
Reading file: Data Unpleasant subject 30.mat | File 24 out of 39
Reading file: Data Unpleasant subject 31.mat | File 25 out of 39
Reading file: Data Unpleasant subject 32.mat | File 26 out of 39
Reading file: Data Unpleasant subject 33.mat |
                                               File 27 out of 39
Reading file: Data Unpleasant subject 34.mat
                                               File 28 out of 39
Reading file: Data Unpleasant subject 35.mat
                                               File 29 out of 39
Reading file: Data_Unpleasant_subject_36.mat
                                               File 30 out of 39
Reading file: Data_Unpleasant_subject_37.mat
                                               File 31 out of 39
Reading file: Data_Unpleasant_subject_38.mat
                                               File 32 out of 39
Reading file: Data Unpleasant subject 39.mat | File 33 out of 39
Reading file: Data_Unpleasant_subject_4.mat | File 34 out of 39
Reading file: Data_Unpleasant_subject_5.mat | File 35 out of 39
Reading file: Data_Unpleasant_subject_6.mat | File 36 out of 39
Reading file: Data_Unpleasant_subject_7.mat | File 37 out of 39
Reading file: Data_Unpleasant_subject_8.mat | File 38 out of 39
Reading file: Data_Unpleasant_subject_9.mat | File 39 out of 39
```

Saving conditionData matrix and listSubjects vector as file: Condition_Unpleasant

Once grouped all data from the folder of subject's files in two conditions data, it is saved on a file and workspace. We can use either the workspace data or load it again in a new session:

```
% load('Condition_Pleasant.mat');
% load('Condition_Pleasant.mat');
```

Computing time-GAL method

Now, data is ready to be included in the toolbox as input. We use the time-GAL toolbox to compare Pleasant vs. Unpleasant EEG responses. To speed-up the MVPA decoding process, we takes advantage of the parallel computing toolbox implemented in MATLAB by using parameters 'ParallelComputing', true and 'ParallelComputingCores', 4. Since 4 channels are facials and we disregard this information, we use the parameter 'Channels' to select the EEG sensors to be used in the analysis. Finally, results are saved in a mat file.

```
[timeGALoutput] = timeGAL(Data_Condition_Pleasant, Data_Condition_Unpleasant,
List_Condition_Pleasant, List_Condition_Unpleasant, ...
    'ParallelComputing', true, 'ParallelComputingCores', 4, ...
    'Channels', [1:124 129], ...
    'Filename', 'resultsTimeGAL_IAPS_ERP.mat')
```

1. Initializing function.

```
Using Parallel Computing Toolbox with 4 cores
```

Time elapse: 1 minutes 1.341411e+01 seconds

Subject: 19 | 19 out of 39

Starting parallel pool (parpool) using the 'LocalProfile4cores' profile ...

Preserving jobs with IDs: 4 5 6 7 19 25 26 because they contain crash dump files.

You can use 'delete(myCluster.Jobs)' to remove all jobs created with profile LocalProfile4cores. To create 'myCluste Connected to parallel pool with 4 workers.

2. Computing GAL matrices. Progress: Subject: 1 | 1 out of 39 Subject: 2 | 2 out of 39 Subject: 4 | 4 out of 39 Subject: 3 | 3 out of 39 Time elapse: 1 minutes 1.333896e+01 seconds Subject: 8 | 8 out of 39 Time elapse: 1 minutes 1.665973e+01 seconds Subject: 16 | 16 out of 39 Time elapse: 1 minutes 1.999767e+01 seconds Subject: 20 | 20 out of 39 Time elapse: 1 minutes 1.988302e+01 seconds Subject: 12 | 12 out of 39 Time elapse: 1 minutes 1.100019e+01 seconds Subject: 7 | 7 out of 39 Time elapse: 1 minutes 9.525260e+00 seconds Subject: 11 | 11 out of 39 Time elapse: 1 minutes 1.502047e+01 seconds Subject: 15 | 15 out of 39

.
Time elapse: 1 minutes 1.390918e+01 seconds Subject: 6 6 out of 39
.
Subject: 10 10 out of 39
Subject: 14 14 out of 39
.
.
Subject: 5 5 out of 39
Time elapse: 1 minutes 8.520905e+00 seconds
Subject: 13 13 out of 39
Time elapse: 1 minutes 1.159385e+01 seconds
Subject: 9 9 out of 39
Subject: 17 17 out of 39
.
Subject: 22 22 out of 39
Time elapse: 1 minutes 8.900284e+00 seconds
Subject: 28 28 out of 39
Time elapse: 1 minutes 1.378213e+01 seconds Subject: 24 24 out of 39
Time elapse: 1 minutes 1.347139e+01 seconds Subject: 26 26 out of 39
.
Subject: 21 21 out of 39
.
Subject: 27 27 out of 39
Time elapse: 1 minutes 1.118905e+01 seconds Subject: 23 23 out of 39
Time elapse: 1 minutes 1.171646e+01 seconds Subject: 25 25 out of 39
.
Subject: 29 29 out of 39
.
Subject: 30 30 out of 39
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\ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \
Subject: 32 32 out of 39
Time elapse: 1 minutes 6.688112e+00 seconds Subject: 33 33 out of 39

```
Time elapse: 1 minutes 1.673538e+01 seconds
Subject: 34 | 34 out of 39
Time elapse: 1 minutes 1.113843e+01 seconds
Subject: 35 | 35 out of 39
Time elapse: 1 minutes 8.238326e+00 seconds
Subject: 36 | 36 out of 39
Time elapse: 1 minutes 1.118713e+01 seconds
Subject: 37 | 37 out of 39
Time elapse: 1 minutes 7.368735e+00 seconds
Subject: 38 | 38 out of 39
Time elapse: 1 minutes 1.380606e+01 seconds
Subject: 39 | 39 out of 39
Time elapse: 1 minutes 7.253429e+00 seconds Time elapse: 1 minutes 1.039765e+01 seconds Time elapse: 1 minutes 5.00
3. Computing correlation matrix. Progress:
......
4. Combining spatial and temporal information.
5. Calculating statistics and output data.
6. Finishing function.
```

Once decoding calculations has been computed, results can be found in the variable timeGALoutput both in the workspace and the mat file. We can load it if needed in a different session:

Computation of GAL matrices beloging to 39 subjects finished. Time elapsed: 12 minutes and 2.032540e+01econds

```
% load('resultsTimeGAL_IAPS_ERP.mat')
```

Visualization of results

Finally, once time-GAL has been calculated, we can explore the results by visualizing them. All the important data such as GAL, correlation and time-GAL matrices can be found in the timeGALoutput variable (i.e. the file if it was saved). While visualization can be independently crafted by the user, the time-GAL toolbox provides its own function for easiness and convenience. It contains a few parameters to change statistical alpha thresholds, titles, file saving or resolutions, for example. However, for simplicity, here we only use the function fed with the time-GAL output:

```
visualizationTimeGAL(timeGALoutput)
```

Saving results in: resultsTimeGAL IAPS ERP.mat

TimeGAL: [1×1 struct]
Parameters: [1×1 struct]

timeGALoutput = struct with fields:

GeneralizationMatrix: [1x1 struct]
 CorrelationMatrix: [1x1 struct]

