Biomedical Engineering

ERP Data Analysis Homework

In this report, every step given step by step, and code parts are given under the questions with figures. Additionally, the all of the code is also given in appendices.

1.

The purpose of N400 experiments is to investigate semantic processing. The N400 experiments focus on the modulation of oscillatory neuronal activity recorded in the EEG during the reading of sentences that contain either a semantically incongruent word or that are semantically congruent. The outputs of N400 experiments are a negative-going wave peaking at about 400ms, whose amplitude is larger after presentation of a stimulus, but this amplitude can be affected by a number of factors including word class, semantic relatedness to the context, cloze probability,1 word frequency, presentation modality, and verbal working memory load. In general, a larger amplitude N400 will be found to a word that is not related to the context, has a low cloze probability or a low frequency. [1]

N400 can be also feature source for disease detection. For example, according to NeuRA (Neuroscience Research Australia) Foundation, the feature of N400 wave can be differ from the people with schizophrenia such as a medium to large increase in N400 peak latency and a small to medium-sized decrease in N400 amplitude in congruent conditions but not in incongruent conditions when compared to people without schizophrenia.[2]

2.

After installing fieldtrip to MATLAB, first defined the stimuli 99 and 100 respectively. The trials analyzed and defined by using the function "ft_definetrial". While defining the trials, the trials extracted with a 1 sec of pre-stimulus and 2 sec of post-stimulus period. The all parts of process are applied for 99 and 100 trials separately. The code paths are given for congruent and incongruent sentence in Figure1 and Figure2.

```
restoredefaultpath
addpath C:\Users\Busra\Documents\MATLAB\fieldtrip-20180925
ft_defaults

cfg            = [];
cfg.dataset    = 'ERP_N400.trc';
cfg.headerfile = 'ERP_N400';
cfg.continuous = 'yes';


cfg = [];
cfg.dataset               = 'ERP_N400.trc';
cfg.trialdef.eventtype  = 'MARKER';
cfg.trialdef.eventvalue = {100}; % 100 is cogrent
cfg.trialdef.prestim    = 1; % seconds
cfg.trialdef.poststim   = 2; % seconds
cfg.trialfun            = 'ft_trialfun_general';
cfg                     = ft_definetrial(cfg);
```

Figure1: 100, Congruent

```
restoredefaultpath
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cfg = [];
cfg.dataset               = 'ERP_N400.trc';
cfg.trialdef.eventtype  = 'MARKER';
cfg.trialdef.eventvalue = {99}; % 99 is incogrent
cfg.trialdef.prestim    = 1; % seconds
cfg.trialdef.poststim   = 2; % seconds
cfg.trialfun            = 'ft_trialfun_general';
cfg                     = ft_definetrial(cfg);
```

Figure2: 99, Incongruent

3.

Then with “ft_preprocessing”, preprocessing is performed. During preprocessing, a band-pass filter between 1-10 Hz with a 2nd order Butterworth filter is used and applied demean to data separately. The same code is applied for congruent and incongruent sentence given in Figure3.

```
cfg.continuous          = 'yes';    % data is continuous
cfg.channel             = 'Fz';
cfg.bpfilter            = 'yes';    % we do apply a band-pass filter
cfg.bpfreq              = [1 10];   % bandpass frequency is 1-10
cfg.bpfilttype          ='but';     % filter type
cfg.bpfiltord           =2;         % order of filter
cfg.demean              = 'yes';    % demean (baseline correct) ...
cfg.detrend             = 'no';     % do not detrend
data                    = ft_preprocessing(cfg);
```

Figure3: Preprocessing

4.

Then, taking average process is run by using the “ft_timelockanalysis” and while averaging the data, the mean from all data is removed. The same code is applied for congruent and incongruent sentence given in Figure4 and Figure5.

```
cfg                 = [];
cfg.trials          ='all';
cfg.removemean      ='yes';
cfg.keeptrials      ='no';
cfg.channel         = 'Fz';
ERP_cogrent         = ft_timelockanalysis(cfg, data);
```

Figure4: Timelock Analysis for congruent

```
cfg                 = [];
cfg.trials          ='all';
cfg.removemean      ='yes';
cfg.keeptrials      ='no';
cfg.channel         = 'Fz';
ERP_incogrent       = ft_timelockanalysis(cfg, data);
```

Figure5: Timelock analysis for incongruent

5.

After timelock analysis, baseline correction is performed by using the function “ft_timelockbaseline”. Signal baseline is adjusted. The same code is applied for congruent and incongruent sentence given in Figure6 and Figure7.

```
cfg=[];
cfg.baseline        = [0 1];
cfg.channel         = 'Fz';
ERP_cogrent         = ft_timelockbaseline(cfg, ERP_cogrent);
```

Figure6: Timelock Baseline Analysis for congruent

```
cfg                 =[];
cfg.baseline        = [0 -0.3];
cfg.channel         = 'Fz';
ERP_incogrent       = ft_timelockbaseline(cfg, ERP_incogrent);
```

Figure7: Timelock Baseline Analysis for incongruent

6.
Finally, both conditions (congruent & incongruent) are plotted by using “ft_singleplotER”. x and y axis labels, legends and title are added. The code is given in Figure8 and the output of code is also given Figure 9.

```
%% plot
cfg                  = [];
cfg.xlim             = [0 1];
cfg.ylim             = [-7 6];
cfg.channel          = 'Fz';
cfg.fontsize         = 10;
cfg.linewidth        = 3;
cfg.graphcolor       = 'brgkywrgbkywrgbkywrgbkyw';
cfg.layout           = 'natmeg_customized_eeg1005.lay';

figure
ft_singleplotER(cfg, ERP_incogrent,ERP_cogrent);
title ('N400 experiment ERPs');
xlabel('time (sec)');
ylabel('Amplitudeo (mV)');
legend('Incogrent ERP','Cogrent ERP');
```

Figure8: SingleplotER

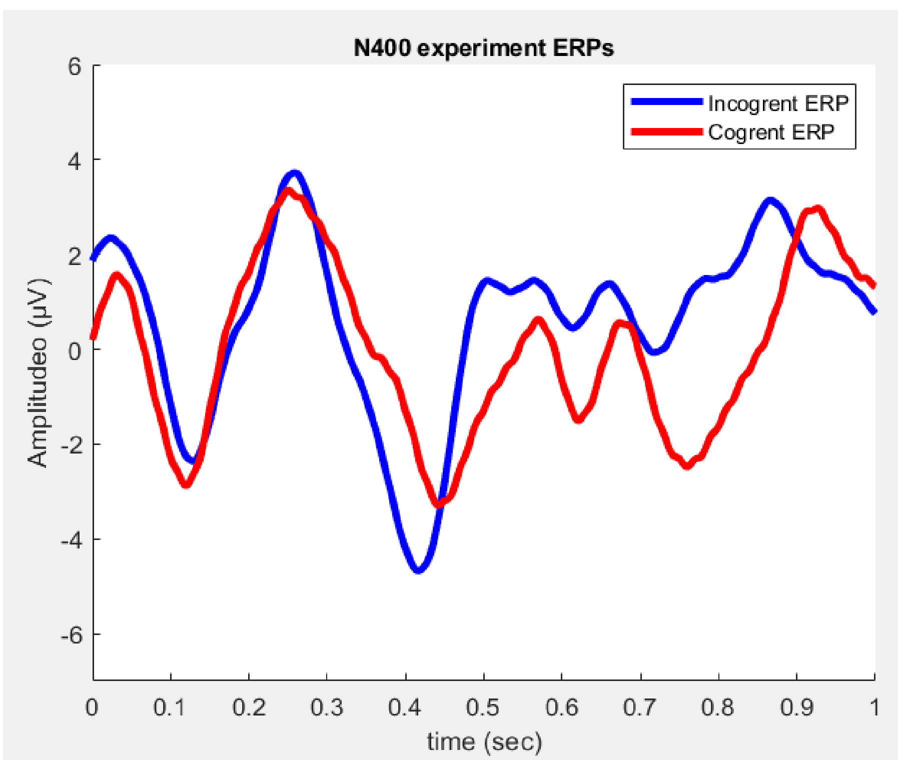

Figure9: ERPs Plot for 1 second

7.
The results;

- In incongruent ERP, we can see the more negative peak around 400ms than congruent peak as expected. The peak formed after 400 milliseconds after the last word of the sentence is seen.
- The peak value of congruent is also negative in this graphics, this error may be caused by wrong baseline analysis made during processing, but the amplitude difference between peaks is approximately 4µV. Nevertheless, difference can be noticed.
- Incongruent signal may have been affected by trouble focusing because of the distraction of outside sounds, mental state being in a place first time (unfamiliar environment), claustrophobia due to being in a dark and enclosed space. These may be the reason for the peak seen little after from 400 milliseconds. Because, the frontal lobe(Fz) is responsible for express language (Broca's Aphasia), flexibility in thinking and persistence of a single idea (Perseveration), focusing on a task (Attention), mood fluctuations (Emotional lability).
- In addition, the signal can be change with word frequency, verbal working memory, and feelings about the word demonstrated on computer.
- Furthermore, we can see P200 the positive peak around 200ms for both signal because of attention, language, and memory related process happened during experiment.
- The 2 peaks occurred around 600ms and 700ms, remembering the other words and thinking whole sentence in brain may be the reason of these peaks.

References

[1] Hald, L. A., Bastiaansen, M. C., & Hagoort, P. (2006). EEG theta and gamma responses to semantic violations in online sentence processing. *Brain and language*, *96*(1), 90-105.

[2] NeuRA (Neuroscience Research Australia) Foundation, October 2020, N400, 11/21/2021, [https://library.neura.edu.au/schizophrenia/physical-features/functional-changes/electrophysiology/n400/]

Appendices

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title ('N400 experiment ERPs');
xlabel('time (sec)');
ylabel('Amplitudeo (µV)');
legend('Incogrent ERP','Cogrent ERP');
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