Laboratory Exercise 2.1

Multi-channel EEG: Recording EEG

1. Introduction

This laboratory exercise intends to:

1. Familiarize you with a multichannel EEG recording amplifier setup.
2. Introduce you to preparation of a subject for an EEG recording session.
3. Practically show you the behaviour of ongoing EEG and various noise sources in temporal, special and frequency domains.
4. Familiarize you with EEGLAB opensource EEG analysis software

2. Hardware and software required

Amplifier setup	g.HIamp	
Electrodes	g.SCARABEO active electrodes	
	Active electrode connector box	
	g.GAMMAcap electrode cap	
	Conductive gel	
Data recording	Computer Lab streaming layer (LSL) gNEEDaccess MATLAB	
Data analysis	MATLAB, EEGLAB	https://sccn.ucsd.edu/eeglab/index.php

3. EEG recording amplifier

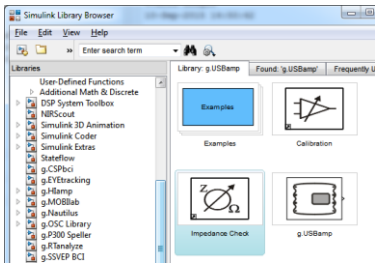
The amplifier used is g.HIamp produced by an Austrian company g.tec medical engineering GmbH. Together with, we will be using an EEG cap fixed with g.SCARABEO active electrodes. Unlike passive electrodes, these active electrodes, pre-amplify the EEG in-situ and transmit to the main amplifier (g.HIamp). Therefore, less susceptible to noise resulting in a high signal to noise ratio. The active electrodes are placed on a head cap g.GAMMAcap according to the 10-20 system.

The digitised data from the main amplifier are read through a pipeline of opensource software.

4. Subject preparation with the electrode setup

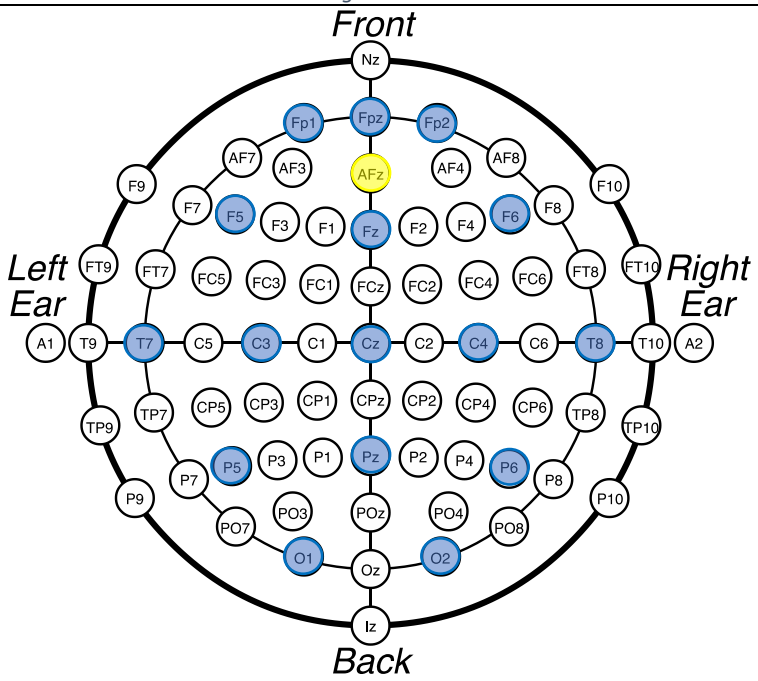
a. Place the electrodes on the cap according to the Table 1. The topological map of the same is also shown there. *Observe the example demonstrated by the instructor before tying yourself.*
b. Connect the other end of the electrode leads to the active electrode box.
c. Connect the active electrode box → g.HIamp amplifier → computer.
d. Wear the cap with electrodes on the head and firmly tighten using the strap under the chin.
e. Fill each electrode with conductive gel using the provided syringe. Fill the 'ground (AFz) and the impedance (Z1) electrodes first. This will enable measuring inter-electrode impedances described in the next section.

Inter-electrode impedance measurement



f. Open the MATLAB Simulink and run the g.tec 'Impedance Check' block.
g. At the electrode box, fix the 'Z1' electrode to channel one and the channel 1 electrode to any other slot (e.g. 20). *This is temporary.*
h. Apply electrode gel into each of the electrode from the given syringe until indicators turn green.
i. Reconnect channel 1 electrode to the original port.

Table 1 - Electrode montage

1	Fp1	
2	Fpz	
3	Fp2	
4	F5	
5	Fz	
6	F6	
7	T7	
8	C3	
9	Cz	
10	C4	
11	T8	
12	P5	
13	Pz	
14	P6	
15	O1	
16	O2	
GND	AFz	Common Ground
Z1	Any location	For impedance measurements

5. Real-time observation of EEG

a. Capture the data stream sent by the g.HIamp from a local area network (LAN) defined by Lab Streaming Layer (LSL) in the computer.
b. Displayed it on MATLAB using `vis_stream.m`

Referencing

c. Observe how the average referencing affect the EEG signal.

Check the validity of EEG data

d. Ask the subject to relax and close eyes → you should see rhythmic alpha activity appear
e. Ask the subject to open eyes → you should see rhythmic alpha activity suppress
f. Ask the subject to blink → you should see spikes on the channels connected to the anterior reign of the head

6. Connecting the keyboard for event markers

To add markers to events (so that you can later analyse EEG knowing time intervals related to particular events like eye movement etc. see Figure 1 for a visualisation), we use keyboard inputs. Similar to the g.HIamp, the keyboard will also be connected to the LSL so that we get a time stamped keyboard inputs which can be recorded together with EEG.

a. Link the keyboard by running the latest version of the 'Windows keyboard' app downloaded from ftp://sccn.ucsd.edu/pub/software/LSL/Apps/
b. Run latest version of the 'LabRecorder' app downloaded from the above link. You should see both the g.HIamp and the keyboard listed here, if they are properly connected.
c. Now you're ready to record data in .xdf format (extended data format https://github.com/sccn/xdf/wiki/Specifications).

7. Experiment

The basic idea of the experiment is to collect a continuous EEG recording while changing the brain state and introducing artifacts (purposefully) at specific time point (Figure 1). The data can be analysed offline (Event keys are defined in Table 2). You have to instruct the subject to perform each of the event tasks at specific time points. Press the event key on the keyboard just before instructing. The durations given here are approximates (you anyway will be able to identify the time segment from the keyboard input during offline analysis).

Table 2 - Definitions of events

Event key	Event description	Event short-name
A	Eyes closed	i_close
B	Eyes open	i_open
C	Blink (close and open)	blinks
D	Eyeball movement left-right (eyes open)	i_LR
E	Eyeball movement up-down (eyes open)	i_UD
F	Teeth clenching	teeth
G	Head movement (random)	Head
H	Noise source ON	noise_ON
I	Noise source OFF	noise_OFF

Table 3 - Sequence of events

Event key	Duration (s)	Description
-	10	Relaxed and eyes open (default)
A	5	
B	5	
A	5	
B	5	
-	5	Relaxed and eyes open (default)
C		
C		
C		
D		Center-left-right-center
-	5	Relaxed and eyes open (default)
E		Center-up-down-center
-	5	Relaxed and eyes open (default)
F	2	
-	5	Relaxed and eyes open (default)
F	2	
-	5	Relaxed and eyes open (default)
F, C	5	Together
-	5	Relaxed and eyes open (default)
G	5	
-	10	Relaxed and eyes open (default)
H	5	Near the right temporal lobe
H, C	5	
I	5	
H	5	Near the left temporal lobe
H, C	5	
I	5	

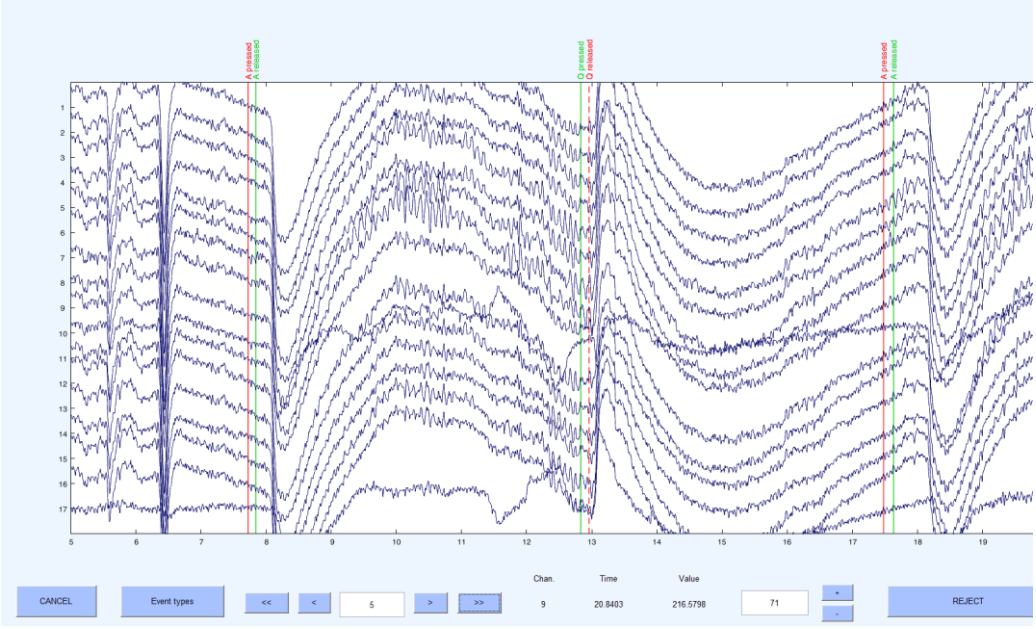


Figure 1 - Visualisation of the EEG stream with event markers

8. Cleaning and storing the equipment

Proper cleaning and storing of the equipment used for this practical very important since, it involves electrode/electrolytes. If kept for prolonged periods, oxidation will degrade the performance in the future experiments. Following is the procedure to clean the electrodes and the cap:

a. Switch off the power of the g.HIamp and remove the electrode box from it.
b. The cap should be washed with the electrodes. But do NOT wet the electrode box.
c. Use a regular shampoo mixed in lukewarm water to wash the cap.
d. Use the provided brush to remove gel within the electrode hole.
e. Wash the whole cap with renewed water until all the gel is removed.
f. Let it dry inside the lab.

The subject should wipe off the remaining gel from the head. It is advised to have a head shower immediately to avoid any skin irritations.