Neural Science for Engineers
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Lecture - 52
Introduction and Applications of Event Related Potentials

Hello everyone. Welcome to the course Neural Science for Engineers. I am Rathin Joshi, a PhD scholar from BEES lab, Electronic System Engineering Department, Indian Institute of Science. Also, I am the TA of the course.

In today's couple of short modules, we will be discussing about some of the recent trends in Neural Engineering. We will be mainly focusing on computational part and how to understand and interpret the biopotentials acquired at a different level of brain.

Like as you all know there is something called EEG Electroencephalography, which is nothing, but electrical discharge generates from your brain. It is recorded from your scalp. Now, there are different types of electrodes which record this kind of biopotentials from your scalp. If it is on the hair, you might use certain set of electrodes known as spike electrodes because it should go through your hair to record the activity.

If it is on your forehead, you can use other type of electrode. If you are using some gel that is called wet electrode, if you are not using gel that is called dry electrode; both the things have their own pros and cons. So, there are different methods to record EEG basically.

We will try to learn and extract the information out of EEG. Each and every biopotential gives some or the other form of information. Like you know in some movies you would have seen ECG. So, that you know is kind of line will go through.

So, that is the ECG, and that gives you the information regarding the state of functionality of your heart. Whereas EEG reflects your brain activity also, if you give a certain set of events or stimuli and your brain reacts to that. That will give you an idea regarding your sensory system.

Also, we will have a look at a disorder called epilepsy. How using EEG signal we can interpret the information regarding the state of epilepsy. Whether it is spread across the brain or it is localized to one particular area.

All these things we will try to cover in this short module. This is the last week of the course. So, I will not go into detail about that, but the agenda of the class is to get you people to that level that from which you can explore by your own and try to get things done.

So, we will start the first module of the recent trends in Neural Engineering which is known as ERP analysis. Now ERP analysis is event related potential analysis. So, before moving ahead, how we can extract ERP and how we can use mathematical operations to get the thing done? First, we will quickly see what ERP is.

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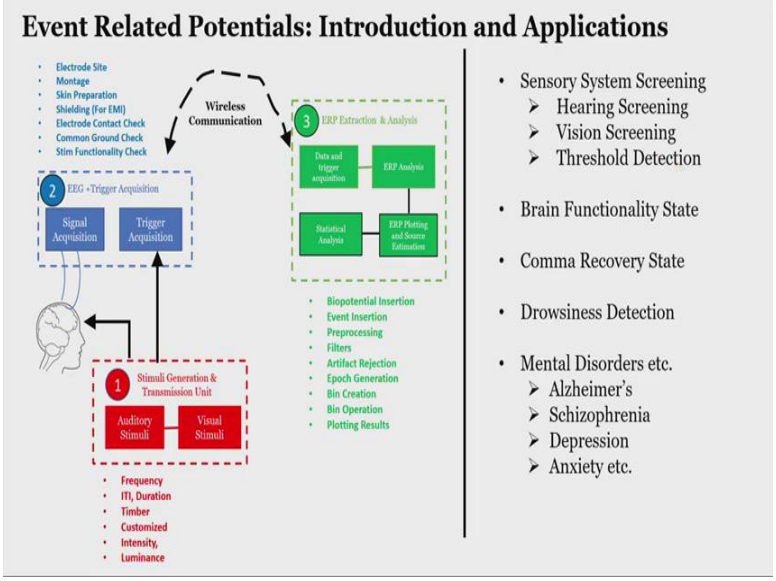

So, let us see that, it is a basic introduction. It looks like a heavy block diagram, but it is very simple, we will start from number one which states a stimuli generation and transmission unit. Now this is basically to check the sensory pathway integrity.

So, which are the sensory pathways we have? We have auditory system, we have visual system, there is something called somato sensory pathways which is nothing but touch, we have smell as well, but here we will focus on auditory and visual stimuli.

So, first thing is, you will design a certain space, specific auditory and visual stimuli which will help you to assess the condition of your system. Now, the thing is, your brain reacts to any kind of event in general as well. Human being reacts to certain things whereas, in terms of neuro physiological way as well, whenever some events happen your brain reacts to that. And it has a certain set of randomness. Not every time your brain reacts exactly the same way.

Additionally, these brain waves are very sensitive, it is of micro-volt range. So, even a certain artifact or even suppose power line interference or if something like your electrodes have been placed near to your heart, you will get ECG artifact.

So, many things you will be facing. So, the moral of the story is that these brain waves which generates as a reaction to certain event is random and considering the fact, we are you know generating a stimuli multiple amounts of time.

So, further we can average it out and we can get an actual response which is neural. It is very important to identify which is the neural response and which is the non neural response. And to make a neural sense out of recorded biopotential or if I am talking about neural to make a neural sense about recorded EEG or ECoG. Preprocessing plays a vital role.

Also, it depends on what are the frequencies you are capturing, there is certain range above which you will say that this cannot be neural, at this level this is out of range. So, that is something called artifact rejection. So, what is your threshold for artifact rejection, all these parameters matter when you preprocess it. So, preprocessing plays a vital role when you are removing a non neural part out of recorded biopotential.

So, this is basically a stimuli generation unit as I mentioned, and several things are important in that. If you are using auditory stimuli, it depends which frequency you are using, also the type of stimuli. Now there is something called tone, there is something called click that when you press a mouse right you will hear the sound of mouse click.

Similarly, there is something called tone, there is something called chop. So, all these different time type of sounds generate a different effect on your brain. So, it is important to identify that exactly which frequency you are going to give as a stimuli. Also, there are some potential which generates due to the change of frequency or let us say change

of time. So, that also is important that how many events you are using, and those events are having which kind of parameter?

One of them is frequency other is called ITI, ITI is Inter Trial Interval. Now, it is important that whenever you are recording, next sound as I mentioned we are going to consider multiple epox. So, ta ta ta ta ta ta ta ta ta it will keep on coming, in between ta and ta what is the time gap. So, that is nothing, but your inter trial interval. One more thing is when we are giving this sound, this sound will be on for certain set of time, mostly in terms of few milliseconds then there will be a gap.

So, if you are aware of the basics of electronics, that is nothing but on time and off time of particular wave of your pulse. So, how much duration you want that signal to be on. So, that also matters. Also there is a timber. So, timber is, if you are a music lover or if you know a few things, the G sharp of guitar sounds different than G sharp of keyboard, both are G sharps both are same frequency, but it sounds different.

So, that timber factor is there. Another thing is you can customize. How this customized stimuli matters? Suppose a person is in coma or suffering from mental disorder, that person is more responsive to a sound from their loved ones. Like if some patient is there if you give them a sound of normal tones, they might respond, might not respond as well. It depends on the state of his mental neuro physiological behavior or neuro physiological system.

But the thing is if someone is in coma there is something called coma recovery. What are the chances he will recover from coma depends on if you give them a customized stimuli, if you ask her loved ones her spouse, her parents to record and give a particular auditory stimuli, there are high chances and research has shown that there are high chances that a person can come out of that particular state easily.

So, this customization also matters. Again, when I talk about visual stimuli the intensity of light or intensity of a particular image, all these things matter. Also, the luminance. There are some potentials which will be generated due to the change of images at same luminance. Now, which are the kind of images, there can be checkerboard, there can be inverted checkerboard, there can be blue ball, big blue ball, red balls so many things are there.

Human brain is very responsive to the red color. So, generally people avoid using red color because it generates so many other things as well. So, first and foremost the basic step you should know is, how you are generating a stimuli and you are presenting it is to human brain.

Now again this is a cartoon what you can see here, of a human brain and as I have talked about EEG signal analysis, I am taking recordings from scalp. Now, generally it is not required that you take recording only from two electrodes. This is just an illustration to give you an idea that these are the places electrodes have been placed to acquire the bio potential EEG.

Also in the previous module, Professor Pandya has discussed that there is a 10-20 system. So, which will completely from your nasan to enian and your right ear to left ear, they will divide your entire scalp into different position which is known as 10-20 system.

So, it will give you an idea that how to name or how to address. Considering that if this is on midline, we can say that this is fz and cz, just to give you an idea so you can brush up the last topic what I have discussed. So, this is the signal acquisition. First thing is the stimuli generation. Also, stimuli communication or stimuli transmission is as important as stimuli generation. Now, what is stimuli transmission?

So, when I am presenting a particular set of stimuli that particular stimuli should reach to my acquisition system as well. Because you have seen a particular image, you have heard a particular sound, but exactly at what time it happened? So, the timing information is very crucial because based on that, based on the onset of your event you are analyzing the further data you are checking how your brain has reacted, etcetera.

So, this stimuli transmission is important, it should go to your acquisition system. I will come to acquisition system later, but first thing is stimuli generation is to generate a stimuli. Stimuli transmission is to communicate or transmit the timing information from your stimuli generation unit to your acquisition device.

So, flow wise this red color block is basically stimuli transmission unit which will be presented to a human being. From human being electrodes would be placed and bio potential is acquired. Now, this electrode can be placed on scalp. First and foremost the most primary diagnostic method is your EEG.

Secondly, EEG is very frequently used to assess the brain because it is a real time signature, not 100 percent real time, but it is an acceptable range. And it has an excellent temporal resolution. There are two types of resolution, very important to assess the brain, ephemera is already discussed as a part of course, that using dicom you can see the ephemera and all these thing which offers excellent spatial resolution, whereas EEG offers excellent temporal resolution.

So, if you have some vision issue or some cognitive decline something, EEG might be useful, it will tell you how fast your reflexes are, or which pathway has some issue. Also, in particular pathway, suppose I talk about auditory pathway from my outer ear to auditory cortex is the entire auditory pathway. So, like from going from place one to place two, Bangalore to Hyderabad, there are different milestones.

Same as from outer ear to auditory cortex there are different milestones. So, that different milestones have their own pattern signatures. So, when you give a particular specifically designed auditor stimuli all these things should be present to tell you that entire pathway is working fine. Same goes for visual pathway as well, same goes for somatosensory nervous system, somatosensory system as well.

So, the thing what I was discussing is that EEG as recorded from your scalp, it is a noninvasive way, offers excellent temporal resolution. If you want to go further there is a limitation with EEG that it has a limited spatial resolution because when you record from the scalp that potential is because there are so many underlying sources within.

So, you do not know exactly from where this thing is happening, if you want to do that you can do of course, fMRI, but for that you should know exactly which brain region you are interested in. Secondly you can also open the skull and try to go inside, that will increase your spatial resolution. It will give you more information.

But everything comes at the cost of opening your skull which requires a neurosurgeon, high risk of damaging things as well as the high risk of tissue damage. Also, you will be anesthetized so there will be an effect of anesthesia as well in your recording. So, first of all this is like signal acquisition. Now signal acquisition is basically recording your bio potentials EEG, ECG, etcetera.

In this case for when I talk about brain its ECG, EEG or ECoG or SEEG. SEEG is something called Stereo EEG. We will go into detail later, but a this is basically your acquisition. Now, acquisition like stimuli generation depends on several factors.

One of them is the most important thing, is where you are recording. You cannot put electrode all over your head to measure something. Yes, if you do not know the source initially for first, time that is ok otherwise you cannot put your electrode all over the skull. So, electrode site is important. Also, when you are recording apart from your active electrode.

Now, what is active electrode or what is main electrode? That is when you place your electrode over your skull to record the activity, but ultimately all this acquisition unit is electronically made off instrumentation amplifier, which requires two inputs. So, one of them is active electrode or active input and reference. So, you need to put somewhere reference also, you need to put somewhere ground also.

So, this reference and ground are very important. It should be placed generally far away from your active side. Now when I say far away, it is not like that I will put my active electrode here and I will put my ground electrode five feet away. It will be there on my body only, but either it will be on my mastoid this called mastoid, or I will put it somewhere in my forehead or something little bit different from your electrodes placed here.

So, this is basically the montage, also skin preparation. Now, skin preparation comes into a picture for a wet electrode. So, there are some of the electrodes, earlier days people were using wet electrode which will be used with some adhesive gel. So, then what will happen is, electrode will be placed, some gel will be put all over, whenever electrodes are there and then you record.

But nowadays people have opted for dry electrode to reduce skin preparation time and there are adequate conductive dry electrode available. So, you do not have to do scalp skin preparation and go through this thing. Another main thing is shielding. So, when you are recording, wires and all will go through from your head to acquisition system.

Now, anywhere even if a small unshielded part is there, that can act as an antenna that will be susceptible to all the noise nearby. Why this is susceptible? Generally, also we

have so many wires around, then nothing happens, and everything works fine, because generally whatever the system they have the certain magnitude. This brain wave and EEG are very low magnitude in microvolts, so susceptible to all the kinds of noise. Very sensitive.

So, it is very important that your shielding would be very proper if you want to go ahead. Also, electrode contact check. So, this thing is like when electrode is placed even if you move. Suppose your electrode are placed here even if you blink your eye or move your eye that electrode can capture that movement or that electrode response accordingly.

So, the main thing is that it is very important to place your electrode properly and make sure it is conductive throughout the study. Generally, in many of the EEG studies and all a patient is advised to just lie or even sleep and without any kind of movement. Because even a smallest movement will get captured, it will disturb the entire acquisition set up and you might not get the neural response which you want to get.

So, electrode contact check is very important. Nowadays, in most of the acquisition system there are like in traffic signal you have three lights red, green and orange same thing is there in terms of electrode contact check as well. What they do is simple they will measure the impedance.

If that impedance goes above certain level which means your conductivity reduced and at that time, they will turn the light from green to orange or orange to red. If you have a green light throughout the recording, it means your device works perfectly fine or your acquisition at least works perfectly fine.

So, it is very important to check all these electrode contact checks. Also, common ground, it's one of the basic things for any electronic system design not only EEG or something and stream functionality check. Stream functionality check is nothing but jitter or when exactly it should come, it should come.

You have suppose ITI, I told you ITI Inter Trial Interval, 600 milli second or anything. So, if it is 600 milliseconds. When first event comes at zeroth millisecond next should come at 600 milliseconds not at 620, not at 580. I just gave you one example of 20 millisecond jitter on both sides. It should come exactly where you want it to come.

So, considering that fact the stimuli functionality check is very important. Once all these biopotentials and triggers have been recorded, it is important to transmit to a certain computational system where you can play with the data and make all sense out of it.

Generating stimuli and getting the data, as well as trigger is important, but making sense out of it is equally important. Why? Because what you are going to do? First you will get some file, you import it into x y z software. Generally, people use MATLAB as a computational software.

You import the data into MATLAB, you try to figure out what are the data, what are the triggers, how many electrodes were there corresponding to that what particular data correspond to what electrode. Then you take the data, you take the data then you do all sorts of processing on that.

First thing is biopotential insertion, event insertion. So, basically this, biopotential is signal acquisition, event is this trigger acquisition. Further you preprocess it, you check whether it looks how it looks and you might not be able to make the sense out of it because it is raw data, you have to filter it out. Now, for filtering for human noninvasive way of recording that is EEG. For scalp recorded EEG, frequency range is defined or range of interest. If you record it from your scalp, you can take from one to thirty or something. Unless and until you are doing some specific application, experimentation, like you are inducing gamma waves and all.

So, human brain waves have been classified into different frequency range beta, theta, alpha, gamma. And when you go to sleep this range will kind of shift from one set of range to another set of range. Basically, it shifts from high frequency to low frequency. When you are in deep sleep it will be having lower frequency.

So, similar thing, like these filters and all are very important. Now for this kind of ERP experimentation visual or auditory what we will see is whether you are attentive, you are not sleeping in that time.

So, what happens is for awake human scalp recorded EEG, there are some ranges defined. Generally, what we take is from 1 to 30 or 3 to 30, 0.5 to 30 based on your hertz. And additionally, we will also check for the notch filter like you have a powerline interference or not.

All these things will see in the next module when we will be discussing about the ERP extraction, very important topic. We will go through all these things, also artifact rejection as I mentioned that if your value goes out of certain range which you define as threshold you can identify this, you can reject that particular epoch.

Now, what is epoch? Epoch means when one particular sound is given, you are recording little bit after that, like you have as I mentioned ITI 600 millisecond, you are interested in one sound that comes from zeroth second or let us let us say -100 second to 500 milliseconds.

So, if you want to record that, that is your one epoch. If you are repeating the same sound 100 times to identify how the response is, you are having 100 epochs. Then you go through artifact rejection, there some epochs will get removed. If that epoch will get removed, you will have a limited number, out of 100 let us say 78 is there, 22 epochs are removed.

Then you have to further consider that 78 electrodes because those epochs lie in the range of neural potential. We will see everything in detail, I will show it to you. Also, if there are multiple types of sound, you can create different bins. This is for one sound, these all are the epoch which is stored in that bin.

For other sound, these all are the epoch which is stored in that bin. Like that you can create different bins and then you can do the operation. You can check the difference between different bins behavior, like bin 1 this sound this is the behavior, bin 2 this sound this is the behavior, bin 3 this sound this is the behavior. You can check the difference between average value, you will get an idea in response to which particular event your brain has reacted more or less, vice versa.

So, all these things you can do. Final thing is to plot the result. And further if you want you can do source estimation. If you have multiple electrodes you can try to do imaging or imaging basically are used for fMRI, but what I say is you can try to check how underlying source are there. You can check all sorts of thing.

So, this is basically the overall flow, transmission happens using wireless communication protocol; that is why it limits the range of frequency or your sampling frequency because

all these things are of responses belonging in milliseconds range you know from 0 to 200 millisecond, 0 to 300 millisecond.

And there are some responses which are very fast, within first 10 millisecond you need to acquire that. So, when sound comes that is something called Auditory Brainstem Response, ABR, in first 10 milli second you have to capture that. If you miss that gone. So, that first 10 milli second is very important. During the 10 milli second you should at least have 100 samples which says that your sampling frequency should be at least 10 kilo hertz or something.

So, it is kind of very nice and that is why I said it is a kind of recent advances and all. It is very important that you are transmitting your data at adequate rate. Now there are two ways to transmit; one is wireless, one is with wire. With wire increase circuitry and complexity wireless decrease that, but wireless come at the cost of reduce sampling frequency or reduce communication of frequency.

So, this thing you can clearly identify based on your application, what do you want to record and what should be your sampling frequency, at which rate you are going to transmit the data?

Again, there are a lot of things like whether you are transferring serially, parallelly, wirelessly which protocol you are using whether you are using Wi-Fi whether you are using Bluetooth low energy module, these things come in the picture.

But there exist systems which are doing this and commercially available slightly not affordable, but there are systems available at like, somewhere around 1 lakh for 16 channel you can record or 15000 rupees for this 8-channel system from open BCI.

So, we will quickly see the applications of all this ERP related experimentation. Where it can be useful? So, mostly I have covered most of the thing. First thing is it might be useful in sensory systems screening. So, here you can see that is a hearing screening basically your check your auditory pathway, vision screening also threshold detection. What is threshold detection? I am saying something, and you are able to listen to that.

Now, if I say something, you might be able to listen to that. If I say now, you might not listen. So, the volume or you know intensity of the thing what I am speaking. Same way

you can give different amount of audios and we need to check whether you are able to listen a hear to that or not.

So, that is basically your hearing screening or and threshold identification. Now, for deaf people or who are hearing impaired, they might not be able to hear the sound which you can easily hear, but they also have their own set of thresholds. So, threshold detection. Also, when you are going through some treatment or medical therapy related to your sensory system or related to your auditory system, they will keep on checking threshold detection whether it is increasing or not.

So, this is basically like for sensory systems can you get? Also includes somatosensory as well. Also, it checks your peripheral nervous system when like it will stimulate your brain and check that. Stimulate a particular area of your brain and check a particular limb, whether your right leg, left leg, right hand, left hand moves or not.

So, there are areas identified in the brain, but for that you have to do the brain surgery. Areas identified in the brain when you try to stimulate or give a current pulse to a particular area it will move a certain limb, or it will move a certain leg or hand of yours.

So, it will check two things, it will also check your somatosensory system, also your peripheral nervous system works fine or not. Also, there is something called brain functionality test whether you are giving a certain set of audiovisual stimuli you can check get an all over idea of your brain at different level, cortex level, prior to cortex, all this thing you can check.

One another application is a coma recovery state like certain people are there in coma like out of 20, 30, 50 people which 5 or 10 have high chances of coming out of that state. Now why it is important? Because if a person is brain dead or in coma, there is some expenditure you need to spend daily.

So, we all believe in optimal stuff that it might get recovered, but the thing is some point of time you might not be sure till what point of time you need to keep spending on that particular patient.

So, out of a 100 or out of 1000 patients, which 100 or which 10, which or some first 10, 20 person have high chances of coming out of that set. You can identify by using

different ERP experiments. As I mentioned you can customize your stimuli for those patients and try to screen them at least. That out of this 1000 if you want to focus, focus on first this 10 or 100.

Further is drowsiness detection, it is very important when it comes to driving safety or even flying, pilots and all this thing. They or even most of the drivers, they drive in odd hours, we are not sure whether they are completely attentive or not. So, this thing you can identify using some ERPs, that is event related potentials, which can measure the attention. So, how attentive a particular person is before driving or flying. It can save many mishaps if we can actually detect this thing. Also, some of you in metro cities would have seen that breathalyzers are there.

Police check whether you are too much affected by alcohol or not. So, this similar thing you can check with the ERP experimentation as well. Further there are some more mental disorders situations known as Alzheimer, which is like a kind of a memory loss, schizophrenia, person will become too much angry. Now, there is something called gaming EEG. I mentioned that visual stimuli is there. So, gaming EEG means a particular game is being designed to and it will be given to a patient to play.

Now, a schizophrenic patient will get angry easily and have more amount of anger than normal or control patients. If you make a certain set of one player game where a player moves and try to like if you I am not sure if you have played Contra or Mario, it will give you an idea that you know if a certain player moves, schizophrenic patient might hit or try to kill that particular enemy more times, try to press the key at with higher.

So, considering measuring the pressure on the key button push button and see how much time or how enemy is killing. You can also get an identification about schizophrenic patient. You can measure it or screen for that. Depression, anxiety a lot has been spoken in the recent past due to COVID about mental health. So, all these situations can be screen identified using recording ERPs and EEG you can make sense out of it, whether a person is actually improved or is just pretending to be you know it has improved from a particular certain stage.

Also, for a some of the other application lie detection and you know several things it can be useful. Hearing screening there are some other odd advantages as well, like in some of the states government gives some discount or relaxation to the people who have hearing

impairment. So, we can identify that if a person is actually hearing impaired or he is pretending to be that. So, all these things you can identify and these are the applications of event related potential.

So, how we can measure this event related potential? I told you these are the basic building blocks, but how we realize that? So, these are the basic building blocks, how we can realize this thing is simple, by conducting an experiment, how to do an experiment?

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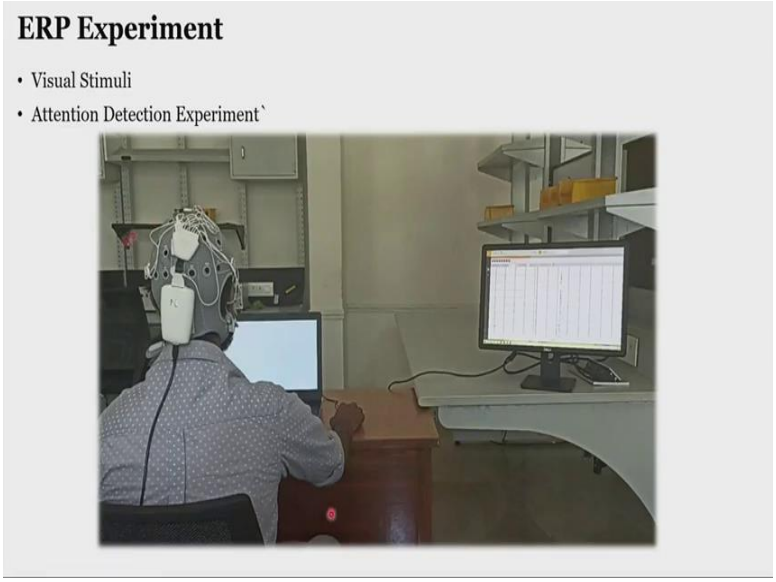

So, in the next video we will see one experiment you can see this is a setup for ERP experiment. So, here the subject is wearing an electrode cape and electrodes are here. This system which you can see here in which stimuli is being presented and here his potentials have been recorded.

Once these potentials are recorded for a experiment, you can process it and make sense out of it. This experiment is using visual stimuli, attention detection. There will be three types of events or images will be coming big blue ball, small blue ball and checkerboard.

And a person is asked to click whenever big ball comes. So, this is basically an experiment. I will quickly show you the video. So, you will get an idea of what exactly the experiment is and further we will discuss about how we can extract this data, how we can make sense out of it. So, I will just show you this experiment like a glimpse of experiment a part of experiment which is being happening.

A subject is wearing a innovio head cap consist of eight electrode, reference electrode and ground electrode. Reference and ground electrode can be seen on the right earlobe. Prior to attaching the reference and ground electrode on the earlobe subject was applied with a gel to improve the conductivity. On the visual presentation system, you can see three different types of event triggers are the small blue ball, big blue ball and checkerboard which will ultimately work as a standard target and distracter.

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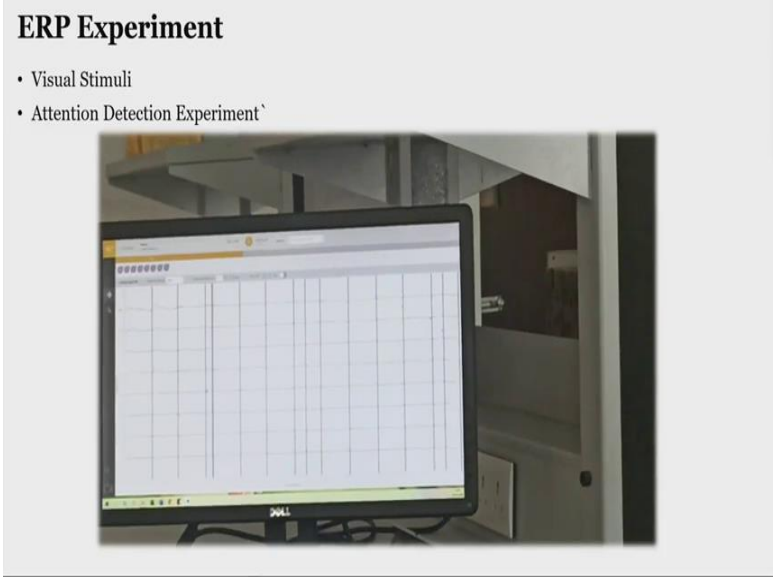

Simultaneously, biopotential from all eight electrodes are recorded along with trigger. Subject is asked to click whenever target stimuli comes. And all these events as well as biopotentials are recorded as an EDF file which will be further used to process P 300 event related potential.

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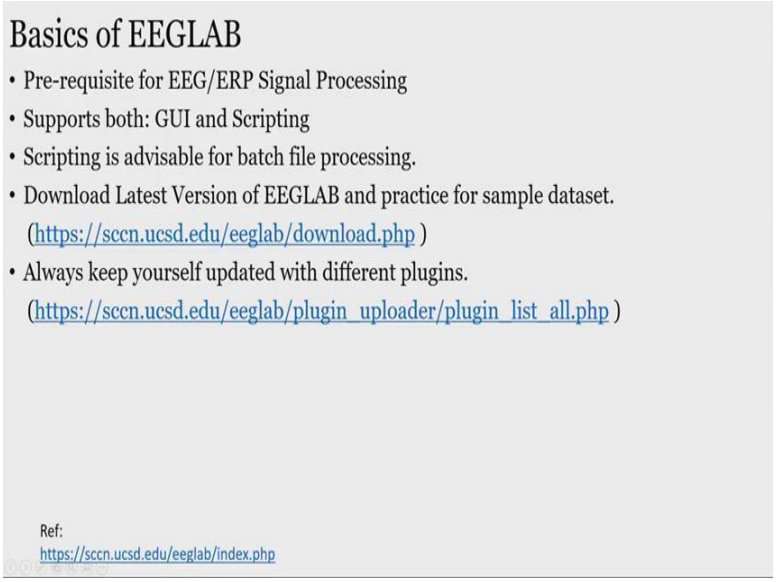

So, you have seen the experimentation being performed. Before showing you how to extract the data, it is important to know the software or the package using which we can play with the EEG data. That is known as EEG lab. It is developed by Swartz center for computational neuroscience, it has an excellent set of plugins using which you can interpret the data in one or the other way.

Like for event related potential there is something called ERP lab, EEP lab is a potential laboratory that is a plugin to EEG lab. So, I will show it to you the EEG lab how it works and all this thing. So, basically to conduct an ERP lab experiment and get the sense out of the data you should know how EEG lab and ERP lab works.

Also, it supports both graphical user interface and scripting, we will see that. Scripting is advisable for batch file processing when you have 100 patients' data, you will not use graphical user interface 100 times.

And you know go through it instead make a script, before lunch you make a script, run the script, by the time you come back from lunch all your data will be processed and your results would be saved. It sounds very nice and funny, but yeah it takes time, but it is a very good thing if you learn scripting and GUI both.

Because when you are doing some form of research or when you are not sure about your parameters of filtering, artifact rejection, etcetera. It is important that you use GUI and

set up one protocol or set up one extraction protocol I should say and then try to generate a script and do the batch file processing, it is important.

So, latest version would be available here and different plugins, these both things I will show it to you.

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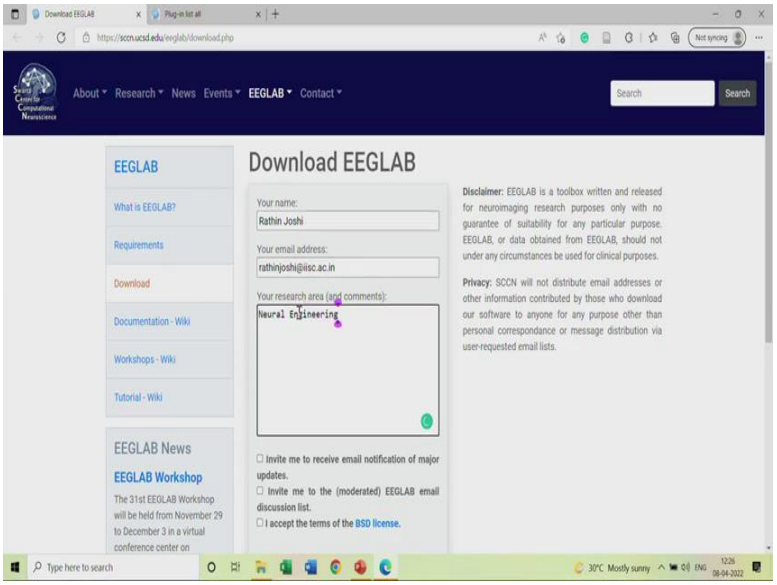

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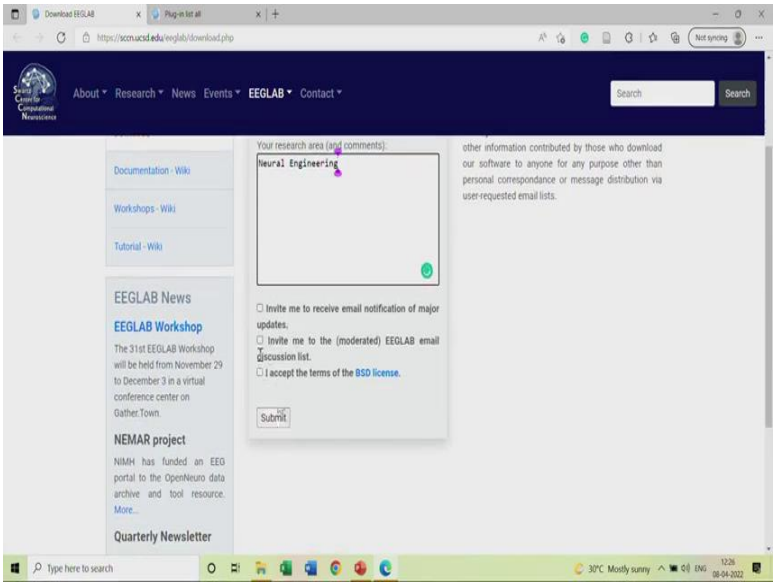

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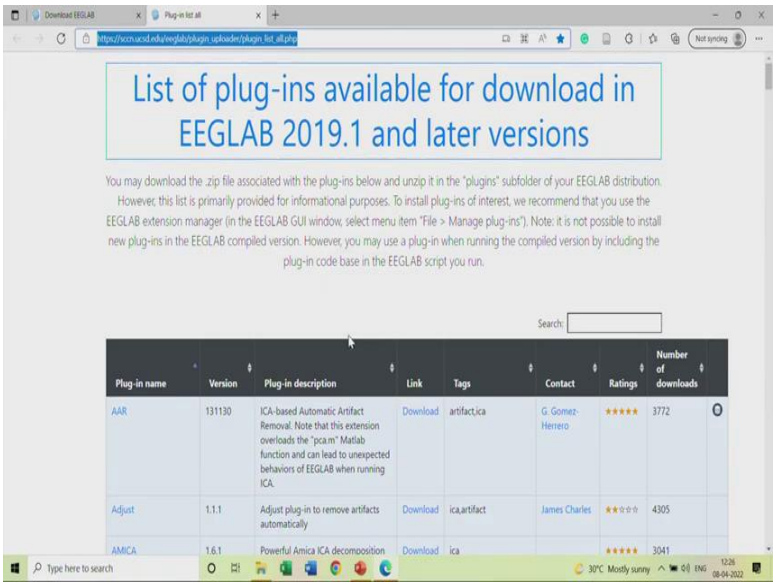

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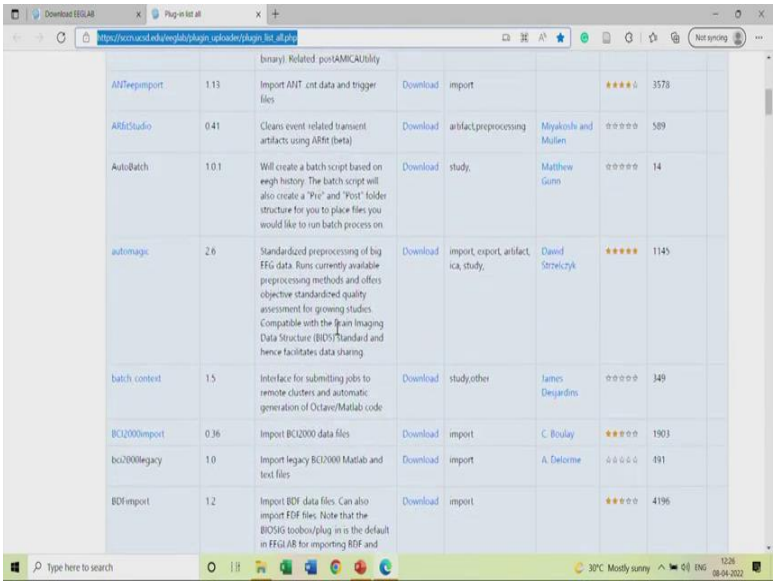

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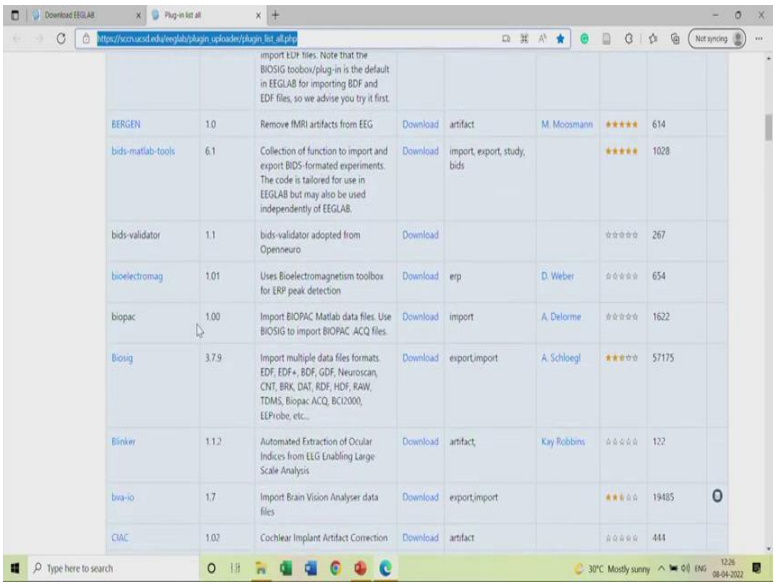

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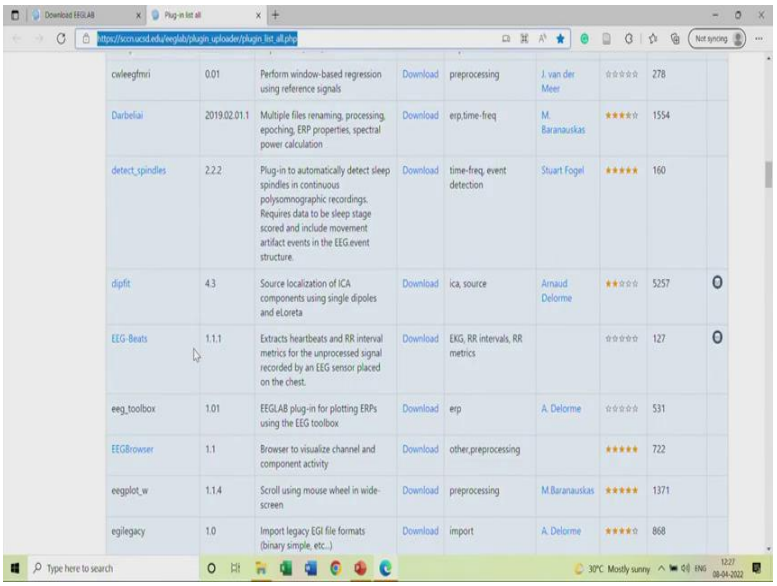

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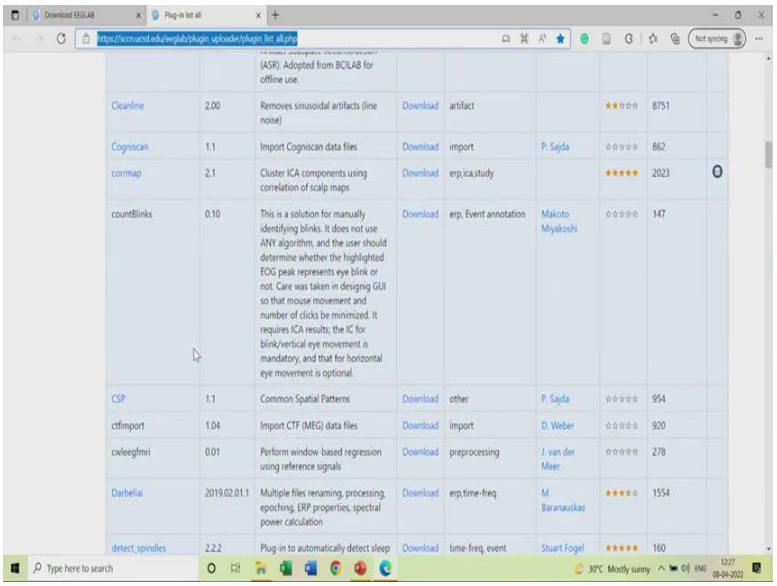

So, this is basically a standard a download page of EEG lab. You can write your name and email Id. They will ask why do you want to download? You can say just write what is your research area? We will write neural engineering. Then you can ask for update and all that is up to you once you submit you will be able to download the EEG lab. And one more thing which I talked about in my presentation is these plugins. So, all these different plugins you can go through it and these plugins are still being updated by one or the other users.

So, I mentioned one of the plugins like this clean line it removes the line noise or sinusoidal artifacts of power line artifact there is a clean row data which use the artifact subspace reconstruction to get the you know preprocessed data.

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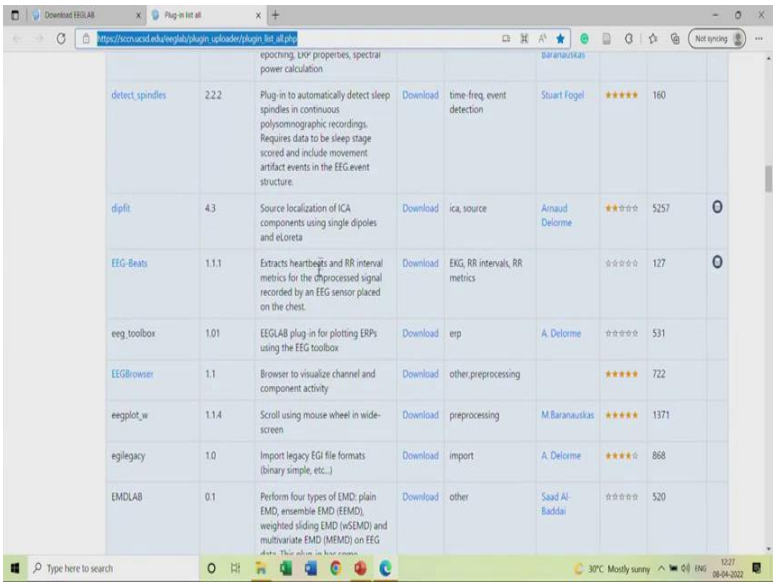

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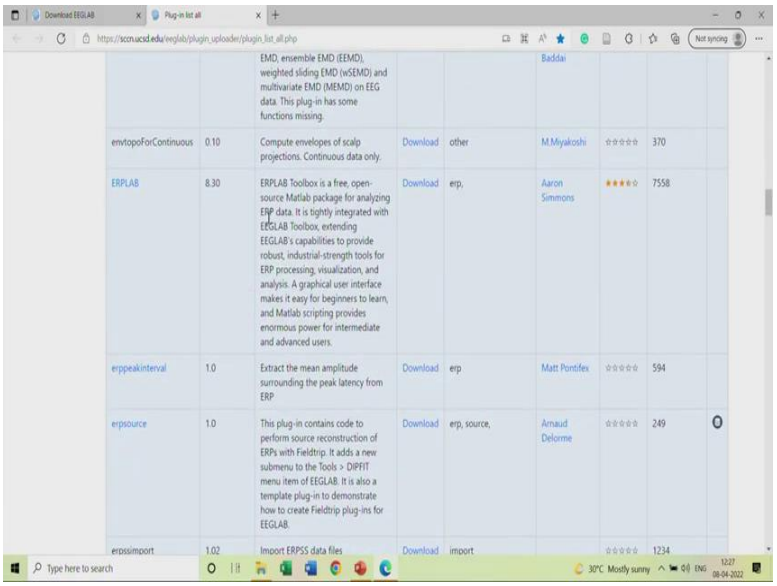

If it is to locate the dipole inside the brain you and eloreta is there. ERP lab is what we are going to see you can also see the download statistic and what are the reviews and all this thing. So, it is a good thing you can download it and put it along with EEG lab to make you know more sense out of that.

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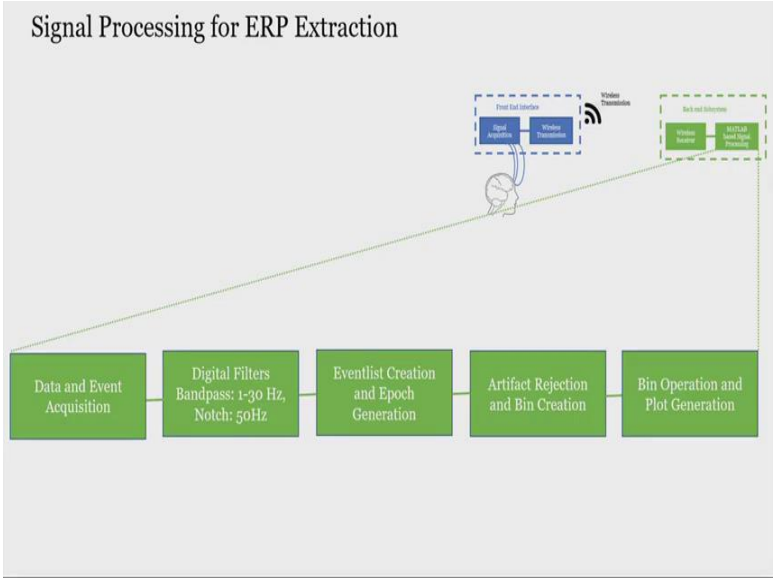

Now, if we go back to the presentation, this is the signal processing flow for ERP extraction. So, now, all of you are aware about this thing, that electrode will be used, it will be transmitted wirelessly, and it will be here. Once you have the file what you are doing?

So, you are acquiring the data as well as event you apply the filters, FIR filters. You can you know perform a comparative analysis of which filter is good also order matters, how much orders you are taking which is an optimal order for a particular acquisition.

You can do all sorts of thing. You can perform a band pass filtering, you can do notch filter, you can create an event list something called event list what is event list we will see that in the next module and we will you can also see the epoch generation generate the epoch and then artifact rejection bean creation and plot.

So, it is a simple method to generate this kind of ERP and these all things can be done using EEG lab and ERP lab. So, in the next module we will see one demo of how you can get the data and generate extract basically ERP of the same experiment which you have seen before. You have seen this experiment how we can make the sense out of the data in that experiment we will see in the next module. Till then, all of you take care, bye.