Ergonomics Research Techniques

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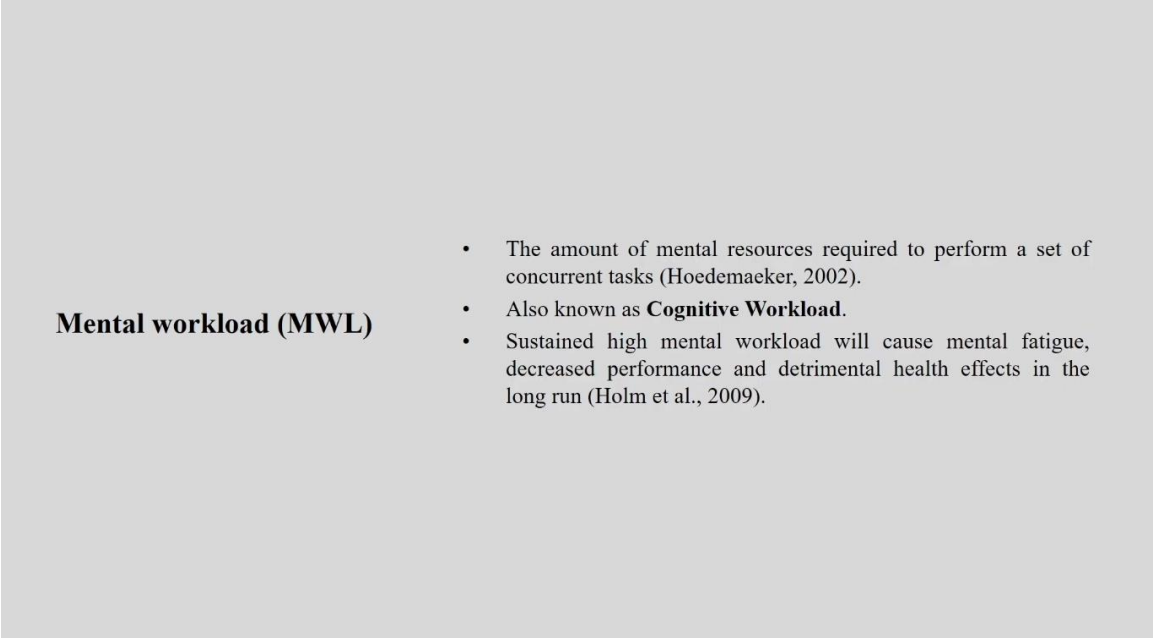
Week 11: Lec 36- Mental workload measurement

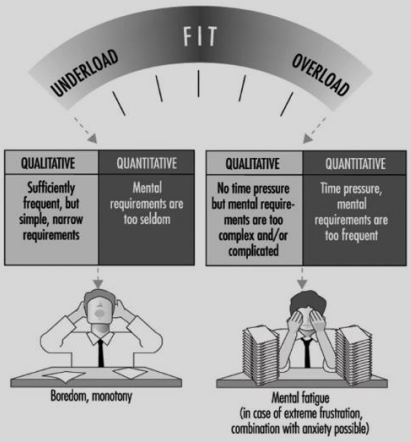
Electroencephalogram (EEG)

Welcome back. Today we will be discussing about the mental workload measurement methods specifically which is under behavioral and cognitive methods.



So, let us understand what is mental workload. It is being described by in 2002 that it is the amount of mental resources ok. Whatever the mental resources are required to perform a set of concurrent task. So, we are talking about there is some kind of mental requirement which you are going to know use it for performing some kind of task ok. So, that amount you need to measure through various types of instrumentation and techniques that we are going to work today. So, that is mental workload. It is also we can consider it as cognitive workload. So, sustained high mental workload definitely will cause some kind of mental fatigue. It is very similar as we have in physical perspective right. So, if you are running then your muscles are using lot of energy and it is getting fatigue slowly. So, if you are working for long hours mentally or physically you are going to get the fatigue. So, when you are sustaining a particular type of work for longer duration it is going to cause mental fatigue. So, if you can measure that fatigue then definitely you

can design the situation or you can design the equipment or the workplace in such a way that there is no accumulation of fatigue. Because we know that if there is an accumulation of fatigue definitely that is going to hamper the physiological responses performance of that particular person right. So, sustained high mental workload definitely will cause the mental fatigue. It will decrease the performance and definitely a detrimental health effects in a long run situation. So, it is being experimented and established in 2009 by Holm et al ok.

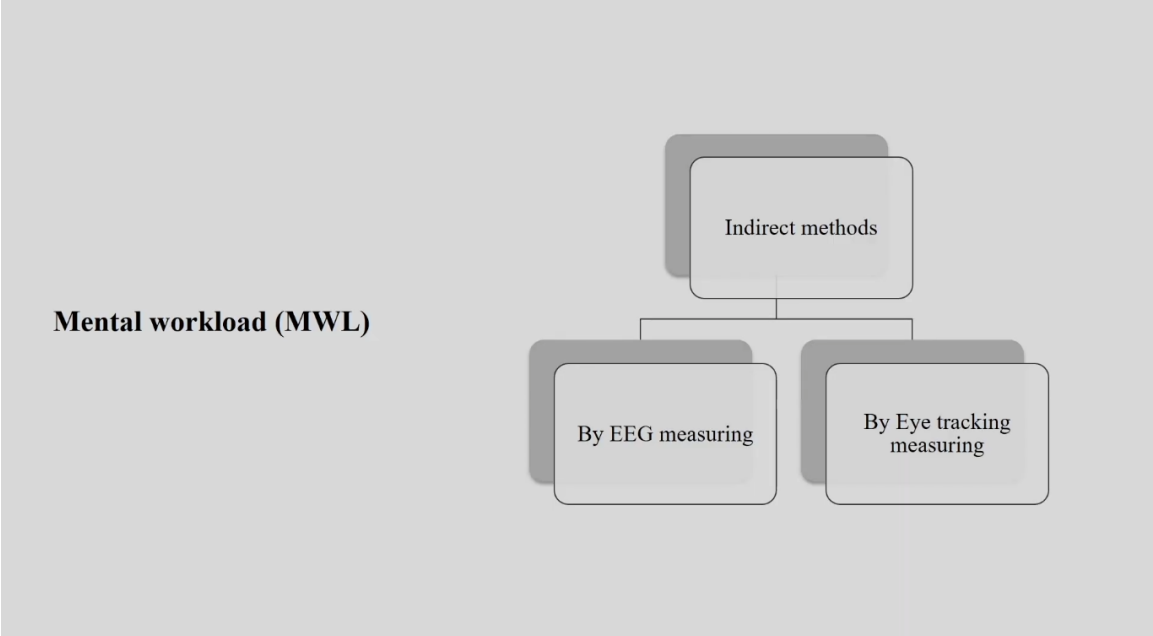


- MWL mainly describes the input aspects of the tasks (the requirements, the demands made by the tasks on the employees).
- MWL is a multidimensional characteristic of task requirements.
- MWL determines (a) behavior, (b) perceived, subjective short-term well-being with consequences for health in long run, (c) psycho-physiological process.

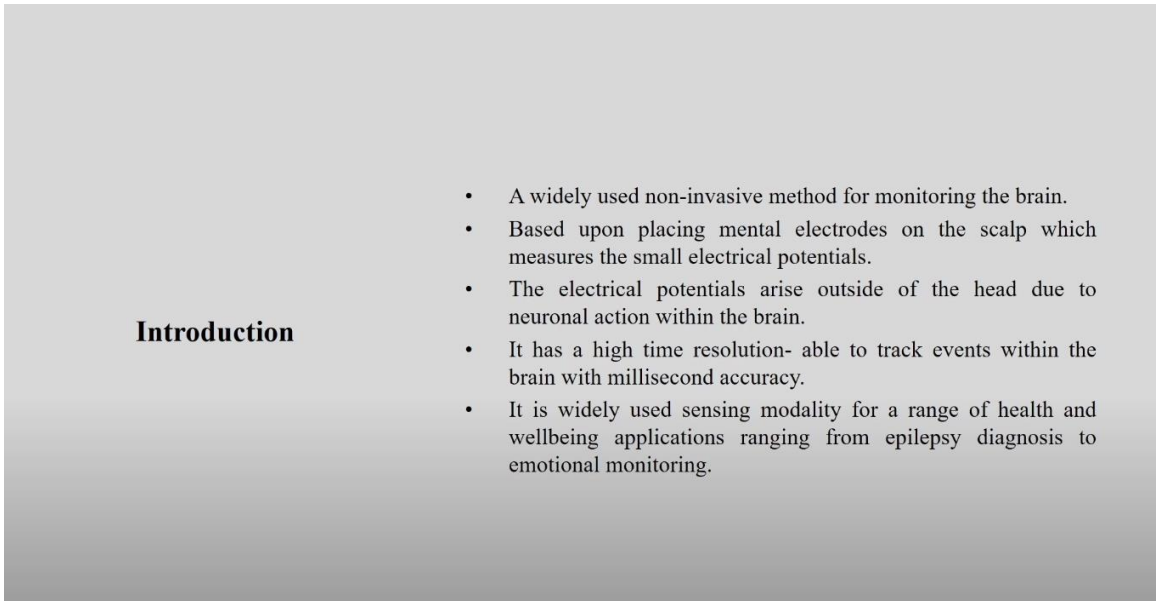
Image source: https://www.iloencyclopaedia.org/part-iv-66769/ergonomics-52353/item/628-mental-workload

So, let us understand little more about mental workload. So, mental workload mainly describes the input aspect of the task which is like the requirements, the demand made by the task on the employee. Now here I would not say only employee any operator of the particular system. If it is at home the homemaker or the person who are getting exposed to that type of demand. If it is a classroom then maybe students or the teachers maybe the person or maybe the operator and they are getting exposed ok. So, we need to understand it is not only in terms of employee. It is the person who are performing in that particular system. So, mental workload is a multi-dimensional characteristics of the task requirement. Mental workload determination that is the behavior perceived subjective short term well-being with consequences of health in a long run and psychophysiological processes are going to get affected and that is why you need to really understand the what is the status of mental workload in a particular working condition ok. So, if this is overload then also it is difficult or it is not good for the performer. If it is under load then also it is not good for the performance. What you need to do is you have to design the situation or you have to design the work in such a way so that it is being optimized ok. If it is optimized then definitely the performance will be at

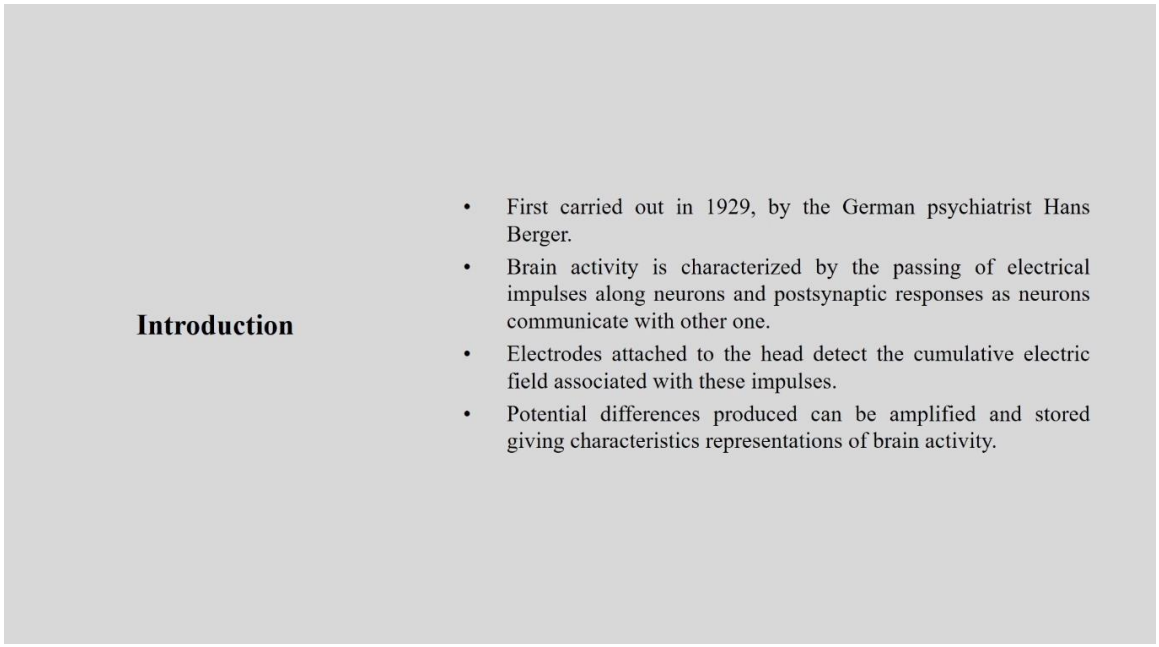
the level of expected maximum possibilities ok. So, neither overload nor under load is expected in any kind of situation.



So, when we are talking about mental workload and measuring through the indirect method two major component comes into picture. One is EEG measuring system, another is by eye tracking measuring system. So, first we will be discussing varieties of EEG and then we will go for the eye tracking. Why EEG? EEG is electroencephalogram. The process is electroencephalography right. So, you are trying to understand what is happening within your brain due to the exposure of some kind of activity or some kind of stimulus. So, we are going to understand that and the second one is the eye tracking. So, when there are visual stimulus how people are understanding it, how people are perceiving it and then how the decision is being taken care. So, that is the eye tracking measurement ok. So, we will be learning these two technique or two method separately in these set of lectures. This is very common and very much important aspect of cognitive ergonomics or when we are talking about something which need to be taken care from the behavioral and cognitive perspective.



So, let us understand what is electroencephalogram. So, a widely used non-invasive. So, here you have to remember this. This is an non-invasive method for monitoring the brain. So, what we are trying to do is we are trying to understand how the brain is functioning and to understand that we are going to place many electrodes on the skull and then whatever the electrical potential is generating we are going to understand or interpret the meaning of those electrical potential. So, it is based upon placing the mental electrodes on the skull which measures the small electrical potential. The electrical potential these electrical potentials are going to arise outside the head due to the neuronal actions within the brain. It has a high time resolution and is able to track events within the brain with a millisecond accuracy ok. It is very important because when we are talking about brain activity, it is within millisecond. It is not in second or in minutes it is within millisecond and it is where it is the system this particular system is accurate so that it can know measure that kind of accuracy. And it is widely used sensing modality for a range of health and well being applications ranging from epilepsy diagnosis to the emotional monitoring ok. So, we can understand various kind of pathological cases and some cases when we are trying to design a particular work environment there also we can use this electro encephalogram.

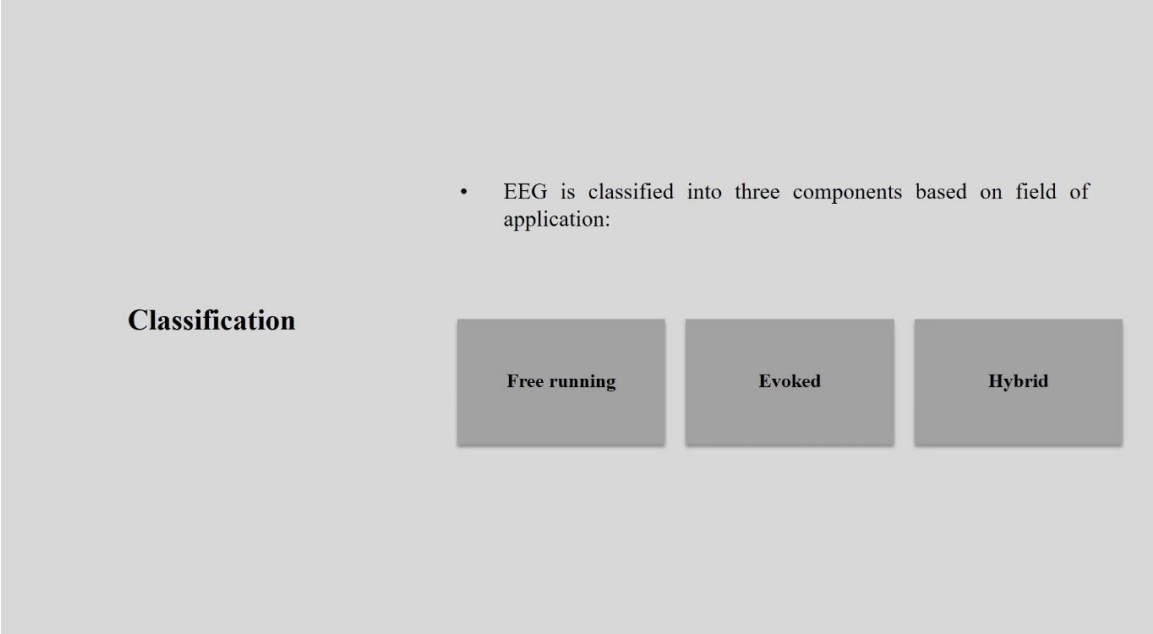


So, if we look at the history we can see that in first in 1929 this particular type of research or particular type of you know data acquisition happened by German psychiatrist he is Hans Berger ok in 1929. So, this brain activity what he did the brain activity is characterized by the passing of electrical impulses along neurons and post synaptic responses as neurons communicate with each other. So, there is one neuron, the another is another you know. So, there is communication from one neuron to another and then next then next like that neural circuits is being formed. So, it this through EEG we are trying to understand that impulses how it is passing. So, electrodes attached to the head detect the cumulative electrical field associated with these impulses. So, potential differences produced can be amplified because you know it is it is a very small amount you really cannot see them right. So, what we need to do we need to amplify them. So, instrument is like that we are going to amplify it. So, potential differences produced can be amplified and stored giving characteristics representation of the brain activity. So, how brain is performing, what brain is thinking, what part of the brain is active, what type of decision are being taken everything we can understand through the potential differences ok. So, that we are going to learn today.

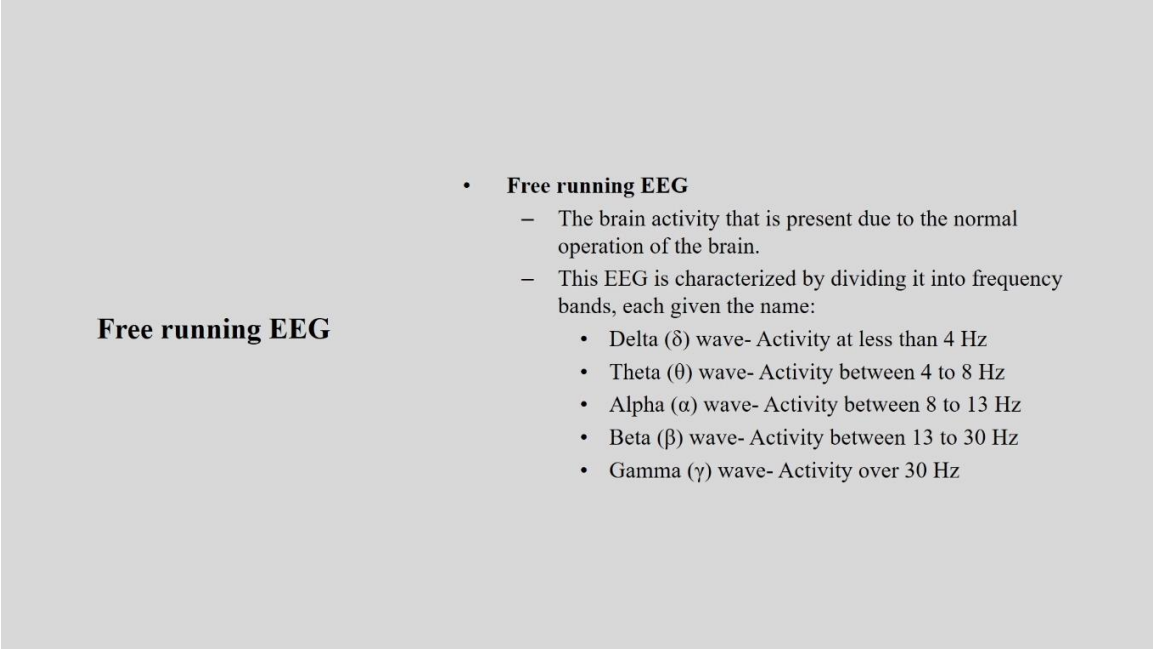
Introduction

- Brain has a large number of electrical sources present in it:
- Each neurons has intrinsic electrical properties as action potential are generated by voltage-gated ion-channels in the cellular membranes.
- Synapses operates based upon the flow of sodium and potassium ions.
- The EEG can be viewed as an emergent property of neuronal and glial cells population and network.
- A voltage waveform with its own characteristic shape and properties appear on the scalp due to the neuronal action within the brain.

So, brain has a large number of electrical resources present in it. So, each neurons has intrinsic electrical properties. So, those things are not part of this course. So, I am not going to explain how that electrical potential generates and all those things, but here it is important to know that every neuron has the intrinsic electrical properties and action potential are can be generated by voltage gated ion channels in the cellular membrane ok. So, there are small small you know very you can measure in micron. So, you know these are the voltage gated ion channels and through which the electrical potential are being generated and that is going to be measured through these instruments. So, synapses operated operates based upon the flow of sodium and potassium ions. I am giving very brief description these things can be taken in separate courses. It is not part of this course ok. So, the EEG can be viewed as an emergent property of neural and glial cell population and network and a voltage waveform with its own characteristic shape. So, every waveform has their own shape and properties appear on the scalp due to the neuronal action within the brain. And these things we are going to measure using EEG system.

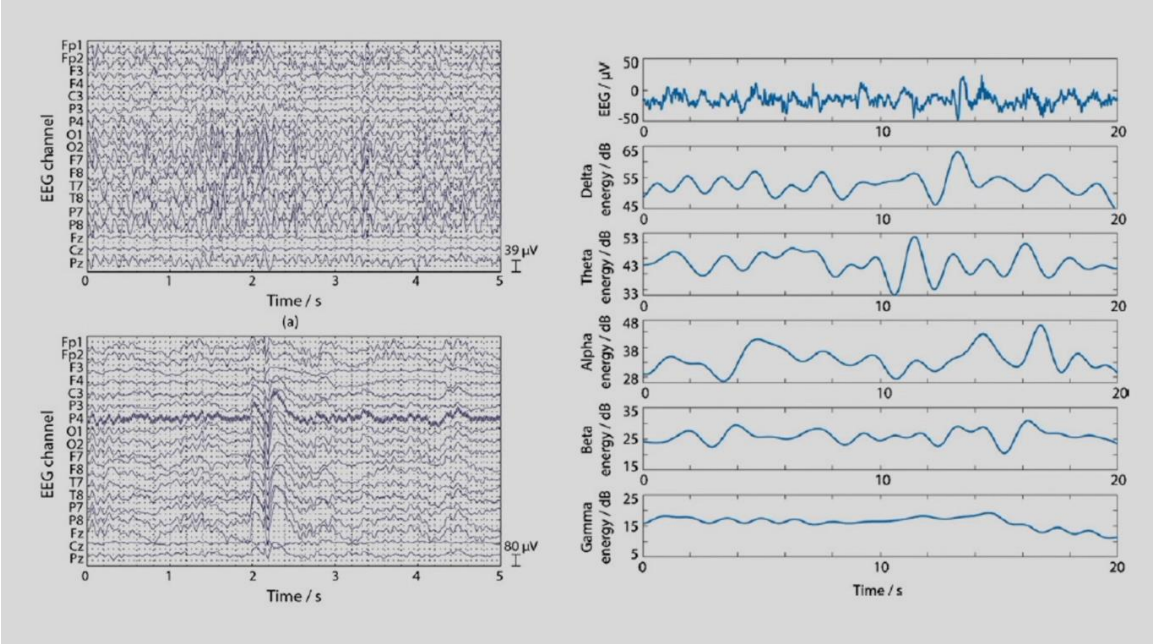


So, if we are looking at the classification of EEG, we can see there are majorly three types of EEG. One is free running, second is evoked and third is hybrid. We are going to describe each of them in these next slides.



So, free running, free running you can understand from the name itself that is what is in general you know if you are not giving any signal in free in a when somebody is not having any kind of stimulus from outside how the brain waves are there. So, the brain activity that is present due to the normal operation of the brain that is free running EEG. This EEG is characterized by dividing it into frequency bands. There are majorly five

bands delta, theta, alpha, beta and gamma. So, you can see here I have mentioned what is the frequency of them. So, delta is like 4 hertz or less than that, theta is 4 to 8, alpha 8 to 13, beta 13 to 13 and gamma is the activity which is more than 30 hertz. So, you can understand how brain is active if we can measure these waves, we can understand at what state our brain is active. So, this is the basics of brain activity and we can understand the position or condition of the brain.

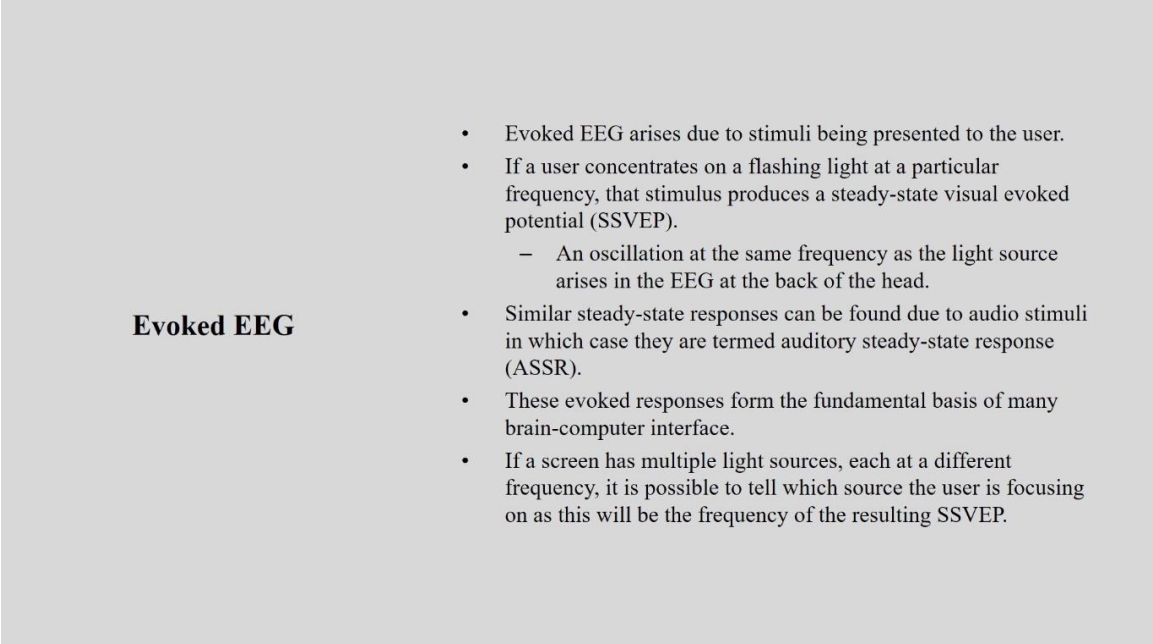


This is just an example how this looks like in the graph when you are going to collect your data. So, this is delta, this is theta example, these are all example ok. These are all data collected in different other studies and we are just representing it for your understanding alpha, beta and gamma.

Free running EEG

- When a user is restful and closes their eyes
  - A dominant alpha (α) rhythm emerges at the back of the head over the occipital cortex.
- The process of falling asleep is associated with alpha (α) activity being replaced by slower theta (θ) activity.
- Within free running EEG, there are then a number of features that occur due to different brain states which will be interest for different applications.

Now here I would like to say when a user is restful like you know taking rest eyes are close then you can see a dominant alpha rhythm emerges at the back of the head over the occipital cortex ok. So, you are you are awake, it is not that you are not you are sleeping ok, you are awake however your eyes are closed. If that is the situation you will see alpha wave is in dominating state. The process of falling asleep so, you are closing your eyes, you are resting if there is alpha wave, but slowly you are falling asleep. Then when what is going to happen? If you are going to fall asleep then the with the alpha wave activity it is going to be replaced by the slower theta wave ok. So, you can understand if there is a shift between alpha to theta that means initial stage you were awake, you are alert, however your eyes were closed. Now due to after you know sustaining that situation for few hours or minutes that is being replaced by theta that means you are actually going to sleep, you are slowly falling asleep ok. So, within so, that way you can understand how the brain is active ok. Within free running EEG there are then a number of features that occur due to different brain states which will be in you know which will be interest for different application. So, whenever I am talking about looking at something then you know how the stimulus is getting exposed. So, these will we will be you know the the brain waves slowly will change the nature and once there is a change in the nature, we need to understand what is the background of this change of nature and then we can understand what is exactly happening. So, this way free running EEG gives us information about the brain activity. So, this is free running.



Now coming to the next that is the evoked. So, you are going to evoke the EEG through different kinds of stimuli. Maybe it is auditory stimuli, maybe it is visual stimuli. So, if you are giving a visual stimuli how it is you know reacting, if you are you know hearing some kind of sound then how brain is reacting. So, everything we can understand through the evoked EEG and this is the major area where ergonomics people you know the practitioners or designers actually working with this particular area and they are interpreting or analyzing evoked EEG and trying to understand and modify or intervene in different way ok. So, evoked EEG arises due to stimuli definitely being presented to the user. If the user concentrates on a flashing light at a particular frequency ok maybe red light or maybe some other light in at a different frequency that stimulus produces a steady state visual evoked potential which we call it as SSVEP. And oscillation at the same frequency as light sources arises in the EEG at the back of your head ok. So, that is the occipital cortex. Now similar steady state responses can also be found using your audio stimuli and which is be termed as audio auditory steady state responses. So, depending on the design, depending on the situation or depending on the scenario that you are working you may work with the visual stimuli or you may work with the auditory stimuli. So, these evoked responses form the fundamental basis of many brain computer interfaces. So, if a screen has multiple light sources and each at different frequency it is possible for the experimenter to tell which source of user is focusing on as this will be the frequency of the resulting SSVEP. So, maybe there is green light, red light, orange light or some different types of light and each has different frequency. Now being a observer or being a person who is looking at those lights and we are going to measure the brain waves we can understand that which is getting more concentration from the user as per these lights are concerned. Because if it is a red light of that particular

frequency that is going to be there in my brain ok. So, that way we can understand. So, this way designers design lot many experiments to understand the customers requirement as per the color, as per the position and different situation. So, they take responses from all these brain waves and they try to interpret the data and accordingly according to the result they are going to redesign the situation ok. So, that is the evoked response specifically now we are talking about visual similarly it can happen with the auditory stimuli.

Evoked EEG

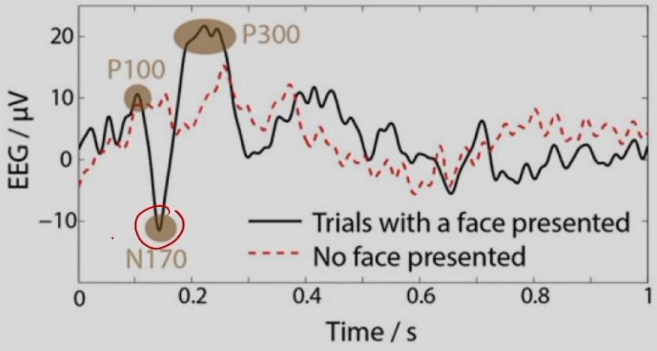
- There are a wide number of evoked responses that are possible due to different forms of stimuli and experimental set ups.
- Event related potentials (ERPs) arise due to the presentation of individual stimuli, with a gap present before a subsequent stimuli presentation.
- Some common ERPs are:
  - P100- elicited by using checkerboard stimulation.
  - N100- produced by the presence of an unexpected stimulus, particularly auditory when no other task is being performed.
  - N170- elicited when a face is present in visual stimuli.
  - P300- produced by an oddball stimulation, when looked for uncommon stimuli are observed in a train of other stimuli.
  - N400- produced in response to the recognition of a face

(*P = positive going deflection; N = negative going deflection*)

So, there are wide number of evoked responses that are responsible due to different forms of stimuli and experimental setups. So, event related potential like you know if there is a particular event and that is actually acting as a stimuli. So, that is the event related potential arise due to the presentation of individual stimuli with a gap present before a subsequent stimuli present. So, some common ERP are P 100. What is P 100? So, elicit by using the check board stimulation. So, if there is a check board stimulation maybe you will get a response of P 100, P means positive ok. N 100 that is the produced by the presence of unexpected stimuli particularly auditory when no other task is being performed ok. So, then N here represents the negative stimuli. So, it is going down positive means it is going up I will show in the picture in the next slide. N 170 these are something which is being already experimented and described you can have your own data. So, N 170 that is the elicit when a face is present in visual stimuli, P 300 which is produced by an oddball stimulation when looked for uncommon stimuli are observed in a train of other stimuli. N 400 produced in response to the recognition of a face. So, these are something which is commonly available, you can refer them or you can define your category ok.

Evoked EEG

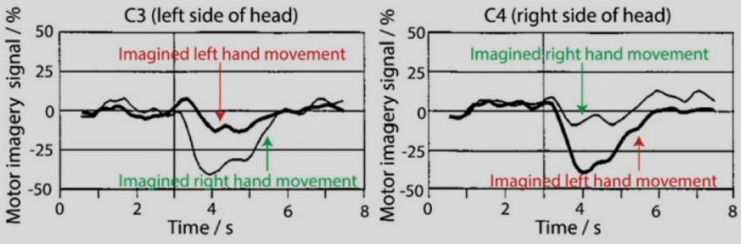
- Following figure shows an example of evoked responses produced during a face detection task where the user was shown a series of picture for 1 sec, followed by 1 sec pause, with the picture randomly selected to be a recognizable face or static noise.
- A number of evoked responses can be seen- P100, N170, P300.



So, here you can see that here it is 170 that means in negative deflation, it is P 300 it is positive deflation. So, here no face presented in a particular experiment, here trials with the particular face presented. So, you can see what is the kind of brain wave differences are happening. So, this is just an example.

Hybrid EEG

- This type of EEG is between the free running and evoked EEG.
- No direct stimuli are presented to the user, but they are asked to think of something or imagine performing an action.
- This can then result in known signal morphologies arising in the EEG.
- The best known such signal is associated with motor imagery:
- When a user is asked to imagine performing a hand movement, EEG activity at 8 – 12 and 18 – 26 Hz decreases over the motor cortex (around the electrode positions C3 and C4)
- There is an event-related desynchronization.



Now third component or third type is the hybrid EEG. By name itself you can understand hybrid means it is a combination right. So, this type of EEG is between the free running and evoked EEG. No direct stimuli are presented to the user by, but they are asked to think of something or imagine if they are performing something there is no

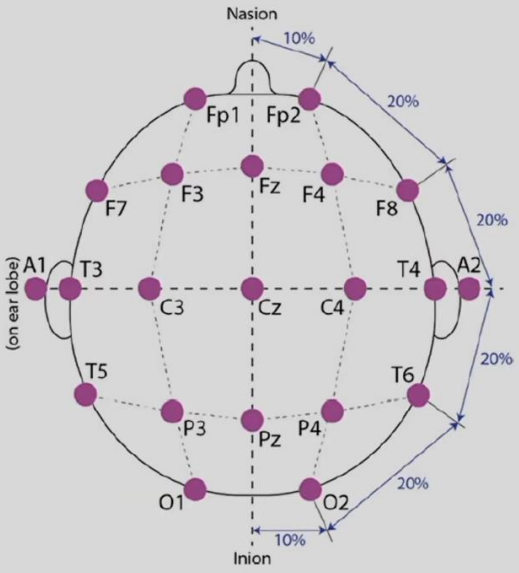
direct stimuli. So, it is not that some light is coming or there is a sound nothing. They are asked that suppose they are doing something they are performing something so they are imagining. So, actually you are not giving any kind of direct stimuli. So, it is it is supposed to be free running whereas, you are asking them to imagine there is a stimuli ok. So, that is why it is not evoked as well. So, in between so that is why it is hybrid. So, this can result in known signal morphologies arising in the EEG. The best known such signal is associated with the some kind of motor activity. Suppose you are being asked that you know you move your right hand, you move your left hand or suppose you are in a traffic signal you are giving a signal to move from one direction to other direction something like that ok. So, this kind of situation you will get the hybrid EEG. So, when a user is asked to imagine performing a hand movement see here it is hand movement EEG activity. Suppose at 8 to 12 and 18 to 26 Hz decreases over the motor cortex C3 and C4 there is an event related desynchronization. So, here you can see that left side of the head this is the kind of responses you are again getting and here it is the right side of the head you are getting this kind of. So, here if it is the left hand movement, here it is the left hand movement. Always you can see for the left head it is on the negative side in this way whereas, in the right side you can see it is more ok. The deflections are more. It is just opposite for the right hand ok. So, for right hand here in the left side it is more whereas, here it is less ok. So, you can understand how so, left brain is connected left brain is connected with right hand and right brain it is connected with your left hand. So, that way we are going to you know imagine my movement and my brain is getting activated ok. So, for example, I am asking that you move your left hand. So, if I am asking or I am trying to imagine to move my left hand definitely the motor activity of my right brain will get activated and that can be measured through your hybrid EEG ok. Is that clear?

Basic set up

- Typical signals detected by scalp-mounted electrodes are in the range 1 – 150 μV over a 0.1 – 60 Hz bandwidth.
- The signals both vary temporally and spatially, and so multiple electrodes are typically used.
- Electrode positions are determined using the 10 – 20 standard, so named as distances between electrodes are measured as being 10% or 20% of the skull dimensions (figure in next slide).
- A pair of electrodes is required in order to obtain a voltage potential difference, and each pair of electrode is connected to an amplifier.
- After suitable amplification and bandwidth limiting, the signals are stored in a suitable location.
- The devices digitize the signals allowing them to be stored, wirelessly transmitted or analyzed in real time

So, let us now understand how the what is the basic setup for EEG recording because till now whatever I we discussed this is the theory right. So, how this will look, but we need to measure it right, using some kind of instrument at the laboratory. So, now, we are going to discuss that part. So, typical signal detected by the scalp mounted electrodes are in the range of 1 to 150 micro volt over 0.1 to 60 hertz bandwidth that we are going to do. So, the signals both vary temporarily and specially because position to position also time to time and so, multiple electrodes are typically we should use. So, electrode positions are determined using the 10 to 20 standard. So, 10-20 we call it 10-20. So, named as the distance between the electrodes are measured as being 10 percent or 20 percent of the skull dimension ok. So, that way that is why it is called 10-20 standards. A pair of electrode is required in order to obtain a voltage potential differences and each pair of electrodes is connected to an amplifier. So, after suitable amplification because we really need to do amplification without amplification we may not read them right. It is because it is very small amount brain waves are very small amounts electrical potential ok. So, after suitable amplification and bandwidth limiting the signals are stored in a suitable location. The devices digitizes the signal allowing them to be stored wirelessly transmitted and analyzed in real time. So, that is the basic setup.

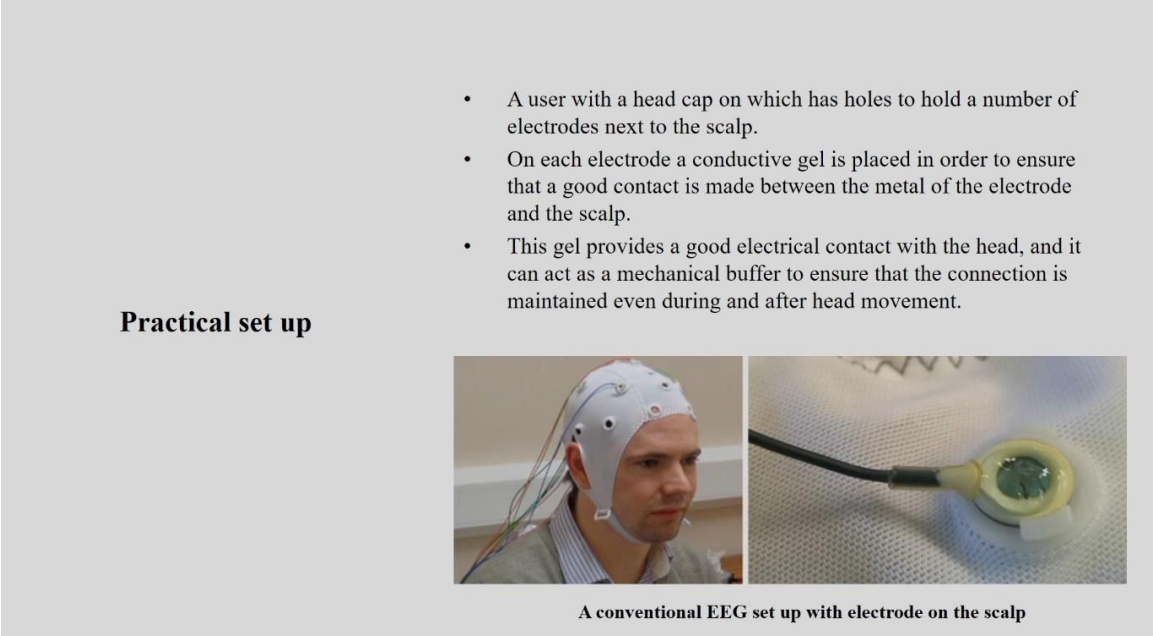
Basic set up



The standard 10 – 20 electrode system for electrode placement and names

Now how it looks? So, you can see it is the top view of a scalp it is a top view of a scalp you can see how you know things are being placed. So, it is 10 20 as per the 10 20 standard the electrodes are being placed. So, you can see they have given specific numbering also ok. So, this is these are the position occipital 1, 2 then you know so like that they have given every nomenclature properly. So, you can have. So, you can see here it is 10 percent here it is 20 20 20 20 and then again here it is 10 percent 10 percent ok. So, if you are going to manually place them you need to really know the

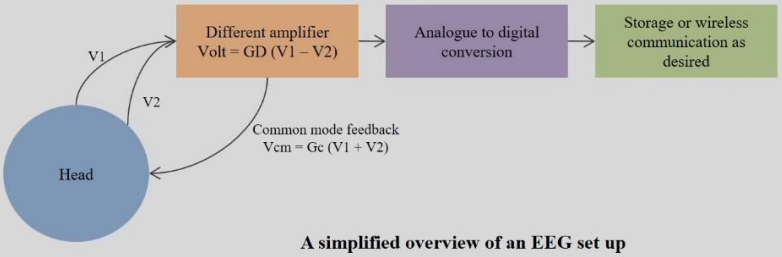
measurement whereas, every nowadays whatever the instruments we are getting we are getting a cap where you have a specific position and you can insert the electrode through that. So, you need not to worry much.



So, here it how it actually looks like. So, you can see these holes are being made already. So, it is being already you know designed in that way. So, a user with a head cap we call it as head cap on which there will be hole and this is going to hold your electrodes next to this scalp. And of course, as these are electrodes what you need to do you need to put the conductive gel ok. If you are not giving conductive gel the electrical transmissions the signalcapturing will not be proper. So, this gel is going to provide a good electrical contact with the head and it can act as a mechanical buffer to ensure that connection is maintained even during and after head movement. Suppose you placed it now you are being asked to do some activities. So, while doing activity definitely your head is going to move in different direction. This head cap is going to ensure and these gels are going to ensure that recording is going properly the capturing system is performing perfectly ok. So, that is why these require this is the requirement.

Practical set up

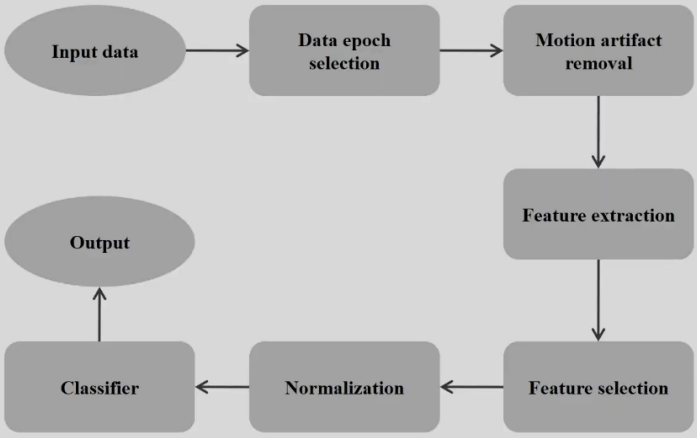
- A conceptual set up of EEG recording instrumentation.
- Electrodes placed on the scalp detects small electrical signal which is amplified and stored.
- A recording the from the electrodes forms one EEG channel, and different montages are possible depending on which electrodes are used.
- Modern set ups favor referential recording as this allows any desired other montage to be derived offline by software.



A simplified overview of an EEG set up

So, a conceptual set of EEG recording instrumentation is required and electrodes need to be placed on the scalp which is being detected small electrical signal with next you are going to amplify it and then finally, you are going to store them for your further analysis. Recording the form of electrodes from the EEG channel and different montages are possible depending on which electrodes are used ok. So, modern setups favor referential recording as this allows any desired other montage to be derived offline by the software and this is the kind of overview of the whole EEG setup. So, here you have head. So, you are getting responses. So, voltage then you are going to get the voltage difference then you are going to what it is coming back here and analog to digital conversion is happening automatically through the programming that is there and then you are going to store the wireless communication as required or as desired ok. So, this is the practical setup for EEG in laboratory.

Signal processing and data analysis



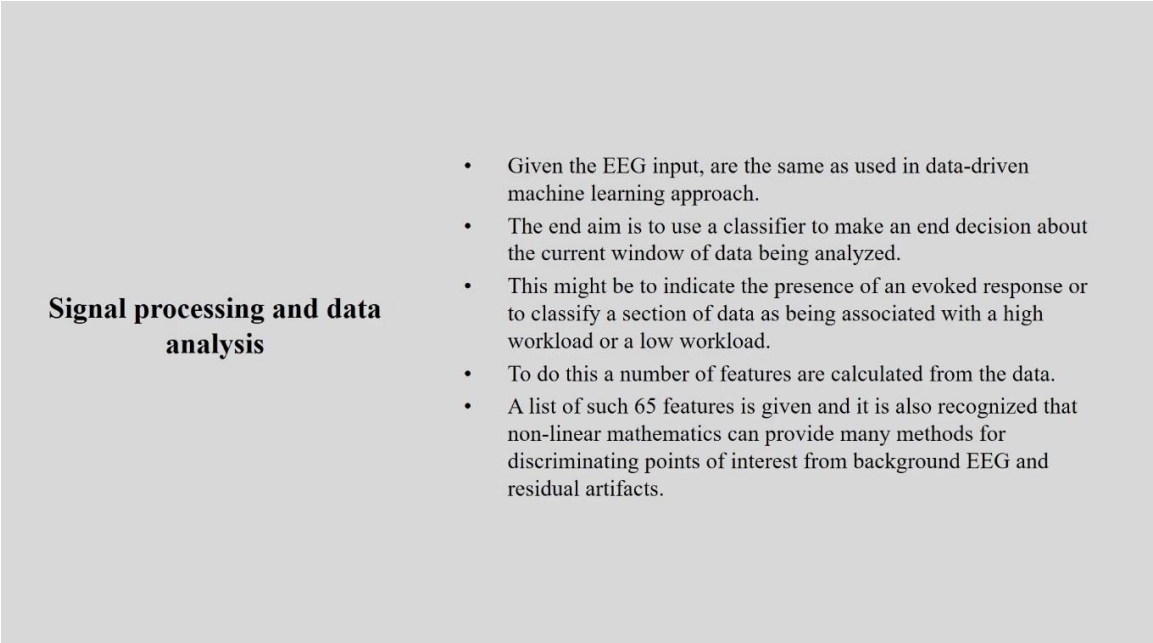
Basic EEG signal processing

So, how the signal processing is happening? You have input data, then you are going to select the you know epoch selection you are going to select the epoch and then motion artifact removal because you know lot of motion artifacts will be there in the epoch potentials then you have to remove them. Once you remove then the feature extraction because you know everything is not required for you, you need something which is specific to your design or your experiment right. So, you are going to extract those feature, then once you are you extracted you will be selecting which one is required for that, then you are going to normalize them, classify them and the final output you are going to get. So, this is the basic flow of the EEG signal processing.

Signal processing and data analysis

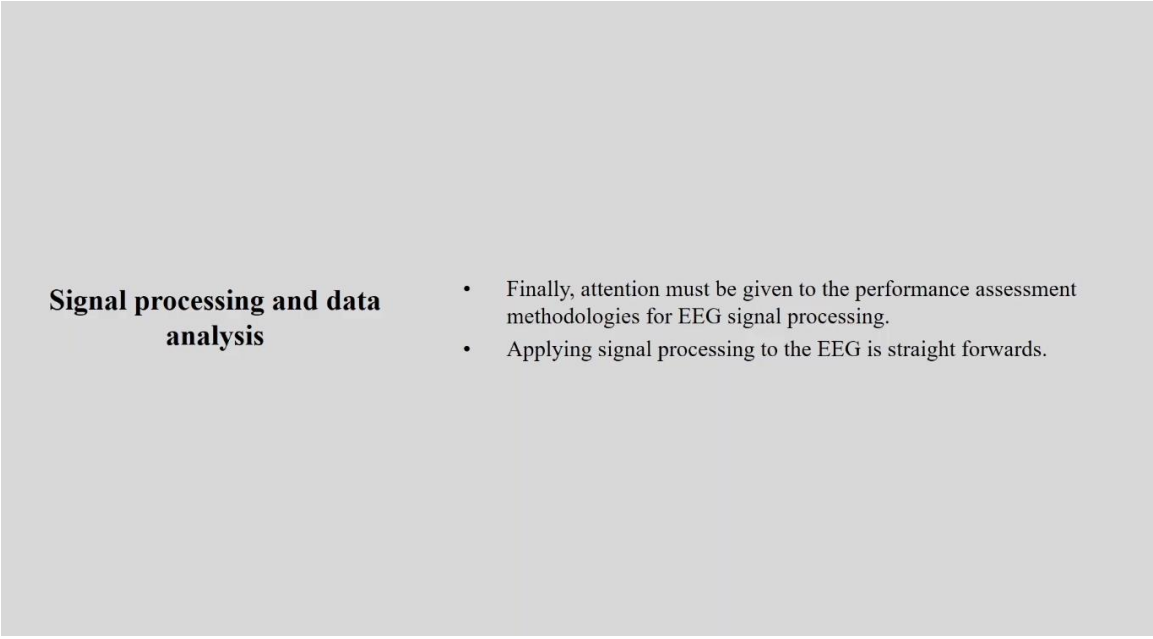
- EEG data is the input to the signal processing chain.
- **Motion artifacts-** when the user's own movements affect the placement of the sensor or its contact pressure to the skin.
- Motion artifacts can be minimized at the data collection stage by ensuring that the electrodes are correctly and well connected to the head.
- Most approaches for removing such affect and recovering clean EEG data are based upon signal decomposition technique; independent component analysis (ICA) and principle component analysis (PCA).
- **Independent component analysis** (ICA)- allows artifacts removal to be performed without having to be involved with the full mathematical details.
- **Principle component analysis** (PCA)- its mathematical conditioning is dependent on the number of EEG channels present.

So, let us learn little more about it. So, EEG data is the input to the signal processing chain because first you are going to get the response your EEG major data ok. Then what you have to do? You have to know about the motion artifact ok. Let us know about it. So, when the user's own movement because when somebody is you have a cap on you and you there is some kind of movement it is going to affect the placement of the sensor or its contact pressure to the skin right. So, motion artifacts can be minimized at the data collection stage by ensuring the electrodes are correctly and well connected to the head. So, here is the how electrical that gel is being introduced ok, how good gel you have kept and the positioning of your cap. So, if it is tight enough and the gel is correctly placed then definitely you are going to eliminate this motion artifacts ok. Most approaches of removing such effect and recovering clean EEG data are based on this signal decomposition technique and independent component analysis and principal component analysis. So, through this you are going to remove the motion artifact. Now let us understand what is independent component analysis and principal component analysis. So, independent component analysis is going to allow the artifacts removal to be performed without having to be involved with the full mathematical detail ok. You are not going to do any kind of detailed mathematical calculation whereas, principal component analysis it is a mathematical conditioning is dependent on the number of EEG channels. So, there are some 16 channels EEG, there are 8 channels EEG. So, based on that it is mathematically going to count it or you know analyze the data and is going to give you the final result ok.



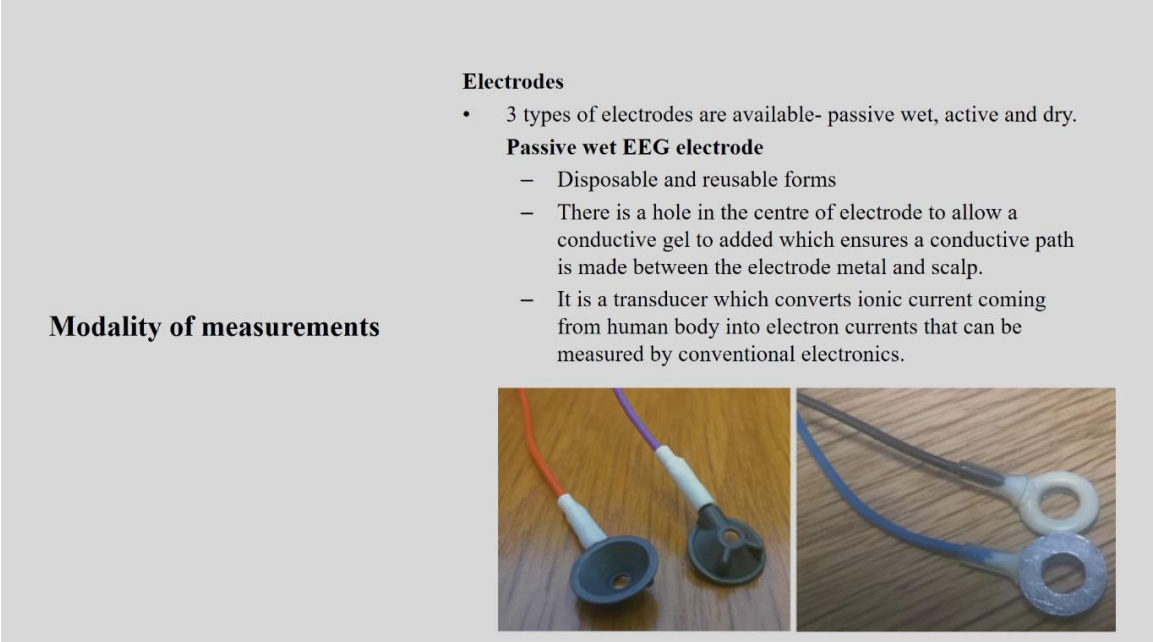
So, it is absolutely based on the kind of data you are using, kind of experiment you are going to conduct and the kind of instrument you are going to use for data collection. Now given the EEG input are the same as used as a in a data driven mechanical learning

machine learning process ok. So simple how you are doing it in machine learning process same way you have to do. Now here sometimes it may happen that you are not you know very much acquainted with the machine learning process and all those thing. Now concern is nowadays the system or the instruments that you are going to use it, they do lot of simplification of the data and you may not need to know the what is happening in the background. It is already going to be programmed and it will be given the final output ok. So, data processing you if you want you can learn it. However, it is not mandatory for someone to know how exactly data processing is happening. You have input and then finally, you give the command to the system and finally, you get your output that is also possible. But many cases it happens the people are interested in the data processing because that is where their research is lying those cases this is important to know. So, the end aim is to use the classifier to make an end decision about the current window of data being analyzed. This might be to indicate the presence of an evoked response or to classify a section of data as being associated with a high workload and a low workload. To do this a number of features are calculated from the data and a list of such a 65 features is given and it is also recognized that non-linear mathematics can provide many methods for discriminating points of interest from background EEG and residual artifacts ok. So, these things you can learn in more detail if you are interested in the signal processing of EEG ok. However in common cases where we are talking about understanding the brain activity in terms of input and the output we may not go into that detail ok.



So, once everything is done finally, you what you are going to do attention must be given to the performance assessment methodology for EEG signal processing and you can

apply signal processing to the EEG is straightforward ok. So, that you can directly take it up.



Now, let us understand more about the electrodes because this is very important- what is available and if based on the what is your availability, you need to decide that what should be the experimental protocol and how you are going to conduct the experiment. So, mainly we have three basic types of electrode. First one is passive weight EEG electrode ok. So, what is it is disposable and reusable form. There is a hole in the center of the electrode to allow a conductive gel that is very important to add it which ensure a conductive path is made between the electrode meant metal and the scalp. So, you have the metal component of the electrode and the scalp in between there is a conductance is required right. So, this conductive gel is going to create that particular path. So, it is a transducer which converts ionic current coming from human body into electron currents that can be measured by the conventional electronics ok. So, this is the passive weight EEG electrodes.

Modality of measurements

Active EEG electrode

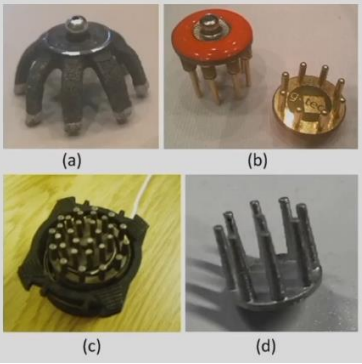
- A buffer amplifier is placed on top of the electrode itself.
- It reduces main interference and artifacts due to movement of recording wires.
- If a buffer amplifier is included, the cable is connected to the low-output impedance buffer and the same amount of induced current produces a much smaller interfering voltage.
- The high impedance node between the amplifier and the electrode is made to be much shorter minimizing the path for interference to be introduced.

Second one is active EEG electrode. Now it is very commonly available. So, a buffer amplifier is placed on top of the electrode itself. So, already you have a buffer amplifier there. It reduces main interference and artifacts due to the movement of the recording wires. You have lot of recording. So, it is going to do the things at the very beginning. So, these wire is not going to interfere the data collection. If a buffer amplifier is included, the cable is connected to the low output impedance buffer and the same amount of induced current produces a much smaller interfering voltage. So, if you are having less interfering voltage, definitely it is going to help or show your data more clean ok. So, the high impedance node between the amplifier and the electrode is made to be much shorter minimizing the path for interference to be introduced ok. So, this is the active EEG electrode.

Modality of measurements

Dry electrodes

- No need to have a conductive gel.
- This electrode is based on a 3mm steel disc coated with nitride on one side and an impedance-converting amplifier on the other.
- It is much more difficult to keep the electrodes in place and next to the scalp for long-term recordings.
- Most dry electrodes having fingers to better penetrate the hair.
- These are attached to springs to help keep them place.

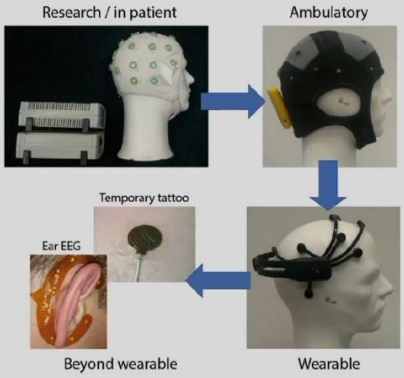


Next and final one is the dry electrodes. So, no need to have a conductive gel. So, earlier cases you need to have some conductive gel. Here you do not need any kind of conductive gel and this electrode is based on the 3 millimeter steel disc coated with the nitride on one side and an impedance converting amplifier on the other side. So, you have two sides, one side you are having no nitride, another side you have impedance converting amplifier. So, it is much more difficult to keep the electrode in place and next to this scalp for longer time ok. So, this is little difficult for us because you can see these all are something metal bodies right. So, it is very difficult to keep it on your scalp for longer duration. Most dry electrodes having fingers to better penetrate the hair and because you know it is going to insert and these are attached to you know springs to help keep them in place. So, you are placing it and then there will be some kind of clip. So, it is going to place it properly. However, as it is not having any kind of gel there is always a chance that there will be some kind of displacement.

Modality of measurements

Instrumentation

- Following figure shows the evaluation of EEG instrumentation.
- These are basically 4 types-
  - Research Lab/ Inpatient
  - Ambulatory
  - Wearable
  - Beyond wearable



So, these are the kind of instruments you have. Mainly we have instrument which is going to be used at the laboratory research labs these are big ok. Then some are ambulatory, some are wearable and some are beyond your wearable cases ok. So, let me explain each of them.

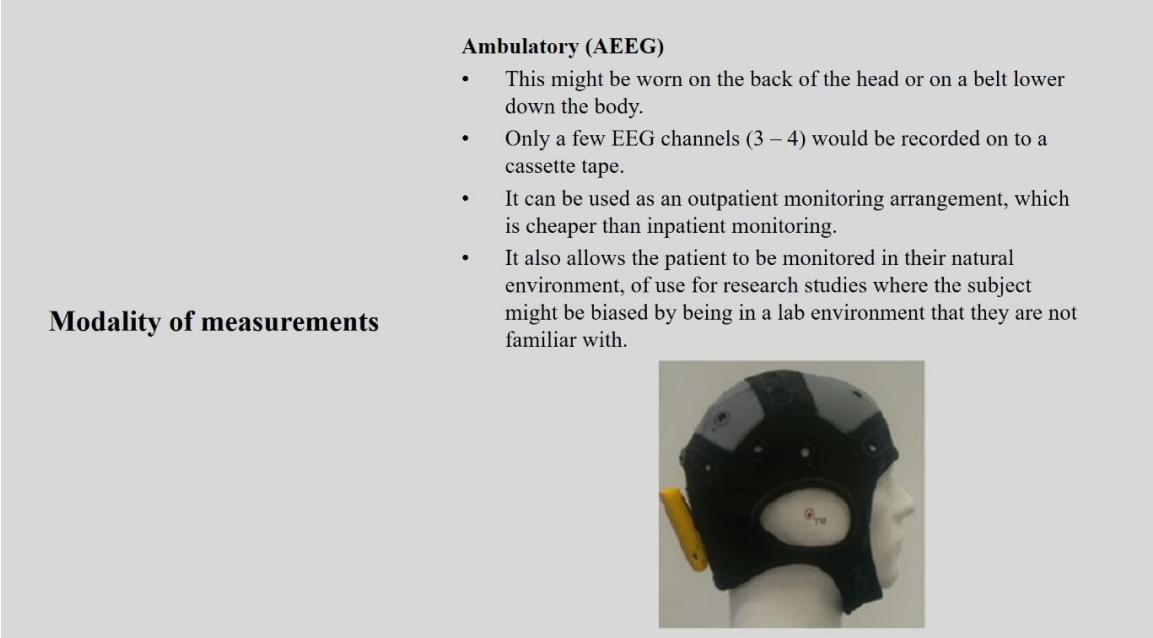
Modality of measurements

Research Lab/ Inpatient

- Large, non-portable and very high quality, flexible in their use.
- Can be use for anything from a standard short EEG test for clinical use which lasts between 20 to 30 min, upto a few hours for experiments in a research laboratory.
- Also used for sleep testing.
- The electrode set up is typically passive wet EEG electrodes, with long wires connected the electrodes to an amplifier box.

Of course, when we are talking about research lab this is a big setup with lot of wear, lot of detailing. So, you will get lot of accurate data if it is at the laboratory. So, it is large definitely it is nonportable, very high quality, flexible in their uses ok. And can be used for anything from a standard short EEG test for clinical use which last between 20 to 30

minutes. So, you can see the experiment duration is quite longer. Also you use this type of instrument for sleep recording because you know lot of things happen during we are sleeping, how brain is active during our sleep. So, in both cases we use this type of instruments. And the electrode setup is typically passive with electrodes because you can see that it is for longer duration. So, you are putting the gel and the contact is being established for longer hours ok and it always has long wares ok. So, it is a big setup and it is in the laboratory. So, you cannot do any kind of you know it does not have any kind of portability. So, this is one type.



Second type is ambulatory. So, this might be worn on the back of the head or on the belt lower down the body. Only a few EEG channels. So, here you can see lot many EEG channels ok. Mostly 16 channel, 32 channels EEG over research laboratory cases. Whereas, if you are talking about ambulatory, here very less number of channels present. So, you can see the accuracy level also is quite you know different than the research lab EEG. It can be used as an outpatient monitoring arrangement. So, if you want to do something at the field ok, those cases you can use it and it is cheaper than any other case ok. It also allows the patient to be monitored in their natural environment. So, that is why I said suppose you want to do some kind of study from the field ok. So, some worker is working in a particular field maybe at the workplace ok. There you would like to monitor their brain activity. For those cases this type of instrument is possible for you to introduce ok. So, first one maybe in a simulated condition whereas, the second one that is the ambulatory you can definitely use it in original like in at the real time situation ok. So, that is the benefit of this particular type of instrument.

Modality of measurements

Wearable

- It creates smaller and more discrete EEG units that are quick and easy to set up by non-trained users.
- It is normally based upon using headsets with arms that wrap around the head, rather than needing a full head cap.
- Focus on to low channels counts allowing quicker set ups and the collection of information at key point around the head, rather than full head montage.
- Example- Emotiv, Muse, Neurosky

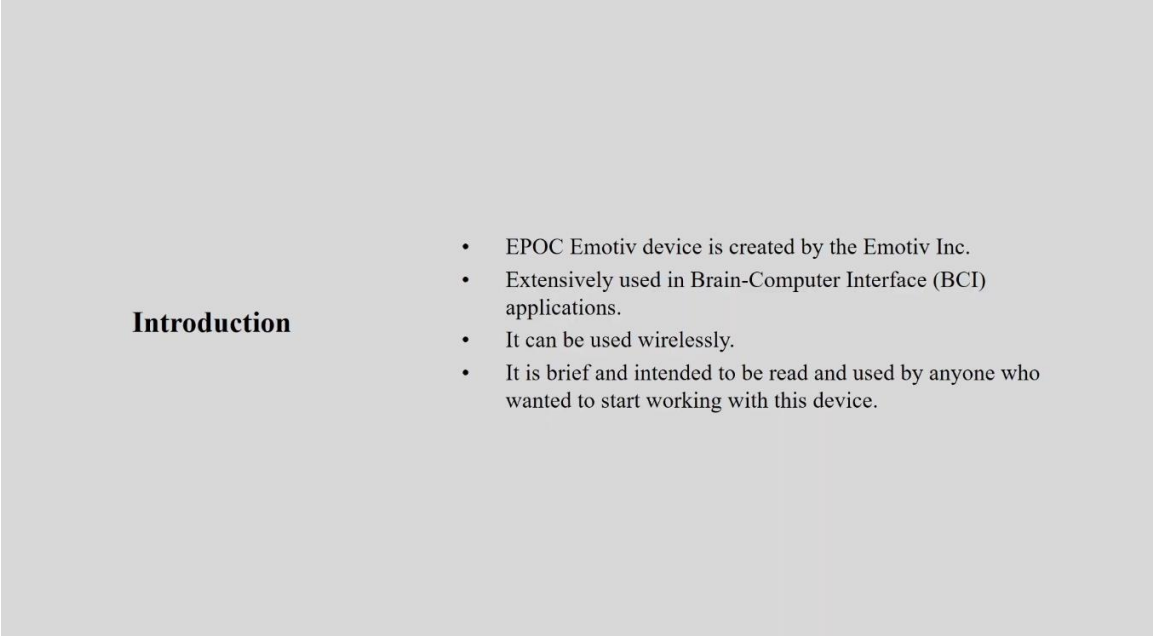
Now you have some instrument which is wearable in nature. It creates smaller and more discrete EEG units that are you know quick and easy to set up by the non-trained users because the positions are very clear. So, you have this particular thing and you have you know things are coming out right. So, if somebody is not trained enough to collect EEG still he or she can use it very easily because it is a specific guideline and the structure. Because of this headband it has a specific structure that can be just need to own it right. So, it is normally based upon using headset with arms that wrap around the head and rather than needing full head cap. You need not to have a full cap. So, you can see only small, small arm is coming out and there is the small electrode. So, focus on low channel counts of course, number of channels are less and allowing quicker setups and the data collection of information at key point around the head rather than the full head montage. So, example is emotive EEG, Muse EEG and all those things. For this cases you can have this type of synth system.

Beyond wearable

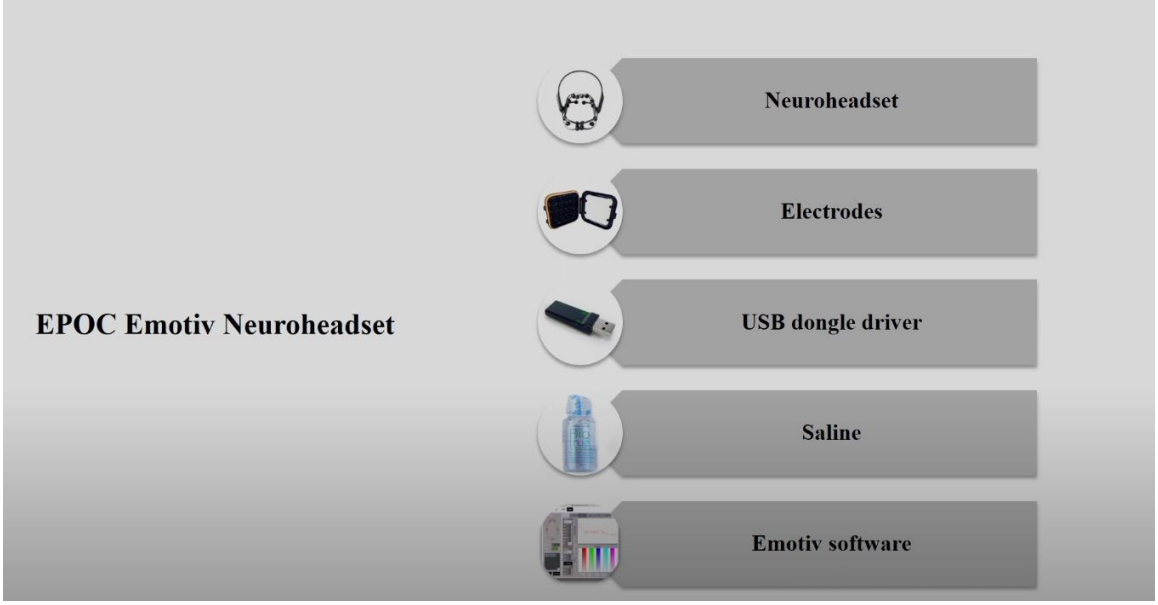
- It uses a hybrid approach of tattoos for non-haired regions and fingered electrodes for hair regions, or only non-haired EEG with signal processing used to project the ear or forehead based signals onto classical electrodes positions.
- Different types of approaches of EEG are present- Forehead, Ear approaches

Modality of measurements

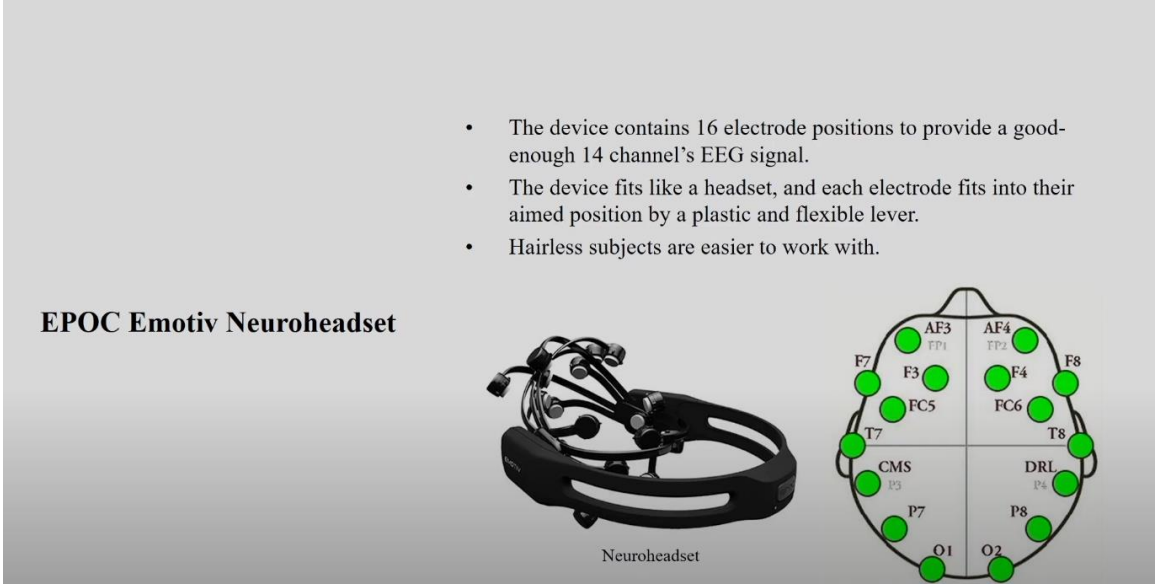
Then fourth one is the beyond variable ok. You can have something putting in this particular part ok. So, it is used as a hybrid approach of tattoos for non-haired region and fingered electrodes for hair regions or only non-haired EEG with signal processing used to project the ear or forehead based signals onto classical electrode position ok. So, you can see how these things are being placed. So, this type of things can be done. However, the kind of use is very different than the research or wearable EEG system. So, different types of approaches for EEG are present forehead, ear, so maybe somewhere here somewhere on the ear plug. So, that type of things are available ok. So, these are the basic varieties of EEG instrument which is available and then using any one of it based on your availability and your research objective you can choose that how what EEG potential or what EEG data you are going to use ok. Now, maybe in the next slides we are going to present that what are the varieties of systems available and then we will take you to the eye tracking latter ok. So, in the next class what we are going to do? We are going to introduce you the epoch emotive device ok, epoch emotive device that we are going to take in the next session. Till now I suggest you read this theory and then what you are going to do because these systems are quite costly ok. It is not available at all at all laboratory, it is not possible ok. But if you get a chance to see them, then you you are suggested that at least you visit nearest laboratory where you have this type of system, you check them, you try to see can you really use them based on this type whatever we have discussed. If you have any doubt on the lecture component and then use of the particular system maybe we can discuss it in detail.



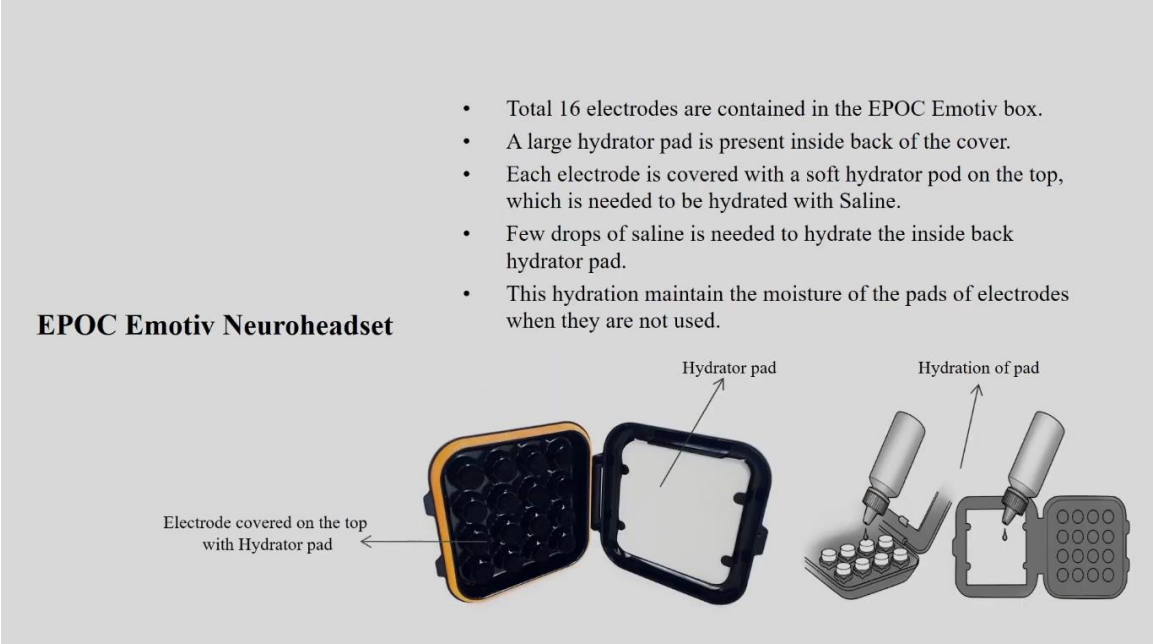
Now we are going to take a specific device that is the emotive EEG device and we are going to understand that how it is being used and what is the process to be followed if we would like to use this particular instrument ok. So, this is a very specific instrument, we call it epoch emotive EEG device. We have this instrument in the laboratory. So that is why I have taken this. You can have many other varieties and you can you can based on your desired objective you can use different other varieties of equipment. But this is a very specific which is connected to emotion, emotive device ok. So, let us start. So, epoch emotive device is being created by emotive named company and it is extensively used in the brain computer interface application. It is importantly when you should know this can be used wirelessly. So, whenever we are having some kind of experiment, where we need that wireless recording of EEG then we can use this particular type of device. It is very brief and intended to be read and used by anyone who wanted to start working with this particular device. So, you should read the basic documents before you start using this particular device.



So, if we go by the kind of components, we have in this epoch emotive EEG system these are the major component that we had. First is neuro headset. How it is we explained in earlier class that we need for recording of brain activity. So, we are going to record the electrical movement right. So, there what we need to do? We need to place the electrodes on the skull and there are varieties of electrodes available based on the type of instrument that we are using.

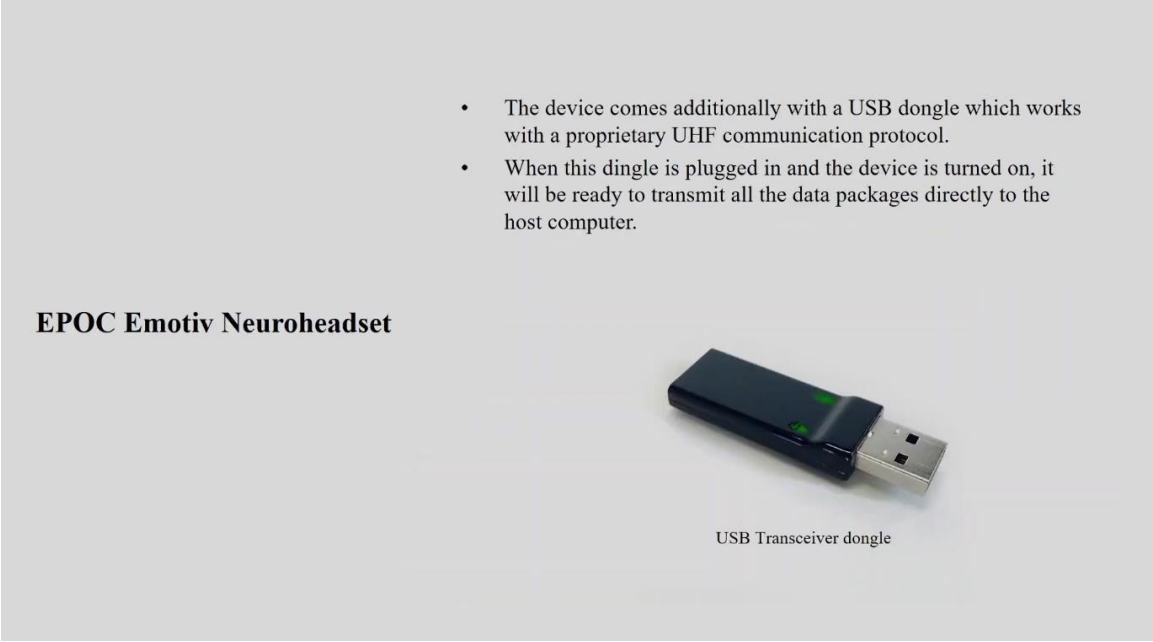


Here what neuro headset we have? It looks like this. You have the channels put in already and it can be owned. It is not a cap. It can be owned separately and you can put those electrode on the skull properly, so that you can have the recording. That is one component. That is the first is neuro headset.



The second one is the electrodes. So, you have a box of electrodes where you can store them and you can use it. We have a dongle USB driver. With that we are going to do the data capturing. We need some kind of saline and the software that is going to analyze the raw data that we are going to collect through this particular system. So, these are the major component we have when we are talking about epoch emotive EEG system. So, first let us understand what is this neuro headset. So, in actual it will be looking like this and you have position of electrodes like this in the this right hand cortex and then left hand. So, you have the positions of the electrodes specifically. So, this particular device will have 16 electrode which is positioned to provide a good enough 14 channels EEG signal. So, here with this particular device we are going to get 14 channels signal that you have to remember. We said that in other EEG we may have 16 channel and 32 channels like that. So, here we are going to get 14 channels EEG signal. The device need to fits like a headset like you are wearing a gear and each electrode fits into their aimed position by a plastic and a flexible lever. So, you have some lever system in this region and it is going to fix on your head on this scalp. If it is hairless if your subject is hairless then it is always good for us to handle the electrodes whereas if it is not then definitely there will be some kind of chances of displacement, repositioning and little bit of noise. So, that you need to take care when you are going to do the data collection. So, this is the basic neuro headset how it looks like. Now second is the electrodes where we are going to keep them and how it will look. So, you can see this is a particular box which will contain the all electrodes. So, total 16 electrodes are contained in the epoch emotive this particular box and a large hydrator pad is present inside back of the conveyor. Why if it is not hydrated enough then it will not establish the connection, it will not establish the contact. So, we need something which is required to keep it

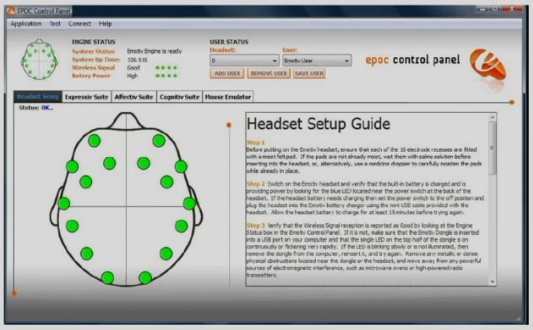
hydrated. So, each electrode is covered with a soft hydrator pod on the top which is needed to be hydrated with saline that is why in the whole kit we will have some kind of saline with us. So, few drops of saline is needed to hydrate the inside back hydrator pad and this hydration maintain the moisture of the pads of the electrode when they are not in use. So, if you are not using it for longer duration, it may happen that it is getting dry. So, if it is dry then there will be a difficulty to establish the contact between through the scalp and therefore, we will not be able to get the good result. So, it is mandatory. So, it is coming under the maintenance part. So, if you are using this particular instrument you have to make sure that it is hydrated properly in a periodic manner. So, if you are not using, if you are not doing any kind of data collection, still within some period of time you have to put the saline so that it remains in hydrated condition.



The third one is this USB transceiver dongle. Why it is required? So, this device comes additionally with a USB dongle which works with a property of UHF communication protocol. So, that is why we need it and when this dongle is plugged in and the device is turned on, it will be ready to transmit all data packages directly to the host computer. So that is this is the main component where you are going to have the data analysis, data collection, data storage and all those things.

EPOC Emotiv Neuroheadset

- Emotiv Control Panel program is installed on a computer.
- It is used to measure the impedance of each electrode.
- This displays indicators that provide real-time information about EmoEngine status and EPOC Neuroheadset sensor contact quality.
- It also exposes user profile management controls.

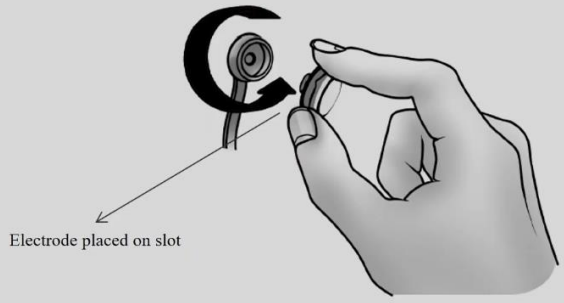


Emotiv Control Panel screen

The next is the kind of panel you are going to see on your screen. So, emotive control panel program is installed on a computer. It is used to measure the impedance of each electrode. It is going to measure that. So, see here you can see all these green things are right. So if it is not connected properly the colors will be different. I will tell you that what color it will be. So if it is not connected properly it will give some other color. If it is connected properly it is going to give you a green color. So this displays indicators that provide real time information about emo engine status and the epoch neuro headset sensors contact quality. It also exposes user profile management control because if you are using, if you are recording data, you need to know the details of the particular person of the particular experiment. So that things are available here.

Setup

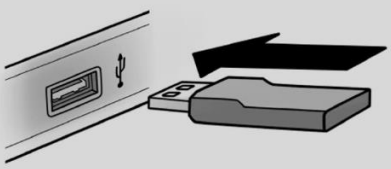
- The headset contains 16 plastic electrode slots.
- Each slot is a plastic cylinder which contains a golden electrode plate at the bottom of it.
- Small pads dumped with saline solution can be inserted on small plastic cases that can be screwed into each slot.
- These plastic cases can be bought separately and the entire set of electrodes can be replaced.



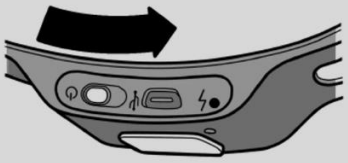
Now how do you set the whole thing and how do you do the data collection? So first is setup. So the headset contains 16 plastic electrode slot. So every slot as I mentioned I will go and show you back again. So here you can see you have slots right. So 16 plastic electrode slots will be there. Each slot is a plastic cylinder which contains a golden electrode plate at the bottom of it. Small pads are dumped with saline solution can be inserted on the small plastic cases that can be screwed into each slot. So you have to put and then you have to screw them. So that it is placed in a proper manner. If it is loose then you will not get the proper recording. These plastic cases can be bought separately because you know it may happen during data collection or for long years it is being damaged or many something goes wrong. So you can buy them separately and the entire set of electrodes can be replaced as well.

Setup

- Insert the supplied USB Transceiver dongle into one the USB slot's.
- Use a USB extension cable and position the Transceiver in prominent location away from monitor and PC to improve poor reception.
- Then turn on the headset using the switch at the bottom end of the headset, holding it close to the Transceiver.



Insert the USB Transceiver dongle



Turn on device and connect to dongle

So what you are going to do? Once these things are done you are going to insert the supplied USB transceiver dongle into the USB slot in your computer and use a USB extension cable and position the transceiver in the prominent location away from the monitor and PC to improve the poor reception. So that you have to maintain and then turn on the headset using the switch at the bottom end of the headset holding it close to the transceiver. So you have to maintain the distance. If it is very far, it will not initially establish the communication between your computer and the headset that you have to remember.

Important notice

Notice 1

- USB dongle works much better when it is attached to a USB extension cable, located around 50 cm from the computer.

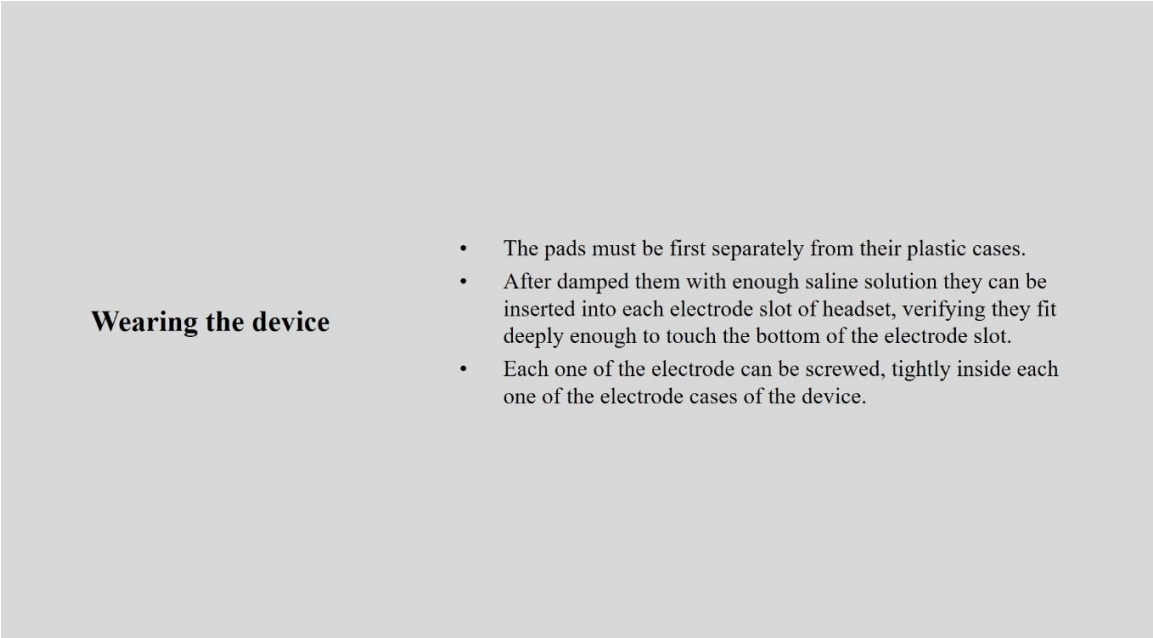
Notice 2

- The electrode pads should be lightly damped in saline solution
- As more dumped they are, the connection is actually better.

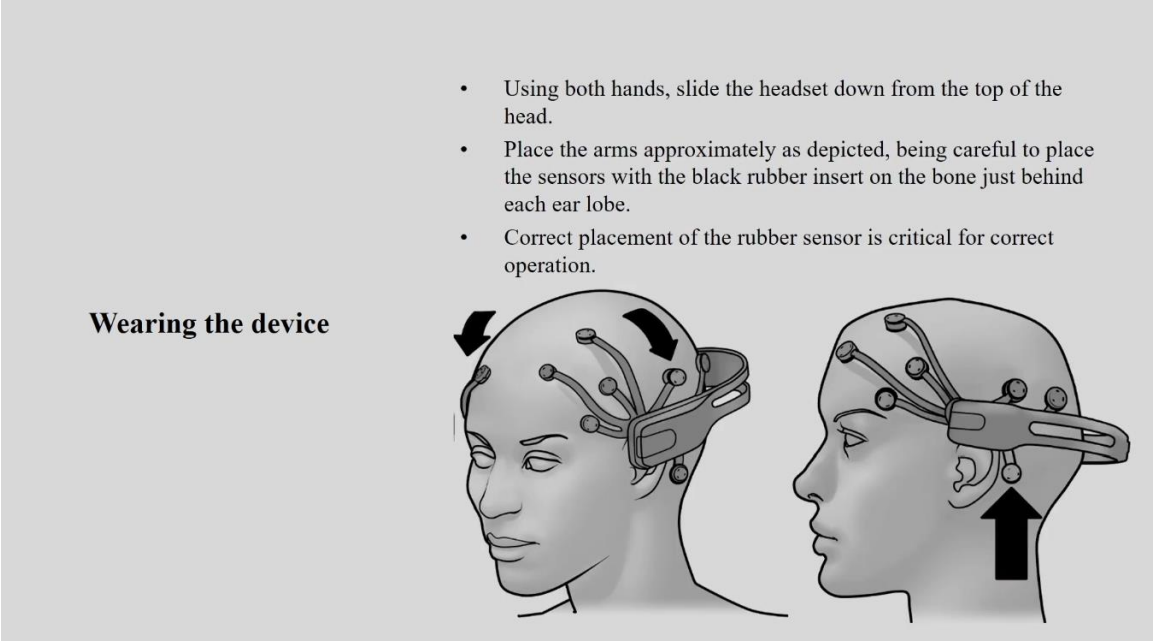
Notice 3

- The box where the electrodes are stored, contains a bigger pad that can be also dumped in saline solution.
- This will really helps to have the electrode pads wet enough for the next recording season.
- Otherwise they get dry and turn very rigid and it is much more difficult to damp them again to work properly.

Now here what are the things you need to monitor or you have to be careful? You may get several types of notices when you are actually starting the experiment. So there are majorly three types of notices are there. Apart from that also if something is different apart from these three, it also may come but these are the three prominent notices that you may receive while doing the setting up phase. The first one is USB dongle works much better when it is attached to a USB extension cable and located around 50 centimeter from the computer. So you need to be very careful that how far you kept the device. If it is very far you will not be able to establish the communication. Second one the electrode pad should be lightly dumped in saline solution as I mentioned because that is going to increase the contact. And as more dumped they are the connection is actually better. And third one is the box where the electrodes are stored contains a bigger pad that can also be dumped into this saline solution and this will really helps to have electrode pads wet enough for the next recording session. Because suppose you are doing the recording now and maybe after 15 days or maybe after a month you are going to record you do not know or maybe on the immediate next day. So if it is immediate next day definitely there is not much problem because you are going to again put your saline water and you are going to use it. However if it is a longer duration you need to make sure you are giving enough saline solution to this pad so that it remains hydrated. If by chance it is going it is getting dry then only you are going to have difficulties in the data recording phase. Otherwise they will get dry and turn very rigid and it is much more difficult to dump them again to work properly. So you have to make sure that it is not dry for when you are keeping it or you are not using it for some period. So this you have to remember.



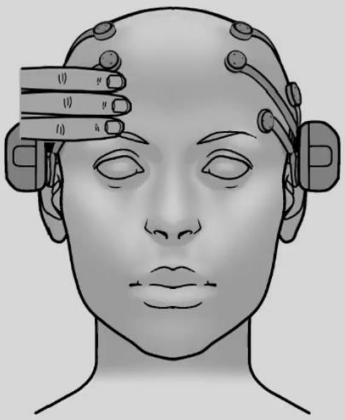
Now how do you wear the device? So the pad must be first separately from their plastic cases. You have to keep them out. After dump them with enough saline solution they can be inserted into each electrode slot of your headset. So on the headset you have selected slots. So you have to insert them, verifying they fit deeply enough to touch the bottom of the electrode slot. This is very important. So if it is not touching the bottom of the electrode slot what is going to happen? It is not going to get the or it is not going to capture the data from the scalp. So what you need to do? You have to make sure it is going the best. So each one of the electrode can be screwed tightly inside each one of the electrode cases of the device. So that you have to make sure.



Now how do you wear it? So here from the photograph you can see how person can wear it. So using both hands so you can put it like this inside the headset down from the top of the head and place the arms, these arms, this side and this side you have arms approximately as depicted in this particular figure being carefully to place the sensor with the black rubber inserted on the bone just behind your earlobe. So here you can place them. So you can clamp it like this. So correct placement of the rubber sensor is critical for correct operation. So it is not that at first day itself you will be able to do it properly as you keep on practicing how to insert it, how to place it probably you will be able to learn it. It is not that difficult, but at the very beginning you will not be able to do it correctly. So you have to keep on practicing. So it is a kind of skill that you need to develop while doing the data collection.

Wearing the device

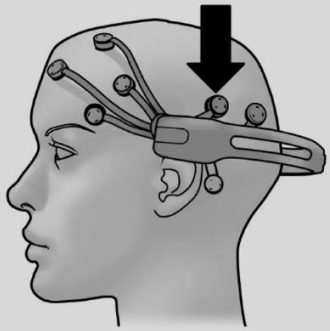
- The 2 front sensors should be approximately at the hairline or about the width of 3 fingers above the eyebrows.



So how do you place the electrodes? What is the kind of measurement you should follow? You should keep your these three fingers here. So from the eyebrow you should keep and the first electrode should come here. So you can see in this how it is being depicted. So this way you can understand where exactly the electrodes to be placed. So these are the reference point.

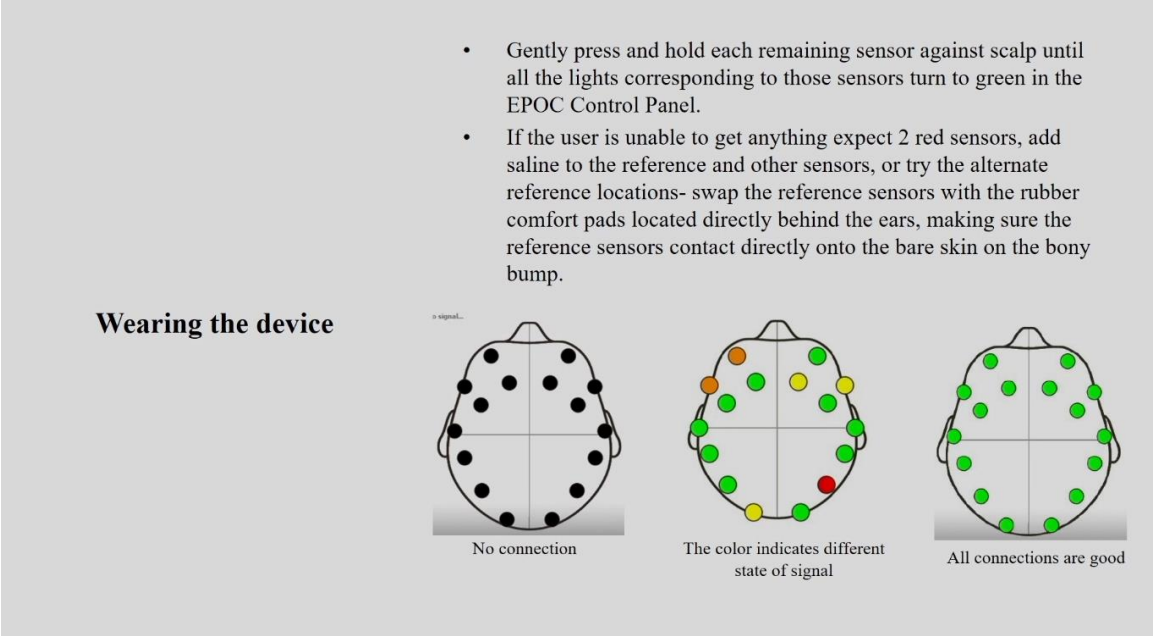
Wearing the device

- After headset is in position, press and hold the 2 reference sensors (located just above and behind the ears) for about 5 – 10 seconds.
- Once USB dingle is connected, a green light start to blink.
- Good contact of reference sensors is the key for a good signal.
- Check that the light corresponding to these 2 reference sensors turn from red to green in the EPOC Control Panel Setup screen.



Now after headset is in position you have to press and hold the two reference sensor for about 5 to 10 seconds. So why we are doing this? Just to locate just above the behind your eyes. So here. Once the USB dongle here it is a spelling mistake. USB dongle is

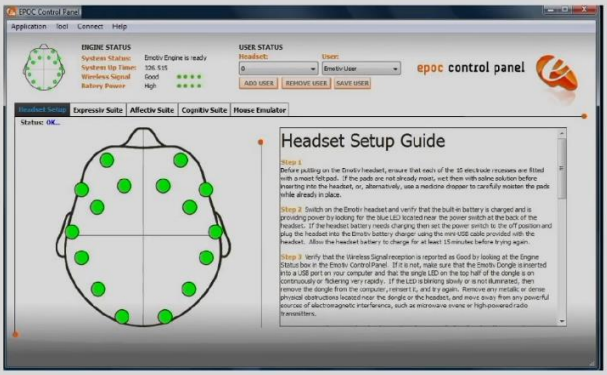
connected a green light will start blinking. So if it is the connection being established properly it will blink as a green light. So good contact of reference sensor is the key for the good signal. So if it is green that means the contact is being established correctly and you are going to get a good recording. So what you need to do? You have to check that the light correspondence corresponding to these two reference sensors turned from red to green in epoch control panel setup screen. So in the setup screen also you need to see how it is turning from red to green. Red means no contact, green means complete contact.



So here you can see the colors. So here you need to press and hold each electrodes remaining sensors against the scalp until all the lights corresponding to each sensor turned into green in the epoch control panel. So you can see the screen, you can see how it is being contacted. So if the signals are green that means contact is being established. If it is red then that means it is not being established. So if the user is unable to get anything expect two red sensor add saline because it appears that you know contact is not proper so you need to hydrate them. You have to add saline water. So here you can see the color indicates the different state of signal. So here it is red, here it is yellow, somewhere these are green, here it is orange, but here you can see that all channels are being placed properly and the contact is being established properly. That is why all electrodes are showing you green color and here it is no color. So it is a black. So that means no connection has been established. So that way you have to make sure that connections are being established. So till you are not establishing the good contact or all are becoming green actually you should not start the data collection process or recording process. So otherwise what will happen you will not get the result properly.

Signal quality screen

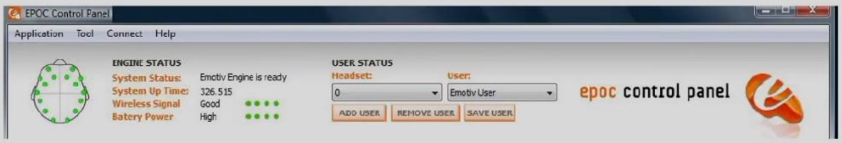
- The objective is to achieve as many green as possible using the EPOC Control Panel and adjusting the position of the various arms accordingly.
- EPOC will still function with some sensor locations showing yellow or orange, and will even cope with a few red or black however the detections will be less reliable in this state.



So the objective is to achieve as many green as possible using the epoch control panel and adjusting the position of the various arms accordingly. Epoch will still function with the same some sensors location showing yellow or orange. It is not that it will not give you result or it will not give the signal, but it is disturbed or it is not that as good as it is green. So we will even cope with few red or black. However, the detection will be less reliable in that particular case. So your aim should be all need to be green. If by chance something is going wrong, so only one is not giving you green signal, maybe you can continue, but you will have to remember there is some problem.

EmoEngine Status Panel

- The top pane of EPOC Control Panel is known as EmoEngine Status Panel.
- This pane displays indicators that provide real-time information about EmoEngine status and EPOC Neuroheadset sensor contact quality.
- It also exposes user profile management control.



EmoEngine Status Panel

So how to look at the status of the panel? The top of the epoch control panel is known as EMO engine status panel. So you are trying to understand what is the status of your current setting. This particular pan displays indicators that provide real time information about EMO engine status and epoch neuro headset sensor contact quality. It also exposes user profile management control.

EmoEngine Status Panel

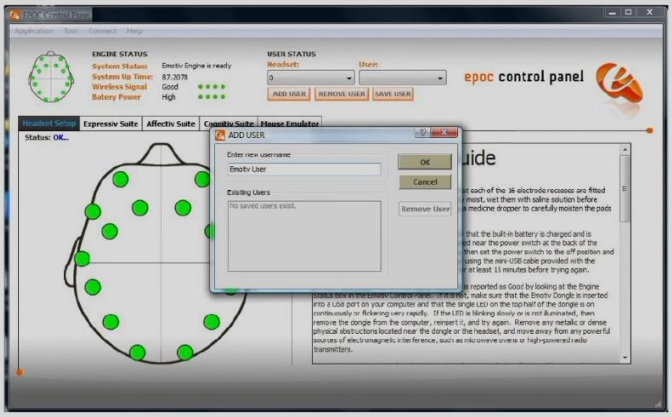
- **System status**: A summary of the general EmoEngine status.
- **System Up Time**: The timestamp (in second) attached to the most recently received EmoState event. Generally, this corresponds to the length of time that the EmoEngine has been running with an EPOC Neuroheadset connected to the USB receiver.
- **Wireless signal**: This displays the quality of the connection between the EPOC Neuroheadset and the Emotiv wireless USB receiver connected to machine.
- **Battery power**: Display an approximation of the remaining charge in an EPOC Neuroheadset's built-in battery.

EmoEngine Status Panel

Now how? So here you can see this particular screen. So it will give you the update about the system status. It will give you an update about the system uptime, how long it is up, what is the status of your wireless signal and the battery power. So that you are going to get from this particular section.

User Status

- Use the controls to manage user profiles and assign a specific user to a specific attached EPOC Neuroheadset.
- EPOC Control Panel only displays status information and detection results for a single EPOC Neuroheadset at a time.

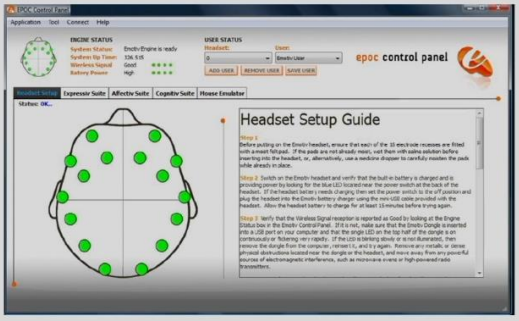


Add new user profile

So what is the kind of user status information we are going to get? So use the control to manage the user profile because when you are doing the data collection, you need to maintain the user's profile that you can manage through this particular panel and assign a specific user to a specific attached epoch neuro headset that is possible. And this control panel only displays the status information and detection result for single epoch neuro headset at a time. It is not that at a time it will show you two or three device. It will show only one neuro headset.

Neuroheadset up

- The head setup panel is displayed by default when starting EPOC Control Panel.
- The color of sensors circle is a representation of the contact quality.
  - Black color- No signal (not acceptable)
  - Red color- very poor signal (not acceptable)
  - Orange color- Poor signal
  - Yellow color- Fair signal
  - Green color- Good signal



Neuroheadset Setup Panel

So the net headset up like when you have this entire thing in place, how what I was talking about in the colors. So black color it says no signal. So if you see somewhere it is black completely that means there is no signal or the contact has not been established. Red color that means very poor signal. It is not acceptable. Orange color it is poor signal but still maybe you can go ahead. So also fair but not exactly or not a complete signal connection. And green means very good signal and you can go ahead with the green signal.

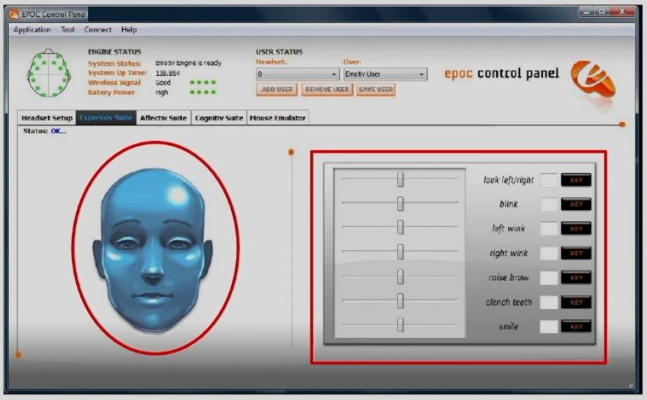
Expressive™ Suite

- It details the facial expressions and non-verbal communications capabilities of the EPOC Neuroheadset.
- Now, if you want to show facial expressions on your avatar, you need only perform them while wearing the EPOC Neuroheadset.
- You can display these expressions on the face of your avatar.

Now how do we understand the expression? So it details the facial expression. So you kept your headset over here. So now you are trying to understand the expression, facial expression and nonverbal communication capabilities of the epoch neuro headset. Now if you want to show facial expression on that particular face, this particular face we call it avatar, you need to only perform them while wearing the epoch neuro headset. You can display this expression on the face of this particular face. That is possible.

Expressive™ Suite

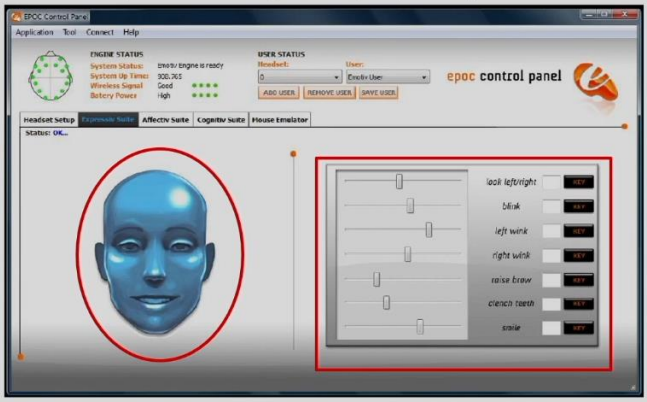
- On the left hand side of the panel, the avatar will mimic your facial expressions, in camera view.
- On the right hand side of the panel is the Sensitivity Panel.



So here you can see I mentioned I cycle it on the left side of the panel this particular thing will mimic. So suppose you are doing like this. So this face also will show you that mimic. And if you are doing something with this particular side it will also show here. On the right hand side the panel in the sensitivity panel. So you can see what is happening here. Blinking, left wing, left right wing, raised eyebrow. Suppose you are using your facial muscle you are using your eyebrow. So exactly what you are doing it is going to mimicked by this particular face showing in the panel.

Expressive™ Suite

- The Sensitivity Panel offers sensitivity adjustments for the Expressive Suite detections.
- For each facial expression, check the performance of the detection.
- Sensitivity can be increased or decreased by moving the sensitivity slider to the right or left, respectively.



The sensitivity panel offers sensitivity adjustment for the expressive suit detection. For each facial expression you need to check the performance of the detection. And sensitivity can be increased or decreased by moving the sensitivity slider to the right and left respectively. That you can do it. So here you can you have the slider you can do it.

Affective™ Suite

- It measures and displays a wide range of subjective emotional responses.
- Levels of interest, excitement, and engagement that experienced in a cyber environment are translated into graphical measurements on the control panel dials, and in some cases, into dynamically changing environments within games are played.

Now then what is the effectiveness? So it measure and display a wide range of subjective emotional responses. So suppose you are crying. So how emotions are getting changed? Level of interest, excitement, engagement. So suppose you are doing something with very lot of you know excite moment. So that thing so that can be experienced in the cyber environment is translated into graphical measurement. Here you can see all these graphical measurement on a control panel dials and in some cases into dynamically changing environment within games are played. Suppose you are doing some racing game. So what is the kind of concentration you have when you are playing? So you are rushing right. So what kind of emotions you are getting? So everything can be recorded in this particular or in this particular screen you can see them. It is recording is definitely happening that you can see them in this particular screen.

Affective™ Suite

- It reports real time changes in the subjective emotions experienced by the user.
- It currently displays 3 short-term and 3 long-term Affective detections: Meditation, Engagement, Excitement.
- Emotions related to Engagement are alertness, vigilance, concentration, stimulation, interest.

So it reports real time changes in the subjective emotion experienced by the user. So it currently displays three short term and three long term affective detections, meditation, engagement and excitement. And emotions related to engagement are alertness, vigilance, concentration, stimulation, interest all these things can be recorded. So here you can see the kind of information you are getting. Excitement then here engagement, here meditation. So what is happening? So you can see the changes in the graphs here. You can see the color. So in this particular case it is sky blue. So it is no change. Whereas what change you are getting here? Excitement you can see the graph of excitement here. So for this particular data there is something is happening in the field of excitement. So you can have this data available.

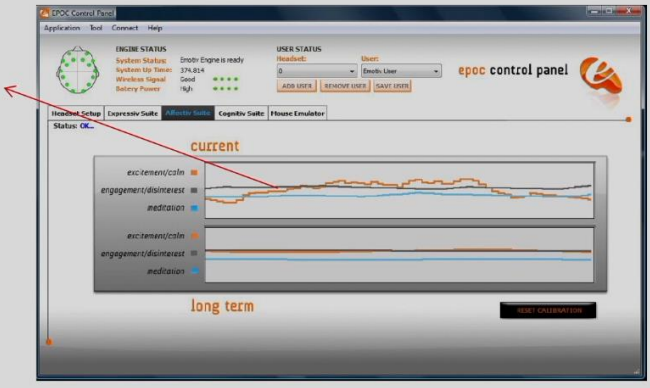
Affective™ Suite

- It contains two graph panes displaying the 3 Affective detections instantaneously and long-term average time scales.
- The top chart is configured to plot 30 sec of data for current and the bottom chart is plotted to display 5 min worth of data for long-term.

So it contains two graph pan, set 1 and set 2 displaying the three affective detection instantaneously and long term average time scale. The top chart is configured to plot 30 second of data for current and the bottom chart is plotted to display 5 minute worth of data for long term. So here you can see one set, here you can see another set.

Affective™ Suite

- Instantaneous Excitement is experienced as an awareness or feeling of physiological arousal with a positive value.
- Related emotions: titillation, nervousness, agitation.
- Long-term excitement is experienced and defined in the same way as Instantaneous.

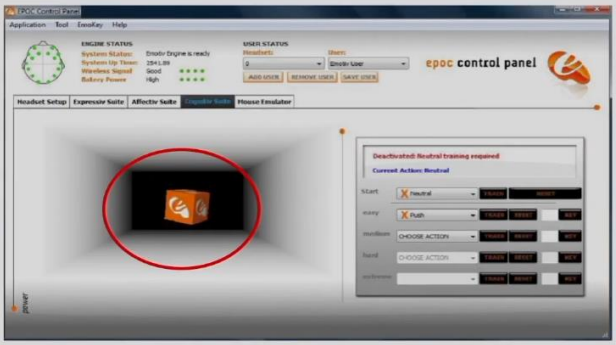


So, instantaneous excitement is experienced as an awareness of feeling of physiological arousal with a positive value. Related emotions will be some kind of nervousness, some kind of agitation that can be also recorded. And long term excitement is experienced and

defined in the same way as instantaneous recording. That can be also done and you can see from these recordings. Now coming to those was emotion.

Cognitive™ Suite

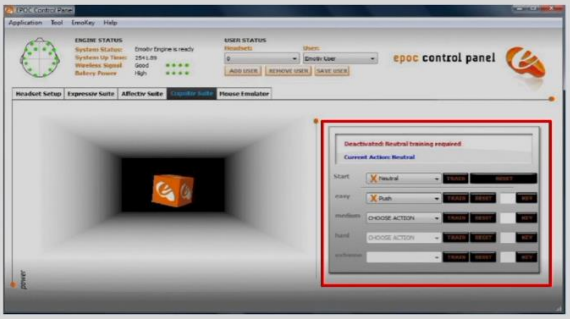
- It uses a virtual 3D cube to display an animated representation of the Cognitive detection output.
- It evaluates a user's real time brainwave activity to discern the user's conscious intent to perform distinct physical actions on a real or virtual object.
- The detection is designed to work with upto 13 different action: 6 directional movements (push, pull, left, right, up, down) and 6 rotations (clockwise, counter clockwise, left, right, forward, backward) and 1 additional action that exists only in the realm of the user's imagination: disappear.



Now coming to cognition or cognitive sight of it. So it uses a virtual 3D cube to display an animated representation of the cognitive detection output. So here you can see. So it evaluates the user's real time brainwave activity to discern the user's consciousness and intent to perform distinct physical action on a real or virtual object. That can be possible here. So the detection is designed to work with up to 13 different actions. Six are the directional movements like push, pull, left, right, up, down like that and six are rotation and clockwise, counterclockwise, left, right, forward, backward and one additional action that exists only in the realm of the user's imagination. Suddenly you are going to disappear. Some information was done and suddenly it is going to disappear. Some photograph is there, it is going to disappear. So such things also can be possible. So total 13 different actions can be performed in this particular case.

Cognitive™ Suite

- The 3D cube assists the user in visualizing the intended action during the training process.
- The information on the right panel displays the current state of cognitive detection and allows the user to define the current set of action.
- A green checkmark is used to indicate that the corresponding action has been trained.
- An orange ‘X’ indicates a lack of training data.
- Pressing the train button, the cognitive training process will start.

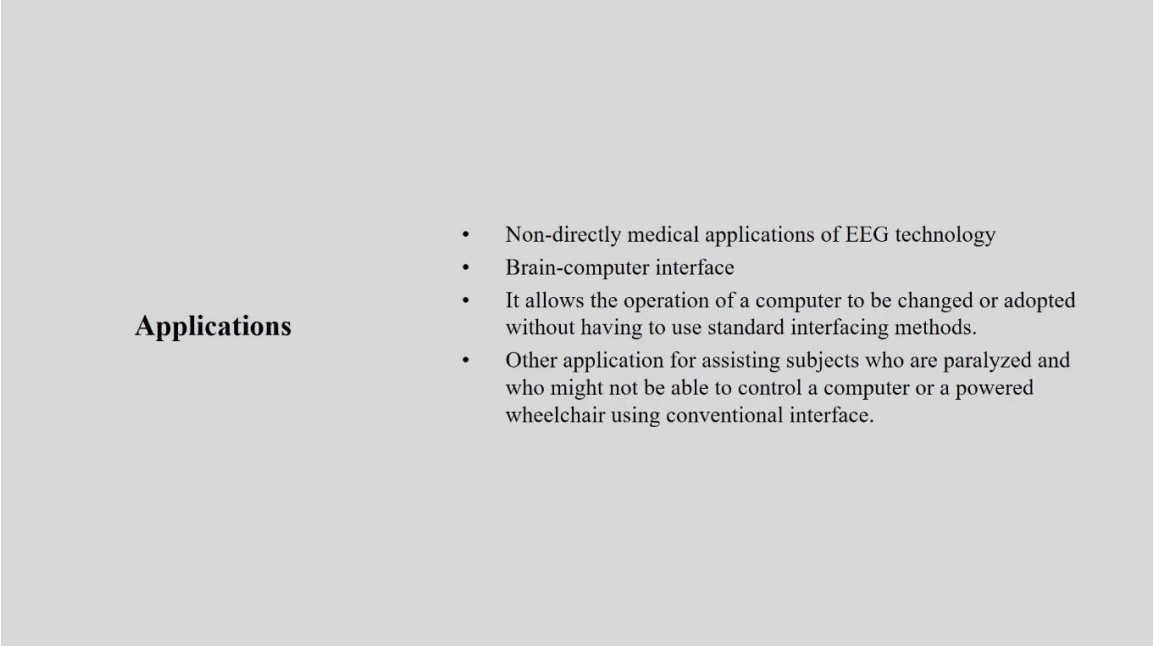


So the 3D cube assists the user in visualizing the intended actions during the training process. So this particular portion. The information on the right panel displays the current status of cognitive detection and allows the user to define the current set of action. So that you have to make sure that how the current set of actions are being planned. So that is how you are going to design your own experiment. A green check mark is used to indicate the corresponding action has been trained. An orange particular cross indicates a lack of training data. So if it is green, then it means training is done properly and now ready for data. So here you can see this cross, right. So that means training is not being done properly. So pressing the brain, train button, the cognitive training process may start. So if you are trained, then you can go ahead with the further step.

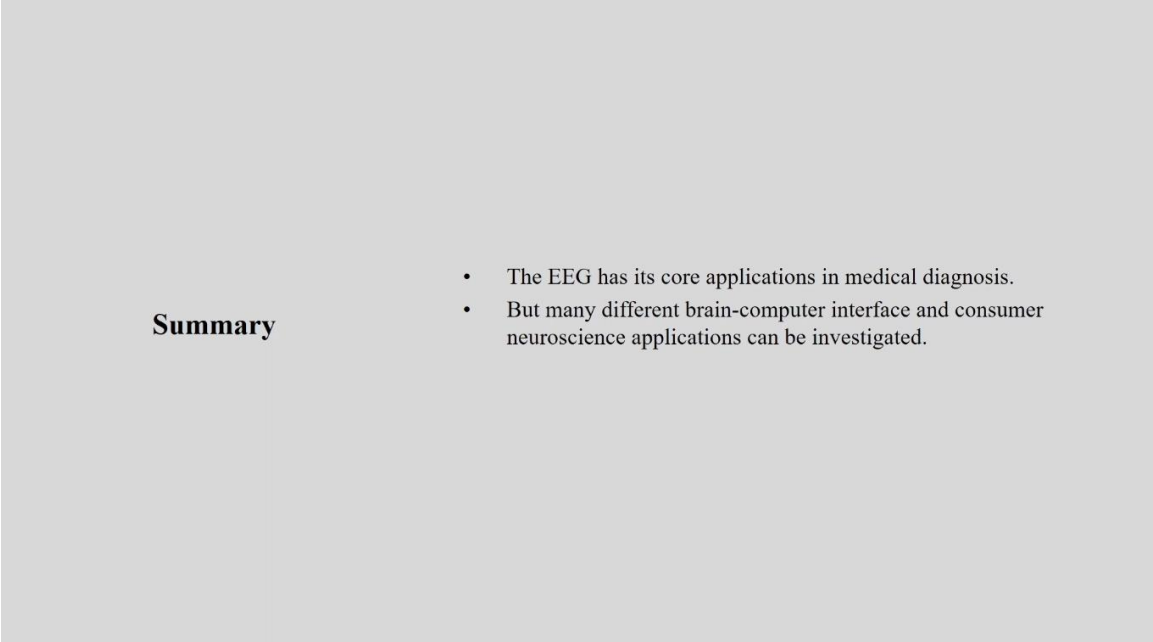
Cognitive™ Suite

- First, train a neutral state.
- Simply relax, act natural and clear the mind.
- Press TRAIN button to bring up the training screen.
- Press GO when you are ready.
- A progress bar will appear as your brainwave are observed.
- Once training is completed, you will be asked to accept or reject the training session by pressing YES or NO.
- Once you accept, you will be automatically returned to the Cognitive Panel Display.

So what you need to do? First you have to train a neural state. Simply you need to relax because you know it is a cognitive process that you are going to monitor and get the measurement. So you have to relax, act naturally. So it need to be like that the natural kind of environment. Although it is a simulated condition, still it need to be naturally equipped, okay. Then you need to clear your mind, press the train button to bring up the training screen. Here you can see it is a training screen and if you press go when you are ready, then the process will start. So a progress bar will appear as your brain wave are being observed. So already electrodes are there on your heads, right. So they are going to capture the data and they are going to see how you are going to get through the training, okay. So if it is happening properly, slowly the nature of this thing will change. So once training is completed, you will be asked to accept or reject the training session by pressing yes or no. So it depends. For each person, time will be different, mode will be different. From experiment to experiment, these things will be changing, okay. Once you accept, you will be automatically returned to the cognitive panel display, okay. Once you accept, your training is done, you will be back to the cognitive panel.



So these are the basic description, what are the things available for the epoch, emotive, EEG system. Now here I would like to say that exactly when you do or when you handle the instrument by yourself, there will be so many other things will come up, okay. This is very basic one, I explained it to you, but you should practice it if you want to use this instrument at your own place, you should practice it. It takes lot of time to understand each component of it and how to deal with them, okay. So it is not very, it is not always possible for someone to explain it theoretically, lot of practical experiences are required. Now I am going to tell where you are going to apply them, okay. So it is a non-directly medical application of EEG technology. So specifically in case of design, in case of you know emotion understanding, psychological field, okay, applied psychology, for those cases we use this type of instrument and the data for our experimental purpose. So brain computer interfaces for those cases also it is required. It allows the operation of a computer to be changed or adapted without having the use of standard interfacing methods, okay. And other applications for assisting the subject who are paralyzed and who might not be able to control a computer or powered wheelchair using conventional interfaces. For all these cases, this emotive EEG, epoch emotive EEG system can be used and you can further analyze the data and you can plan for the rehabilitation or you can plan for the design modification in the situation, okay. So these are the major application of this particular system. However, it is not only restricted to that, based on your understanding, your interest maybe you can do some more changes, okay. You can apply it somewhere else which where you can use this type of data.



So in summary, I would like to say the EEG has its own core application in the field of medical diagnosis. However, in the field of ergonomics, in the field of human factors understanding, in industrial situation, in design field, in psychological field, we can use this information and you can really understand the brain activity and accordingly we can do the intervention or we can do the changes. But many different brain-computer interfaces and consumer neuroscience application can be investigated using this, okay. So these are the applications. You need to really understand how to read the EEG. So that is huge area of research because we will not be able to explain it within short span of time. That is why we have excluded them from this particular class. However, if you have any query regarding the data reading, data interpretation and all those things, we can contact us back through discussion forum or via email or something, okay. That is all for epoch, emotive EEG and overall EEG system. In the next class, we are going to understand the eye tracking system, okay. That is also one typical method or typical instrument used that how we can indirectly understand the cognitive behavior of a person, okay. So that is all for today. Thank you.