

Ergonomics Workplace Analysis
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Lecture - 10
Neuroergonomics in Work Evaluation

Welcome back. So, when we are talking about from the beginning physical ergonomics, cognitive ergonomics, organizational ergonomics and varieties of tools and techniques that we are going to use and we are actually using throughout our research career and of course, you also now be much aware about all those things. At this point of time I would like to introduce a new very emerging field or very versatile area where lots of contribution are required from the sight of ergonomist. This is Neuroergonomics.

So, when we are talking about neuroergonomics I will just give brief introduction of this and how we are going to use this particular area for our advanced research and advanced teaching. That we will be talking for today's class.

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Definition	In simple words, it is the study of brain and behaviour at work (Parasuraman, 1998). This is the combination of two broader areas, which are also interdisciplinary. These are: neuroscience and ergonomics. The focus of neuroergonomics is mainly exploring the neural fundamentals of perceptual and cognitive functions in response to technologies and real-life settings. For example, seeing, hearing, attending, remembering, deciding and planning. It also investigates the neural basis of physical functions such as grasping, moving, lifting etc.
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So, let us understand what it is and how it is little different from whatever we studied in previous classes. So, let us understand this particular definition basically we are talking about brain and behaviour how these two relations are there when we are talking about

workplace. So, it is not very old concept; it is quite new. In 1998 first this definition or introduction of this particular area came into existence.

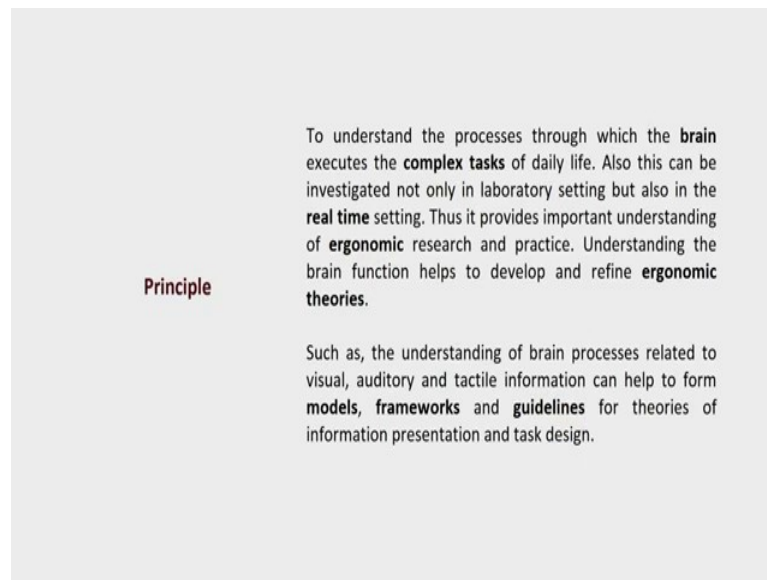
So, it says that when we study brain and the behavior and of these two combination at workplace; we will be discussing that neuroergonomics. So, this is the combination of two broader areas which are interdisciplinary in nature by themselves. So, one is neuroscience another is ergonomics. So, when we are actually merging these two concepts or two areas of interest together then only this particular field has been generated and we are actually practicing it.

So, the focus of neuroergonomics is mainly exploring the neural fundamentals of perceptual and cognitive functions in response to technologies and real-life setting. So, when we are talking about perception and cognition and what is the fundamentals exist behind these phenomena or this science. Specifically in context of technological intervention, technological evaluation or the kind of instrument we are using and in a real life situation that we are going to understand through neuroergonomics.

So, when we are talking about seeing, hearing, attending, remembering everywhere how the neural science is working and how that affects actually the human performance or the kind of activity we are doing at the working setup we will be talking here. So, it further investigates this particular subject or particular domain. No, I do not say subject; it is majorly a domain it mainly investigate the neural basis of any physical function.

Suppose we are talking about holding a particular object. So, when I am holding that what is the neural activity or neural behaviour is present. So, if I am going to study those aspects that will be and then if we transfer that those values or data in the use of ergonomic evaluation that we will be talking as neuroergonomics. So, what is the principle behind this?

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Principle

To understand the processes through which the **brain** executes the **complex tasks** of daily life. Also this can be investigated not only in laboratory setting but also in the **real time** setting. Thus it provides important understanding of **ergonomic** research and practice. Understanding the brain function helps to develop and refine **ergonomic theories**.

Such as, the understanding of brain processes related to visual, auditory and tactile information can help to form **models, frameworks** and **guidelines** for theories of information presentation and task design.

So, when we are talking about understanding the processes through which the brain executes a particular complex task of daily life. So, when we try to understand that process then this particular topic comes into picture. Also this can be investigated not only in the laboratory setting, but also real life that I explained in the first slide itself that always we are talking about these aspects in the real setting. So, understanding the brain function which helps to develop and refine the ergonomics theory. So, that is neuroergonomics.

So, let us understand what it does. It mainly helps to develop different kinds of models, frameworks and guidelines which we can use when we are talking about physical ergonomics, cognitive ergonomics or organizational ergonomics. So, how those neural responses are responsible to execute that particular job we will be talking about those aspects in the field of neuroergonomics.

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Possible Outcomes

- Design of more **efficient** and **safer** working conditions;
- Substantial **economic** benefit;
- Potential beneficiaries: developers of technologies, owners of the systems where the technologies are being used, general public and society at large if the technologies are used widely (as transportation and health care)

Overall, the whole agenda of ergonomics and human factors can be benefited by including the knowledge of brain activities.

So, when we practice neuroergonomics then what exactly we try to do; mainly we try to increase the efficiency of the worker as well as the safety of the person who is in that particular field. So, let us take an example or let us understand how we are going to do that.

So, the person when he or she is operating particular instrument or particular workspace or workplace he or she is interacting with those tools or instrument present at the workplace. Now, if I talk about physical ergonomics, maybe while using that or while operating that particular system lot of biomechanical stress are happening or generating in the body. When that is happening how my brain is behaving towards that and how that is actually maintaining my posture? How I am going to react on that if I understand those critical issues in terms of neuroscience then I may be able to develop some good intervention so that particular problem or issues are getting solved. So, that is the kind of outcome we are normally looking for.

So, of course, it should be substantially economic to the society as well as to the employer. So, mainly when we talk about this type of implementation who are the beneficiaries that may be a big question right because whenever we talk about implementation of ergonomics issues ergonomic intervention there is a question what is the cost, how we are going to implement it; the same question is valid here as well.

So, if we start answering those; here the main beneficiaries will be the developers who are developing those technologies like suppose I am going to use that technology. So, who is developing that because if the developer on the beforehand knows how the neural behaviour of that particular person who is going to use that technology they will be in a better position to answer that.

So, then the developers of course, those owners who will be operating those system also the general public and society if that particular technology is going to be used by the common public; if not those specific group of population who are going to use that. So, these people are the main beneficiaries for this particular neuroergonomic studies and researches.

So, overall the whole agenda of ergonomics and human factors of course, can be benefited because in ergonomics we are talking about the enhancement of productivity. So, whatever technologies we are developing if it is beneficial to enhance the productivity whatever the mean is then ultimately the goal of ergonomics will be achieved. So, that is why neuroergonomics is very important for ergonomics. So, let us understand few techniques.

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Basic Techniques

As this field is related to brain function, the **physiological measures** that gives more or less **objective** representation of it, are the basis of neuroergonomic techniques.

Most direct among them is **EEG or electroencephalogram**. This represents the summated electrical activity of the brain recorded on scalp.

Magnetoencephalography (MEG) consists of the associated magnetic flux that is recorded at the surface of the head.

There are also **event related brain potentials (ERPs)** which represents the brain's response to sensory, cognitive and motor events.

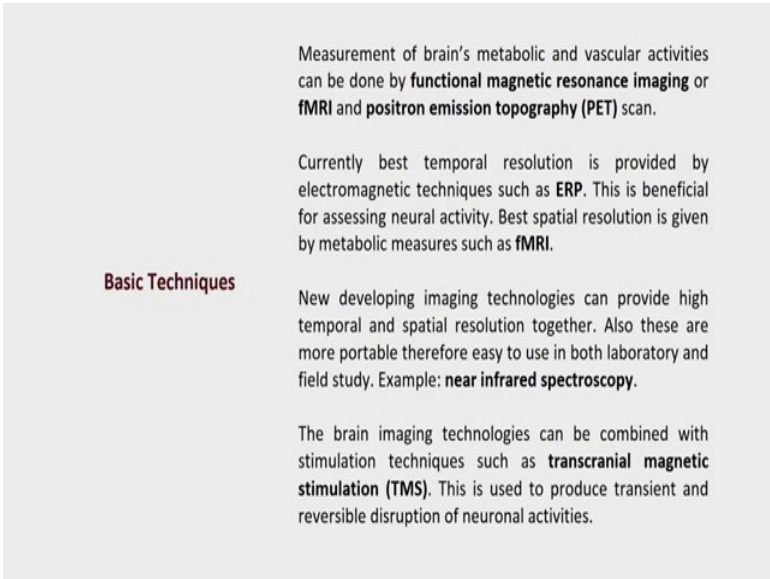
These all are electromagnetic measurements.

So, I am not going to elaborate this one in each technique wise but I will let you know that what are the varieties available. So, if you are interested you go; you can go back and check each one of them but if you have questions regarding the understanding of

these techniques you can come back and ask us ok. So, one of the very common instruments or common techniques that we try to use is event related brain potential or ERP.

It is very important concept what we use in case of neuroergonomics. Also we use magnetoencephalography. Here also we try to understand how the neural behaviour is happening or a how the neural activities are happening to answer or to react to the physical environment or the kind of product we are using ok. So, that is very important.

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Basic Techniques

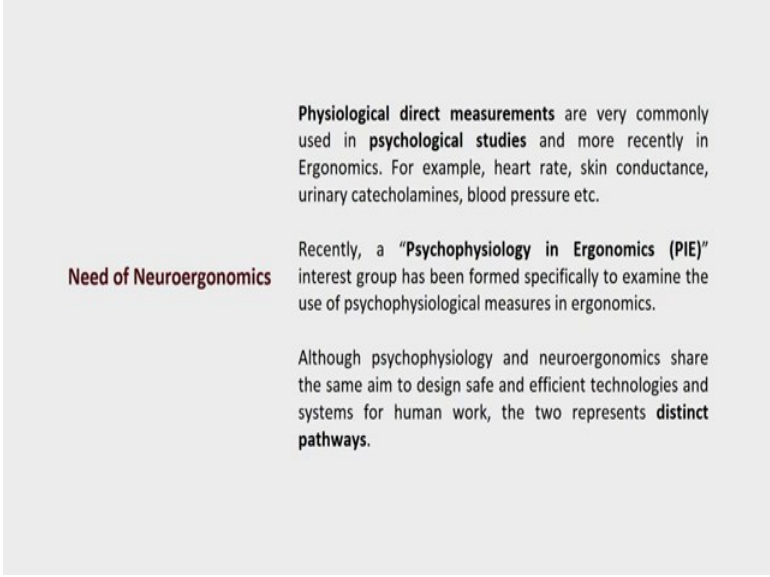
- Measurement of brain's metabolic and vascular activities can be done by **functional magnetic resonance imaging** or **fMRI** and **positron emission topography (PET)** scan.
- Currently best temporal resolution is provided by electromagnetic techniques such as **ERP**. This is beneficial for assessing neural activity. Best spatial resolution is given by metabolic measures such as **fMRI**.
- New developing imaging technologies can provide high temporal and spatial resolution together. Also these are more portable therefore easy to use in both laboratory and field study. Example: **near infrared spectroscopy**.
- The brain imaging technologies can be combined with stimulation techniques such as **transcranial magnetic stimulation (TMS)**. This is used to produce transient and reversible disruption of neuronal activities.

Now, also we have kind of different measurements like these two techniques like fMRI and PET we discussed it earlier in our previous few days back that we used when we are talking about EEG, ECG and all. So, these are some technique especially when we talked about EEG that how brain activities or brain brainwaves we are recording; we mentioned that these techniques like fMRI and PET are more powerful to answer the kind of reactions are happening within the brains. So, kind of responses are getting generated. So, this is very important.

Also in new developing imaging technologies whatever is available can provide the temporal and spatial solution together. So, which actually gives us an understanding how when time goes how the activities or how the reactions are changing within body. So, maybe it is physical maybe it is cognitional or in that case also neural behaviour. So, infrared spectroscopy is very important here.

Also we have transcranial magnetic stimulation. So, here also these techniques are important when we talk about brain imaging technology and using that we can really understand how the neural behaviour and how those things are can be recorded and analyzed for any kind of ergonomic intervention.

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Need of Neuroergonomics

Physiological direct measurements are very commonly used in **psychological studies** and more recently in Ergonomics. For example, heart rate, skin conductance, urinary catecholamines, blood pressure etc.

Recently, a **“Psychophysiology in Ergonomics (PIE)”** interest group has been formed specifically to examine the use of psychophysiological measures in ergonomics.

Although psychophysiology and neuroergonomics share the same aim to design safe and efficient technologies and systems for human work, the two represents **distinct pathways**.

So, physical direct measurement which we already discussed in our first few slides like first few classes basically are very commonly used at psychological studies; more recently in specially in ergonomics. So, heart rate, skin conductance, blood pressure etc. Now these things how is associated with the neuroscience, how these are actually talking about the performance, productivity. When we try to analyse that and link bridge that particular link then if we get to understand that then we will be able to develop such kind of product which is be very useful for the workers.

So, psychophysiology in ergonomics is this particular concept. So, psychophysiology in ergonomics is very upcoming field and they are basically using this neuro ergonomics. Now let us understand where the difference is between psychophysiology and neuroergonomics because terminology wise it looks very similar but these are not really. So, what is the difference?

So, the same we are talking about both are same in terms of if we are talking about aim of these two subject or two these area of research is to design the safe and efficient technology and the system for human work. When we are talking about all these

psychophysiology as well as neuroergonomics both of these research group are talking about the same thing; how to improve the human performance. But when we try to go back and see how they are doing that work the pathway the way of doing work or way of looking at the data is different. So, that is the distinct different features are available for psychophysiology and neuroergonomics.

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Need of Neuroergonomics

Firstly, the focus of psychophysiology is using physiological measures to observe their psychological correlates. On the other hand, neuroergonomics is mostly concerned around brain function. Physiological measures are used here to the extent of providing an index about neural activity.

Secondly, if the physiological measure has less relevance to brain function, such as HR and skin conductance, then the relevance to neuroergonomics is also less and indirect.

Thirdly, in psychophysiology, autonomic nervous system (ANS) plays an important role in relation to **somatic factors, emotion and stress**. In neuroergonomics, however, the role of ANS is mostly explored in relation to **neural activity and human performance**.

So, let us understand few of them. So, first when we are talking about psychophysiology the focus of that particular research area is using physiological measures to observe the psychological correlates. So, that only we do in terms of when we are talking about psychophysiology, but in term in case of neuroergonomics those research groups or those researchers are mostly concerned around the brain function.

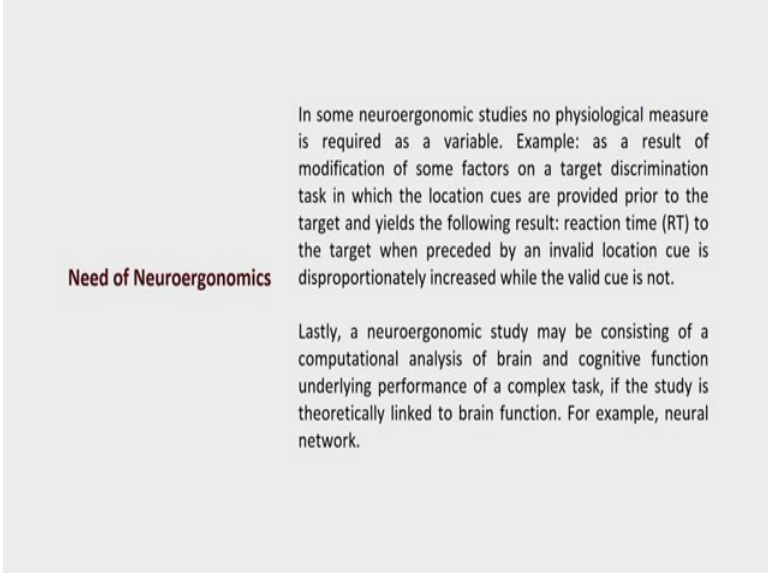
So, physiological measures whatever we get like they are also getting physiological measure, but they are getting those physiological measure to understand the psychological correlates, but here same physiological measures we are using it to understand the brain function.

So, the kind of work like how we are analyzing it; it is different. So, physiological measures are used here to the extent of providing an index about the neural activity that neuroergonomics does. Now take another different way or pathway. So, a physiological measures has less relevance to the brain function such as heart rates, skin conductance

then the relevance of neuroergonomics is also less and indirect but for the psychophysiology it is other way different.

Third in psychophysiology autonomic nervous system plays an important role in relation to somatic factors emotion and stress in neuroergonomics; however, the role of autonomic nervous system is mostly explored in relation of neural activity and human performance. So, it is the same autonomic nervous system functions we are trying to analyse but the objectives of those two subjects or researches are little different. So, that is why these two are different area of research.

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Need of Neuroergonomics

In some neuroergonomic studies no physiological measure is required as a variable. Example: as a result of modification of some factors on a target discrimination task in which the location cues are provided prior to the target and yields the following result: reaction time (RT) to the target when preceded by an invalid location cue is disproportionately increased while the valid cue is not.

Lastly, a neuroergonomic study may be consisting of a computational analysis of brain and cognitive function underlying performance of a complex task, if the study is theoretically linked to brain function. For example, neural network.

So, in some neuroergonomic studies no physiological measures are required as a variable; take example result of modification of some factors on a target discrimination task in which the location cues are provided prior to the target and yields the following results. So, one is reaction time to the target when preceded by an invalid location cue is disproportionately increased while the valid cue is not. This is just an example. The same way we have different scopes of neuroergonomics.

So, when we are talking about psychophysiology and neuroergonomics both all though looks very similar but it is very important to handle this two subject or two research areas differently. But of course, there are lot of scope where the same kind of data we can gather from one study and can use it for further a different way of interpretation for

different subject or different research area. That is why I thought that I will introduce this particular subject.

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Application Areas

Mental Workload and Vigilance:

fMRI observations has showed that **increased blood flow** in **prefrontal cortex** regions can be used to quantify **mental workload**.

Neuroimaging studies have helped to identify the differences among perceptual/cognitive, verbal/spatial, focal/ambient visual processing etc.

It has also helped to understand **working memory** which is the basis of mental workload.

ERP studies such as **P300** have contributed to understand **structural characteristics** of **mental workload**.

Spectral power in different EEG frequency is being used to understand **attentional resources**.

So, where mainly we use them? In mental workload assessment or vigilance assessment. Specifically as I mentioned that fMRI has big role. It is used as a kind of instrument or tool to for this particular research area. So, take example like fMRI observation has showed that increased blood flow in prefrontal cortex. If you have the blood flow has been increased in the prefrontal cortex region that can be used to quantify the mental workload. So, this is one technique.

So, we are trying to understand the kind of fMRI reading and if we see that prefrontal cortex has more blood flow we interpret it as that mental workload is high or it is more than the other one. So, this we may use it. So, to understand the mental workload and understanding the mental workload and doing the intervention or planning for the intervention is really a great challenge nowadays for ergonomists right.

So, because now currently if you see the current job pattern most of the work or work place has been changed from physical manual job to sedentary automated or semi automated jobs where mental workload is very prominent. So, mental workload assessment is very important. So, neuroimaging studies also help to identify the differences among perceptual and cognitive verbal and spatial, focal and ambient visual processing etcetera.

So, this is also important also when we are talking about fMRI or other techniques where we do the brain imaging and all. Working memory is also very important that also we can understand and through that we can take and take an account to understand the kind of performance or productivity they have at the workplace right. So, this specifically when we are talking about assembly line work.

So, the same monotonous jobs they are doing continuously how they are actually coping up with the context how they are actually coping up with the kind of stress they are getting; you know maybe physical stress wise like if you check heart rate, if you check the blood pressure maybe those are near to the base line, but that does not mean that they are not having exertion.

So, what kind of exertion it is and how we are going to do the intervention for them to understand all these details maybe this is one of the tool or one of the way we can go for intervention or specifically design modification that is one thing. Also spectral power in different EEG frequency also can be used to understand the attentional resources like do remember that we talked about alpha, beta, theta all these type of waves when we are discussed the EEG system write how the waves are.

So, if we get to understand how these waves are changing or how these waves are the; what is the pattern of those waves. So, then also we can interpret that how monotony of that particular job (Refer Time: 21:17) and how the mental stress people are getting when they are working at the work place and accordingly we need to plan for intervention maybe modification, maybe changes or maybe something very different that right now we cannot imagine.

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Application Areas

Adaptive automation:

Real time assessment of operators **functional state** is possible.

To provide Adaptive Automation (AA) at the optimal time, one needs to have real-time or near-real-time assessment with an accurate operator state classifier.

Examples are: discriminant analysis and artificial neural networks.

Neuroengineering:

Example: brain-computer interface (BCI)

So, one more thing is the adaptive automation. So, real time assessment is very important for operators in a functional state if it is possible. So, also to provide this automated adaptive automation the optimal time that we need to understand; one needs to have the real-time or near-real-time as real time assessment with an accurate operator state classifier right.

So, that also we need to understand and we can do intervention using these neuroergonomic techniques also neuroengineering mainly the brain computer interface. This is very new emerging field. So, actually lot of studies are happening but not really within India; we rarely get a research publication from Indian context. So, it is a very open field very challenging field. So, any of you are if you are interested for this type of work you can really come up with your proposals.

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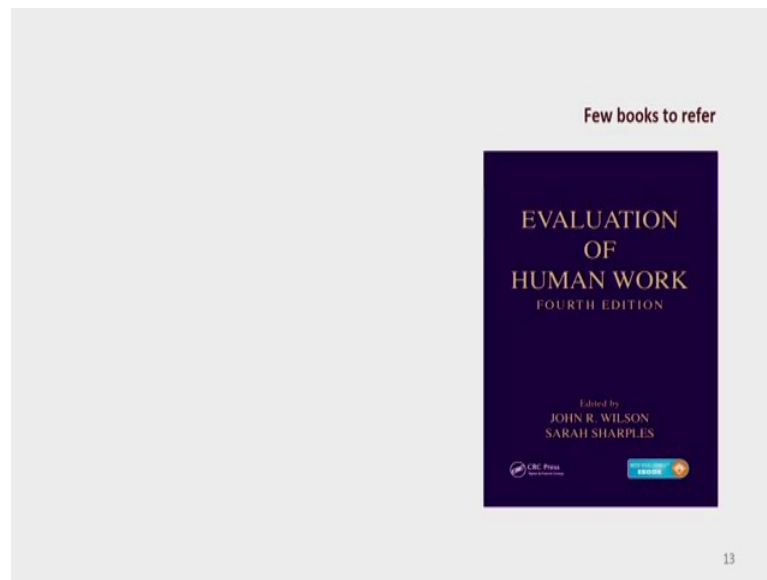
So, again error counting is a big question always from the time when we started practicing or we are doing or where working for ergonomics or working; we are practicing ergonomics right. So, here human error like if you try to see this particular function many physical counting is a very old technique right but this physical counting is not only just human error there are so many other errors associated for any particular task or any particular workplace situation.

So, how like neuroergonomics is a one of the big challenging area where we can classify it, we can specify it and we can give better design solution for reducing human error and as soon as we can reduce human error of course, productivity is going to increase which is the one of the goal of ergonomics.

Also we are talking about learning and skill acquisition which is going to happen if we develop the whole ergonomic work; whole work place in such a way that these elements are being taken care ok. So, learning and skill acquisition will automatically happen. So, these are the major area of application when we are talking about neuroergonomics.

So, as I mentioned in the first beginning of this particular class that I am not going to detail it out but I am just going to introduce this particular subject for you so that you know future research groups you are and you can start working on this particular field. So, this is the major resource book that I used for preparing or understanding this particular a domain or subject.

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Also there are many other books. So, whatever we are referring from the beginning. So, there are also we will get references and also I suggest you should study more of the research papers on neuroergonomics, main; basically these works are being carried out in different good institutes abroad. Right now we have very limited you know scope no, not scope limited resources available maybe especially as per my knowledge within India. So, being the young part counterpart; so, you are of course, can join and then start or building up this particular area of research.

Thank you.