Ergonomics Workplace Analysis
Prof. Urmi R. Salve
Department of Design
Indian Institute of Technology, Guwahati

Lecture - 09
Mental Workload Assessment

Hello everyone, today we will be talking about Mental Workload Assessment. Last class we tried to understand the physical workload assessment. So, this time we are talking about mental workload assessment because when we are talking about ergonomic workplace analysis or evaluation, definitely physical and mental both types of demand or workload assessment is important. Based on the results of these two variables like mental workload and physical workload we need to take decision that how we are going to changes those variables which is impacting on this workload.

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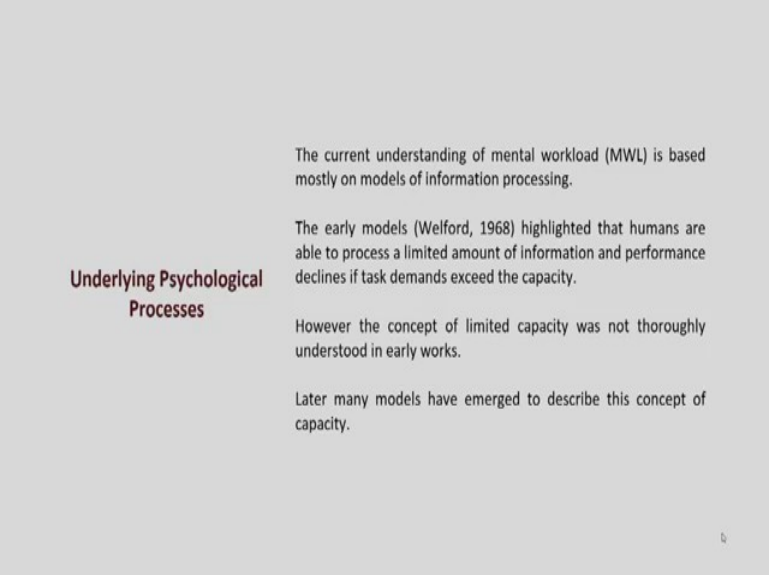

So, let us first understand what is mental workload and then slowly I will take you to what are the varieties of tools and techniques available to evaluate them or assess them. So, what it is? If you talk about mental workload in normal terminology or common understanding, it is mostly kind of models of information processing.

So, when we are talking about like passing on one information and if you remember that how the ergonomic work system or ergo system exist: major three components are one man, machine and environment. So, interaction happens. Information process from each

component like man to machine or machine to man and how these information processing is happening in case of human being. So, we will be talking about in terms of mental workloads. It is very old concept. It is not that we are talking about this type of mental workload assessment recently, it's a very old concept.

So, Welford in 1968, he explained it to a model and he highlighted that humans are able to process a limited amount of information. So, human being has some capacity or capability. We also discussed about this capacity in earlier presentation. He said that human being has limitation to process this type of information and performance declines. So, we are always talking about performance productivity and all those things. He mentioned that performance declines if the task demand exceeds the capacity.

So, the same concept what we are trying to follow in ergonomics that, balancing or optimizing the capacity or capability with the job demand. So, this concept sustain for physical as well as mental. Last time when we discussed about physical workplace assessment and how this has an impact in the ergonomic workplace assessment, it was very clear that if there is a job demand suppose load lifting or load carrying.

If your muscles are not having that much capacity then definitely your performance will reduce. So, what you need to do? You need to understand the capacity or capability of those group of muscles before you decide that this much load is suitable or this much load can be carried or pushed or pull or anything else.

So, same theory sustained for your mental workload. So, when he mentioned that when the demand increases or it is more than the capacity, definitely the total performance of the group of worker or the single individual worker will reduce or will decline. However, the concept of limited capacity was not thoroughly understood in earlier works those days. Now slowly we are having different varieties of model to know describe or elaborate this limited capacity. Later in many models we have, explanations of all these aspects.

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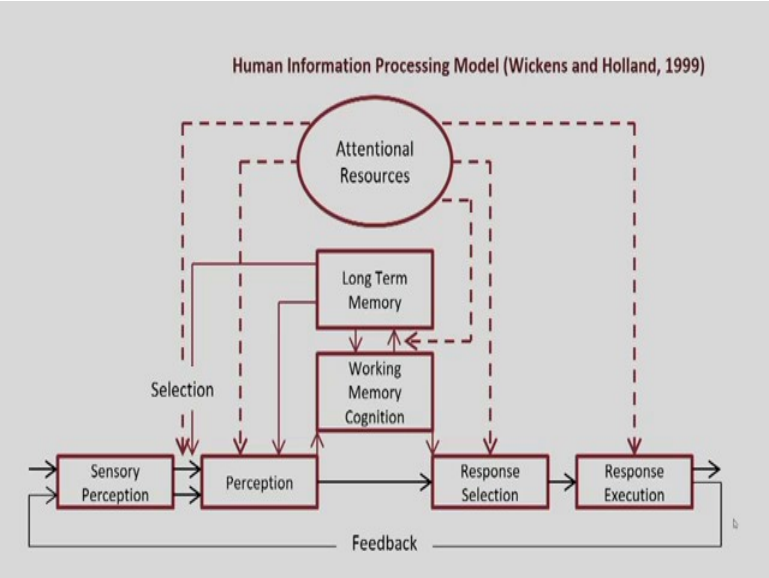

Now this is like a very commonly used model. It is developed in 1999 by Wickens and Holland. The whole model name is human information processing model. So, how this particular model actually works? Here two major components are long term memory and working memory. It has always two ways of information exchange. So, whenever we are working we think what happened earlier and we take decision again what is happening here, now it goes back and state for long term memory. So, these way it has both way communication. Now here one important component of this model is attentional resources. So, these has lot of influence in sensory perception, you have influence here response selection.

Now, when we are talking about response selection, for how I am going to receive or perceive that particular response either between man to man or machine and man. So, how I am receiving that and how I am again responding to that? So, response selection and response execution. When you receive some information, how you are executing then and it has a very closed loop. So, it is a continuous process, it does not stop. So, if a particular cycle of your job or task over than this loop gets break, otherwise it keeps on continuing. So, this is very very important when we are talking about human performance modeling like that.

So, this is the basic model based on that we have several other models, which also try to explain how these informations are getting process. So, when we are talking about job

capacity or capability of a particular person and the kind of demand we have, if we try to analyze that job demand and the capacity of a particular person through this; through this particular model, we will come to know where the problem is how the problem is. So, first we understand where the problem is, then we try to understand how, and then we try to answer how we can answer that particular how.

So, if we can clear that why the what is the root cause of that particular issue or problem may be it is a communication, maybe some information, may be some resources, maybe the lack of capacity to understand that, maybe coding, maybe the whole structure of the instrument, maybe the kind of panel is being designed for that instrument many other things. So, once we understand that, then only our role being an ergonomist will come into picture that how we can reduce that or minimize that or we can eliminate that.

Once we do that, probably what we will do? We will enhance or the performance of that particular person of course, which will improve the productivity of the whole system and that is the aim of an ergonomists. So, that we try to do.

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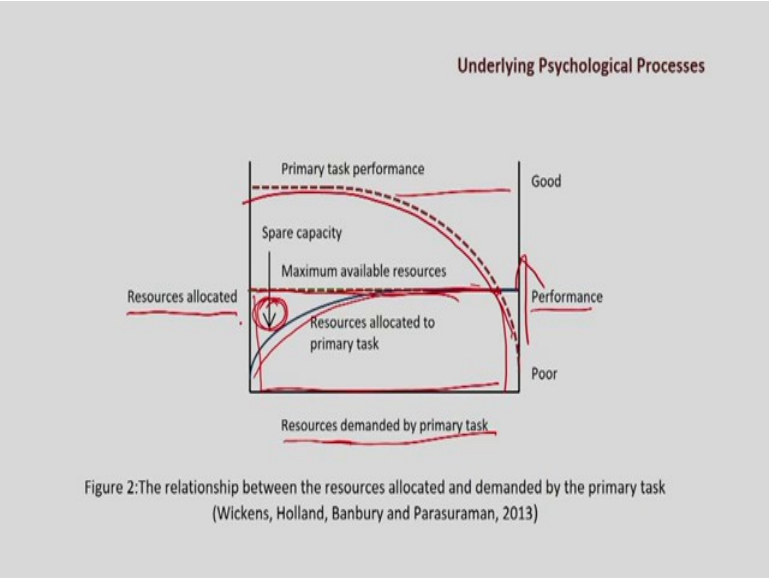

Figure 2:The relationship between the resources allocated and demanded by the primary task (Wickens, Holland, Banbury and Parasuraman, 2013)

Now, let us understand the psychological process of what happens when we are talking about mental load. So, it is again a very new model, it is developed in 2013. So, here three major parameter or variable we are considering; one is resource allocation. So, it is stands in this particular left access other is performance.

So, whenever we are talking about ergonomic evaluation finally, we are going to check with the existing system or with the existing situation or ergo system how my performance is. My means the worker's performance or operator's performance. So, the next variable is performance this is again in the y axis right and then here we are talking about resource demand by the primary task. Now I will be talking later in the about what is primary task and secondary task.

So, in this model we are talking about the primary task. Now you can see when we are in this particular zone; in this particular zone our resource allocation is going on this direction, we have a storage over here. So, we have spare capacity. So, given a chance or given a consideration where we need; we have more capacity. But if job demand is low definitely we will reach somewhere in the maximum level where we will feel good like our performance will be increasing.

Now of course, in a particular system there will be some limitation of the resources. So, maybe if we are drawing this particular line that is the maximum available resources, once it is done I will resources means not only physical component many other things. So, once we restrict that, if still the performance or the primary task demand increases then we may have scarcity over here.

So, here we have spare amount of capacity. So, we can improve our performance. But here we may have a difficulty. So, this particular model is in ideal condition. So, we are talking about how these all variables interact with each other.

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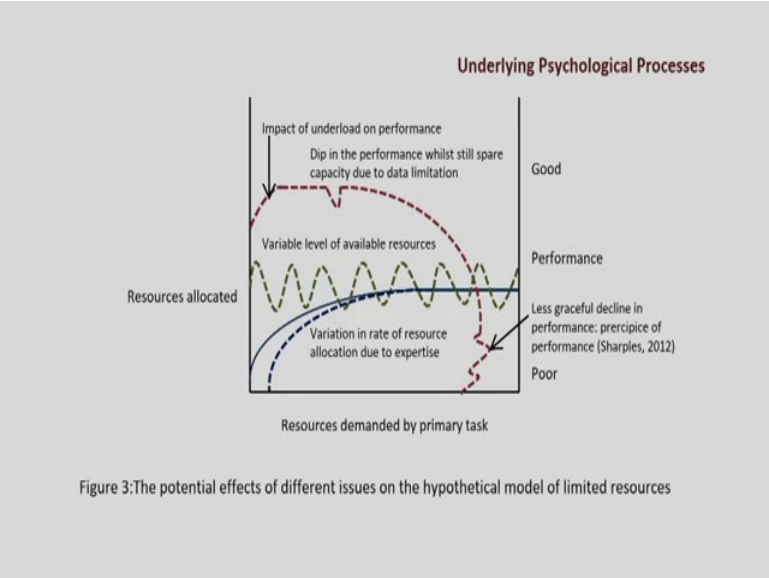

Figure 3:The potential effects of different issues on the hypothetical model of limited resources

Now, let us see what actually happens. So, if you see here all are not going properly. So, in this previous slide you have seen that maximum available resources is on the straight line, but in actual condition like where it is in practical situation. So, it happens like you know this. May be this is not only the actual nature maybe little more different. So, you have varieties.

Variables are same resource allocated, primary task demand and the performance that will be there, but the variables will behave in different way. So, you have to really understand that how it is happening. Again it is being tested by him how the poor performance can be justified or can be evaluated.

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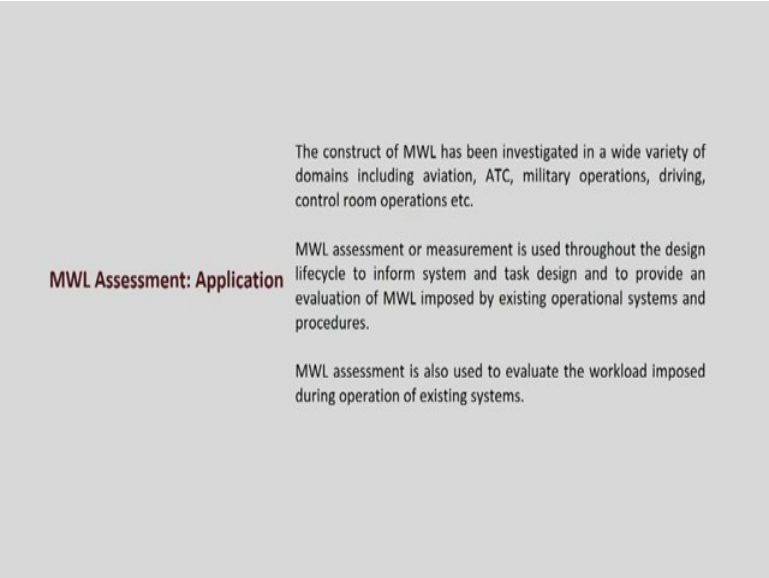

Now, when we are talking mental workload, we should understand when and where we should do and how we are going to apply mental workload assessment process and we can use those data for our evaluation purposes and redesigning. So, actually this mental workload assessment is started in the aviation industry and it continued for military operation, driving, control drone operation etcetera. Further I would like to mention that mental workload assessment or measurement is used throughout the design lifecycle. So, now, suppose you are designing a product or designing a particular service you really want to understand the way while using that product or while using or interacting with those product and services.

How the operator, how the responses are coming and how the mental performance is happening. So, you throughout your product development lifecycle, this particular assessment process is very very important. Also it is used to understand the whatever the existing systems are to understand those we need to do workload assessment.

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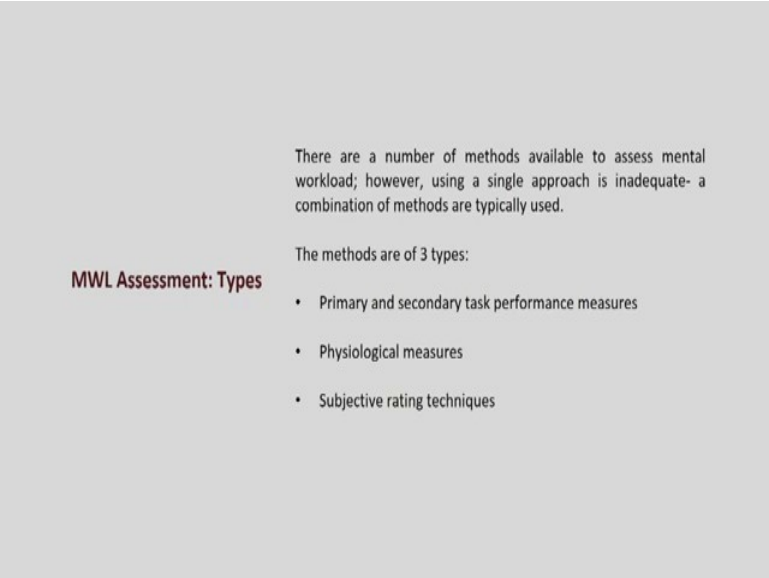

Now, when we are talking about workload assessment, we should know what are the varieties of measurements available ok. Major 3 types of measurement processes are there, but it is not very specific. So, that I should do the first one or second one or third one because depending on my objective of research of or understanding I can combine any one of them or two of them or three of them or I can use a single one as well.

So, again I am repeating the same concept what I am trying to explain you from the first day of my lecture is, always you should select tool, method or guideline based on your requirement, your context, your research objective, your you know hypothesis. So, based on that you can select. So, I will be describing all these three in detail.

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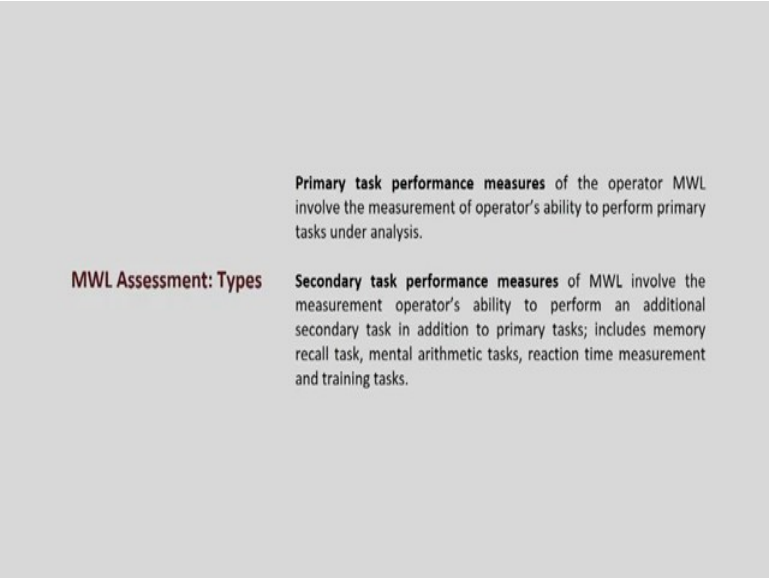

Now, when we are talking about types. So, we will let us understand what is primary task performance or task measure and then what is secondary task performance or measure. So, what it says that of the particular operator involves the measurement of operators ability to perform the primary task under analysis.

So, maybe in a particular job, we have varieties of operation or varieties of task. But for that particular job which one is the primary task? So, we need to understand that. So, once we do lot of other analysis like you know hierarchical task analysis or through physical understanding, observation, we will definitely be able to define for a particular job which one is primary task and which one is the secondary task.

So, concern is for primary task what is the ability? If you try to understand that will be the primary task performance measurement. Of course, the secondary will be like you know measurement of operators ability to perform and additional secondary task in addition to primary task includes memory recall task, mental arithmetic task, reaction time measurement, training task all those things.

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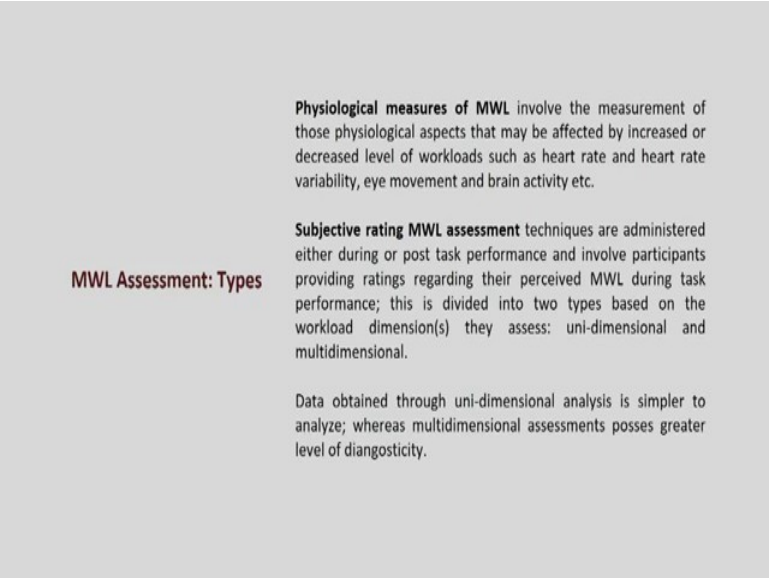

So, these are also very important. Also we should know physiological measure of mental workload. We can in short form call MWL. What it says? When we are talking about mental workload definitely it have an impact on your physiological responses specially your heart rate, your heart rate variability, eye movement, brain activity etc. You may not feel directly, but it has lot of impact. Suppose you are in a very mentally demanding job and you have less time to complete it definitely your heart rate will go high or maybe your EEG pattern will be very different as compared to resting condition.

So, you really need to understand or through measurement or assessment you can definitely define the kind of mental workload we have in that particular situation. The other thing is as we are talking about subjective response. So, like mental workload it is very much of your subjective response dependent situation. Because here adaptation, likeliness, my own understanding, my perception it affects your the responses of the subjective rating. So, that also effect the kind of workload I have. So, if suppose I need to do a particular job what is not of my choice may be kind of mental workload I will get impose on will be very high as compared to the other person or second person who is really happy to do the job.

So, for taking subjective response, the understanding of the pattern of response is very important when we are talking about mental workload. What is important over here to understand the kind of dimensions we get in the subjective responses. We have mainly

two variety: one is uni-dimensional another is multidimensional. Depending on the requirement you will choose what type of tool or techniques you are going to use for your research. So, there are varieties of tool some of them are uni dimensional, some of them are multidimensional. So, based on your requirement you can choose. Also contexts, validity you need to understand and then you can pick one of them to use further.

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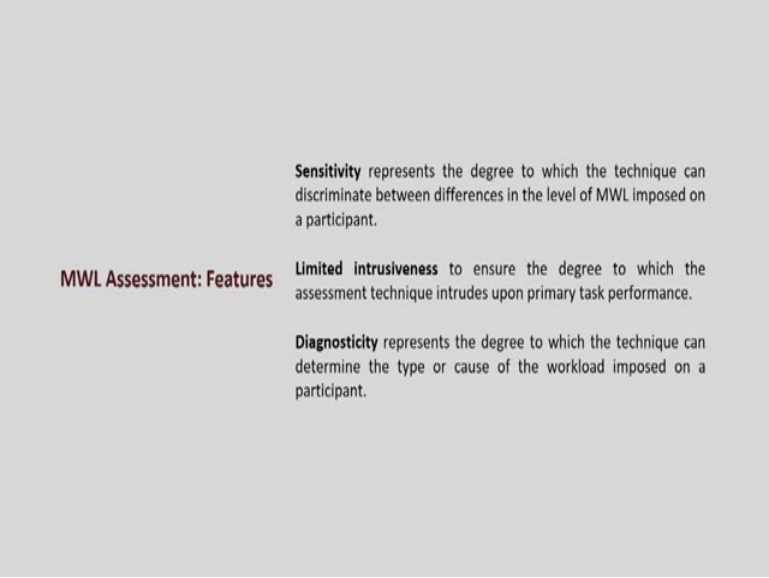

Now, when we are talking about mental workload assessment tool, we need to understand what are the varieties of feature it should have. Because without these features your result will not be showing the actual situation or your prediction maybe somewhere wrong or diverted from the actual situation. So, you should understand the sensitivity, you should understand the limited intrusiveness, you should understand the diagnostic capacity of this particular tool also global sensitivity, transferability, ease of implementation these all are the features should be looked into before you choose a particular tool or technique for assessing the mental workload.

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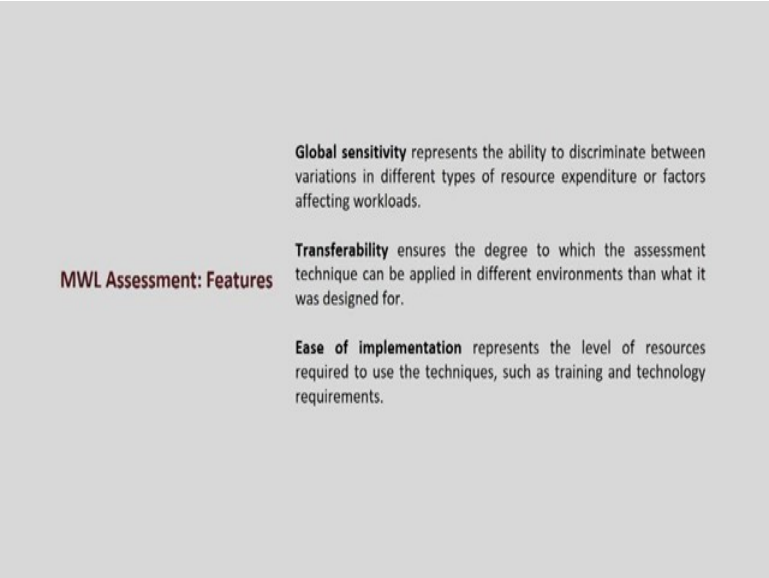

So, you should understand based on your requirement you may choose any one of them. So, everywhere all these features are not equally distributed somewhere it is high, somewhere it is low. So, based on your type of research, your research design you need to choose any one of them.

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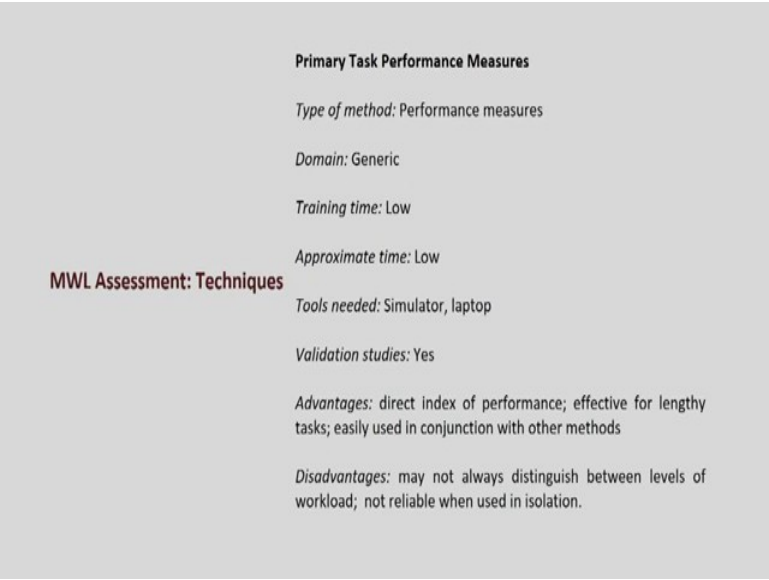

Now, let us understand what is primary task measurement or task performance measurement. So, it is a method mainly we follow is the primary performance measure. So, you are actually measuring the performance. It is very generic in nature. It requires

very low training and the kind of time or kind of duration you should spend for this particular tool is very low. But yes it is a valid study. So, you can use it. It needs very limited amount of infrastructure, that is, only a simulator or laptop. So, what is the advantage? Advantage is it direct index of performance. So, it is gives exactly a particular index. So, effective for lengthy task, so, suppose a task is long enough for 2 hours or maybe 50 minutes for those type of task, we can use it easily can be conjunction with another method like you can use primary task performance measurement as well as a subjective rating.

Then you can have a better understanding how it is in actual. But it has some disadvantage as well because it may not always distinguish between the levels of workload. So, you know very specific levels are not possible to determine. It is not reliable when it used in isolation. So, suppose only this as a tool if you are using and trying to say this is the level or mental workload is this much, then maybe you will not get the success. So, probably it should be used in conjunction with the other relevant tool. Similarly we have secondary task performance because again it is a performance measurement as similar as the primary task measurement the required time, tools, validation are also same.

Here the advantages it is sensitive to workload variation, because when you are talking about primary task and secondary task. So, how what are the varieties available for your secondary task? You can easily come to know and you get a very quick review of this particular tool. But sensitivity as a whole is slow so, you should be very careful to use this as a single individual tool.

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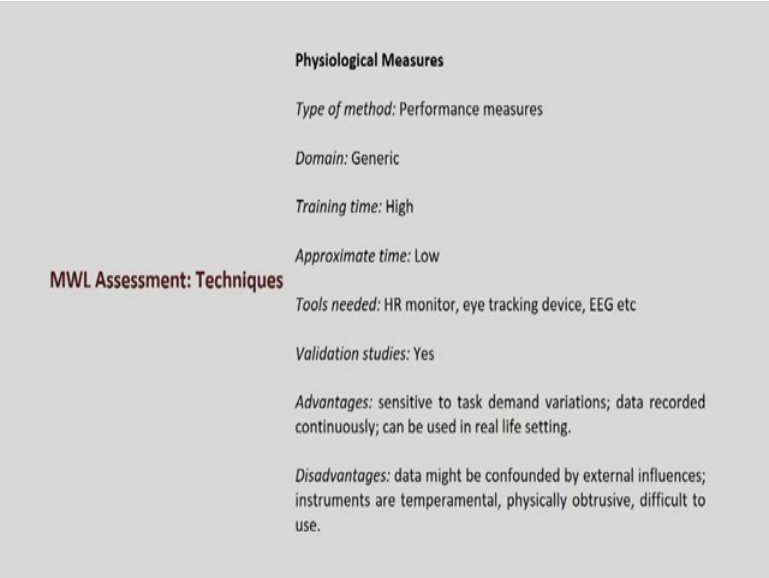

Now physiological measure you know it is again a performance measurement tool and it is generic. But yes while you are using this type of instrument or technique to measure, you really need high amount of training. So, you should understand sensor, you should understand positioning, you should understand which context you are using all the details scientific knowledge you should have before you start you know collecting data for this type of technique.

So, mainly heart rate monitor, eye tracking, then EEG is being used for you know physiological measurement. So, as per as the advantage and disadvantage is concern, it is very much sensitive and tasks variation like if you have very minute deviation from one task to another task, you will get a difference in the result. So, it is very much sensitive. Data is recorded continuously- very important. So, you will get a full data set. Also you can use it in real time situation. So, may be somebody is working in the shop floor if you want to use it, you can you know put those gadgets and instruments and you will get a continuous recording of it based on the provisions like we have some instrument which is telemetry in nature.

So, you can continuously get the data without you know affecting the normal process or the movement of the worker. It is possible. But as per as the disadvantage is concerned, it may have some external influencing factor which is very difficult to interpret many time. This particular instruments are very costly sometime physically obtrusive, difficult to use

you need to have lot of training before utilize or use this particular types of instrument. So, you should be very careful when you are choosing as a variable the physical measures to understand the mental workload.

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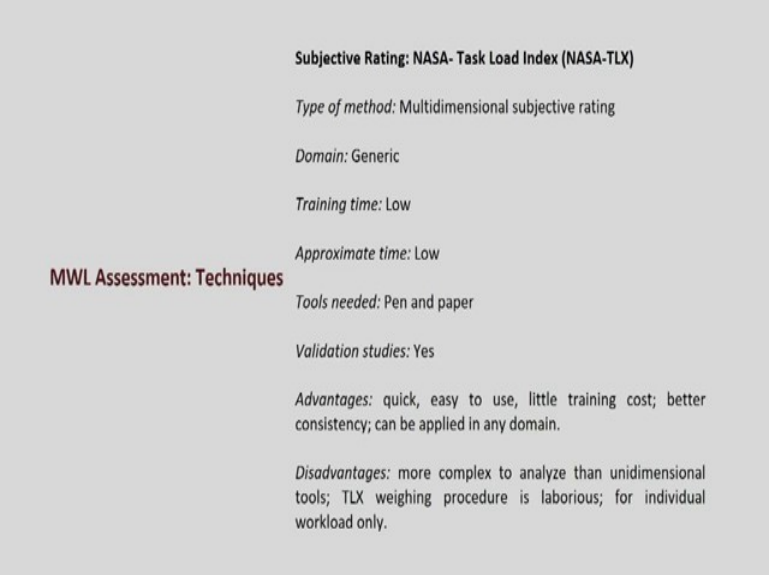

Very commonly widely used tools are subjective rating tools. There are so, many numbers I will explain few of them, let us first explain about the NASA TLX; TLX stands for Task Load Index. It is very very useful tool as per us this you know subjective rating of mental workload is concerned. Here this particular tool is multidimensional subjective rating it does that. Training is very simple so, you really do not need to do much of training.

Time requirement is very less and being a subjective rating scale, it needs simple pen and paper. So, it is quick easy to use little training cost better consistency and can be applied in any domains. So, it is validity is very high. Now still we have some disadvantage more complex to analyze the uni dimensional tool because you know as it is a multidimensional you have varieties of vectors.

So, you really need to put lot of attention over there because if it is uni dimensional in it is very to easy for easy, but here it is a problem. TLX doing procedure is laborious because once you collecting data is not much problem, but when you try to interpret it needs little bit of more concentration more labour for individual workload only this particular tool can be used, if it is a group work you may not use it properly.

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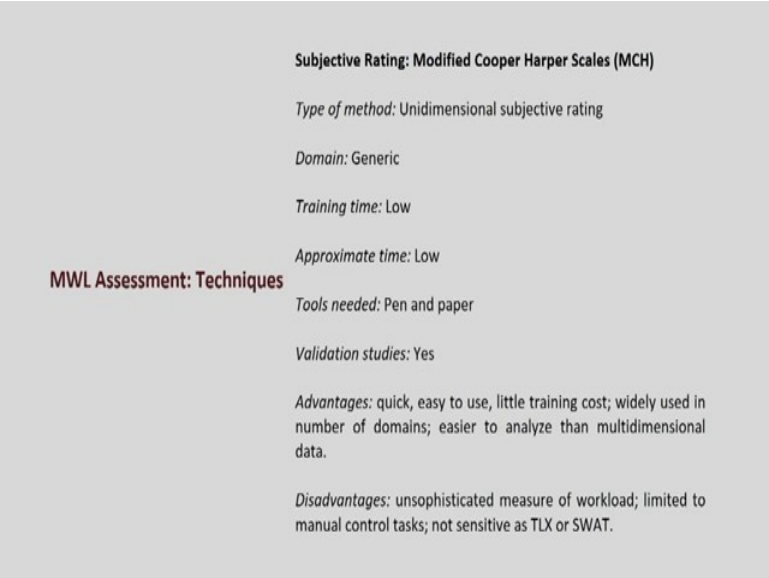

Now one more tool that is the modified Cooper Harper scale the same kind of tool, but the difference is here it is unidimensional subjective rating scale being a subjective rating scale again pen and paper we are going to use similar to NASA TLX it is leads needs very little cost widely used in number of domain, easier to analyzed then multidimensional data.

So, very important, but we have some disadvantage as well. What it is? These are unsophisticated measure of workload, limited manual control task, not sensitive to it is its not that sensitive as the NASA TLX and SWAT analysis I will tell about SWAT later.

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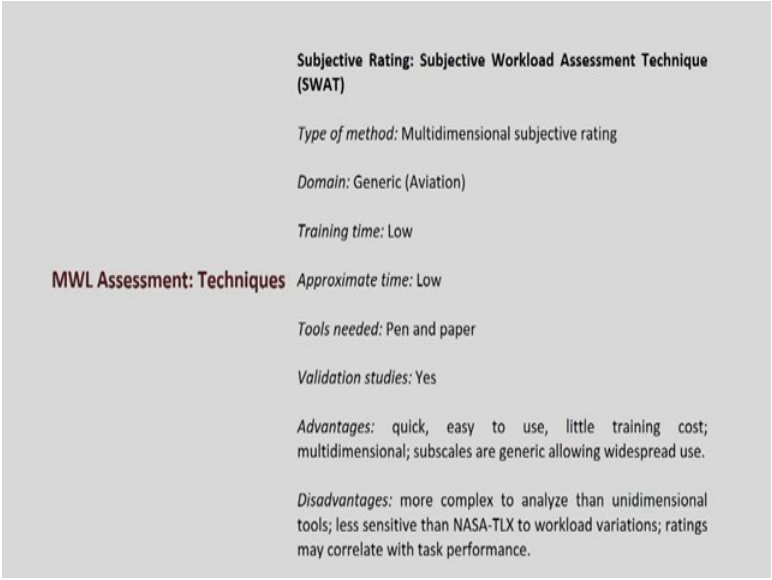

Now, let us take example of subjective workload assessment technique that is SWAT. So, SWAT it is again it is a multidimensional as the NASA TLX mainly it is being used in the aviation industry although it is a generic. But still same pen and paper it is quick easy to use, little training cost multidimensional subscale are generic allowing widespread of use. So, definitely you can use this for your own mental workload assessment.

So, NASA TLX what these comes under similarly you know these are multidimensional and you can get varieties of you know orientation direction to understand where the intervention can be so, very very important.

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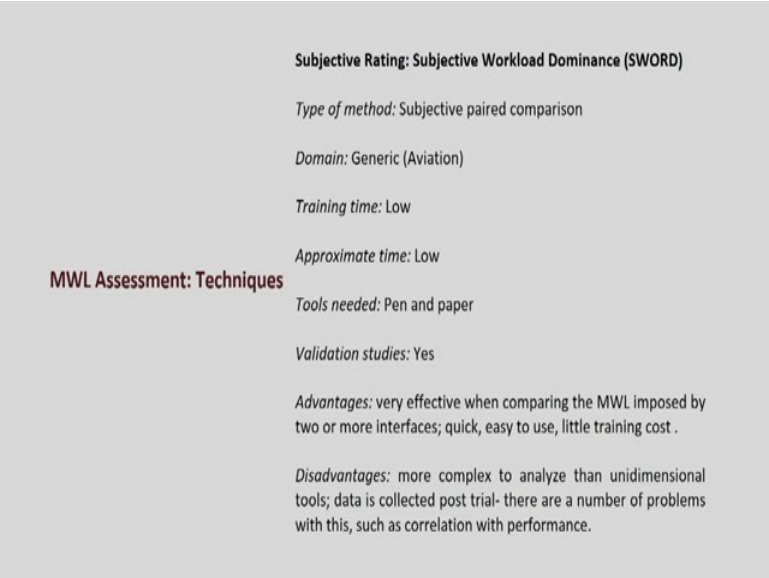

Another one same as the previous that is the subjective workload domains. So, all these tools you can definitely go into detail because each components is not possible within this stipulated time period, I am just naming them. So, you can take your own time to you know read them in detail, how to use it what are the variables are available which one is important where. So, all this thing you can study yourself and if you have any query you definitely can come back.

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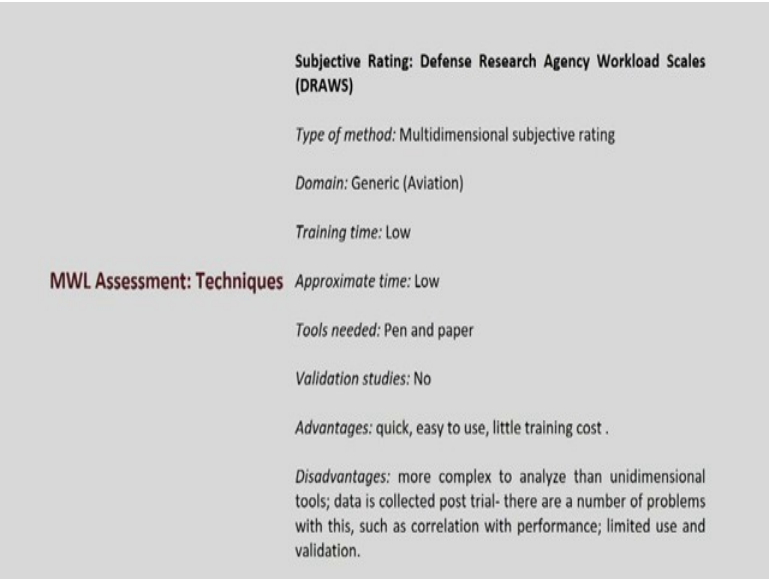

Now, one more tool that is the defense research agency workloads scale, it is mainly used in the aviation industry and as similar the previous scales. It is quick, easy to use and little training cost.

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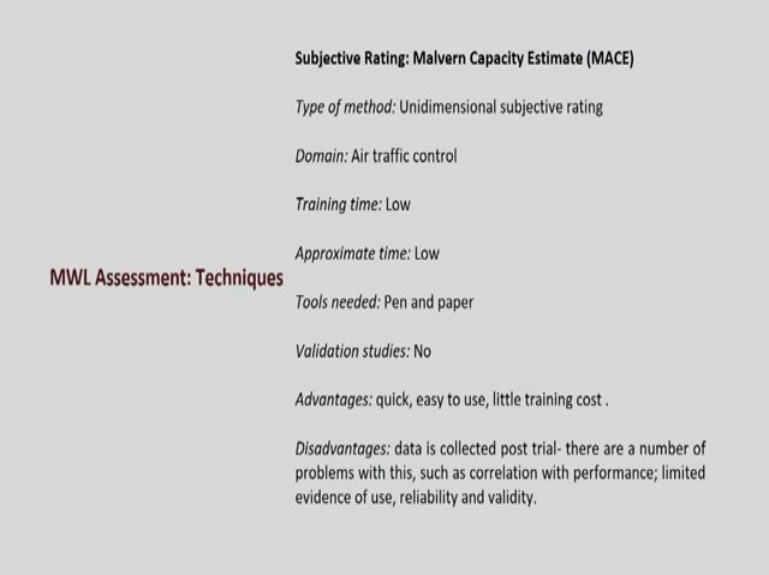

We have Malvern capacity estimate. So, again the difference is here it is uni dimensional; previously these tool was multidimensional SWAT also multidimensional, but this is uni dimensional tool. So, here validation study has not been done. So, based on your context your requirement you can do a pilot and you can validate is it useful for you or is it validate for you or not. So, that you can do definitely before using this tool.

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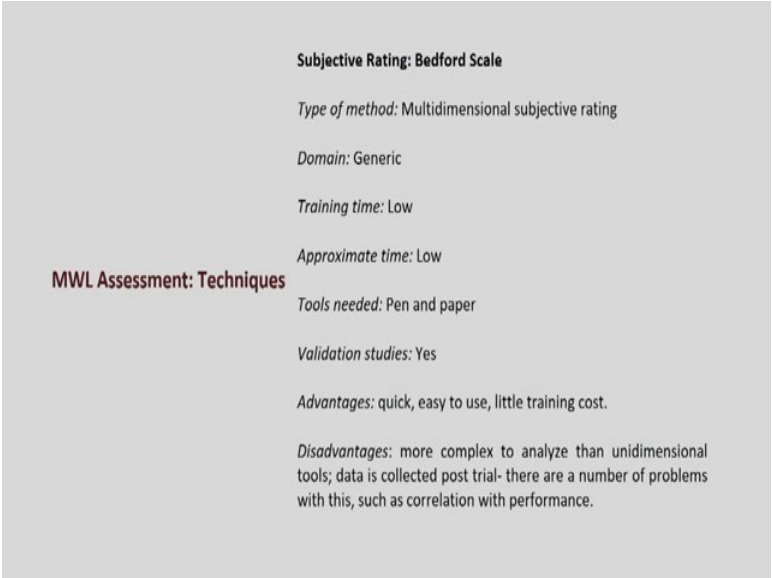

We have Bedford scale again it is a subjective rating scale.

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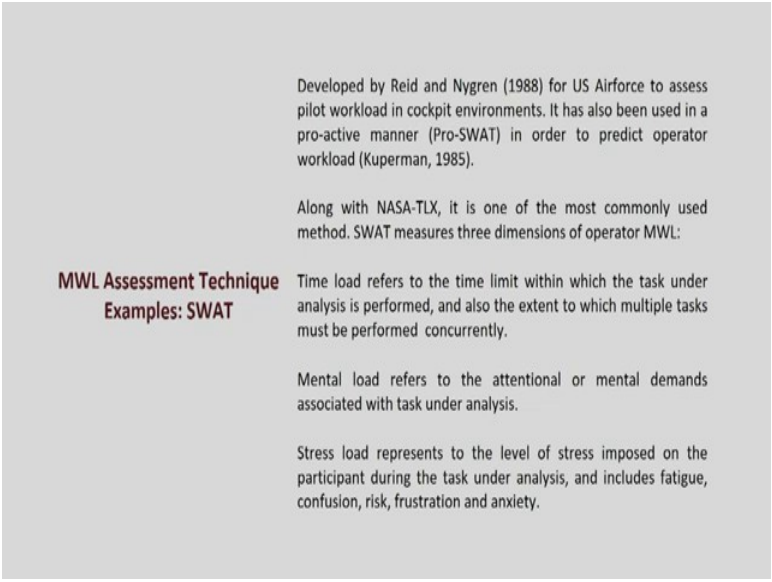

Now, what I will try to explain over here that, with an example how we are going to use one tool. So, this particular tool what we call is SWAT is developed in 1988 for US air force to assess the pilot workload in cockpit environment. So, how much the mental workload exists when a person or pilot is sitting in the airplane cockpit? So, it also been used in the proactive manner like you know without any report also we can use and we can find out specially in the product development face.

So, what it says that along with NASA TLX it is one of the most commonly used method ok. So, SWAT measures three dimensions of the operator of MWL time load, mental load, stress load. So, these are the variables that it measures.

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SWAT Rating Scale

Score	Time Load	Mental Effort Load	Stress Load
1	Often have spare time: interruptions or overlap among other activities occur infrequently or not at all	Very little conscious mental effort on concentration required: activity is almost automatic, requiring little or no attention	Little confusion, risk, frustration or anxiety exists and can be easily accommodated
2	Occasionally have spare time: interruptions or overlap among other activities occur frequently	Moderate conscious mental effort or concentration required: complexity of activity is moderately high due to uncertainty, unpredictability or unfamiliarity; considerable attention is required	Moderate stress due to confusion, frustration or anxiety noticeably adds to workload: significant compensation is required to maintain adequate performance
3	Almost never have spare time: interruption or overlap among activities are very frequent or occur all of the time.	Extensive mental effort and concentration are necessary: very complex activity requiring total attention	High to very intense stress due to confusion, frustration or anxiety: high to extreme determination or self control is required

Now, here we have the details how time load, mental load and stress load can be measured in three scores. So, based on the intensity of the score we will be deciding how we can do the changes in the whole work pattern or instrument used or the manpower recruitment like you know rotation and all those thing. So, this is the this is just an example, you can create your own example with your existing situation or whatever is your research area or your interest area you can create that if you are developing any product you can create for that has well and you can share it to share back with us and then we can find where the problem is and how we can take it further.

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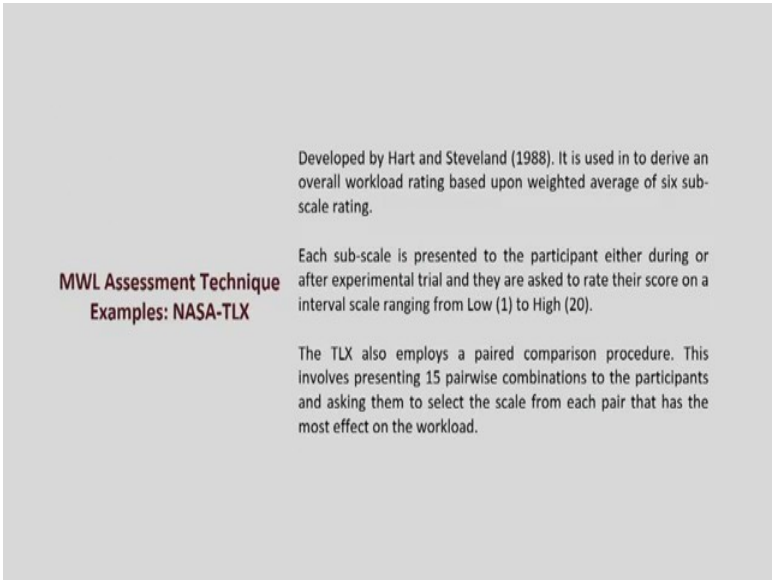

Now, this NASA TLX again we are going to take an example it is again developed in 1988 by Hart and Steveland. So, here we try to score the in a particular interval scale which starts from low insat high and low means 1 high means 20. So, we try to score them at a individual rating and we then again we will analyze it for our convenience.

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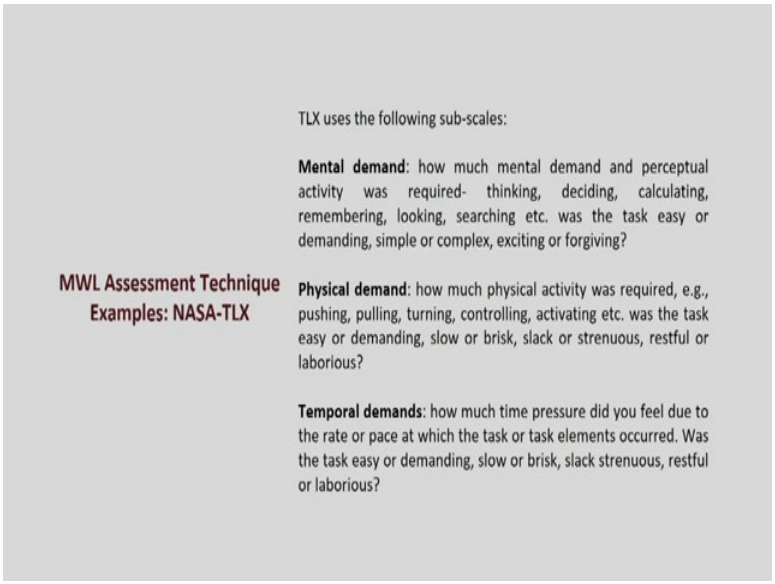

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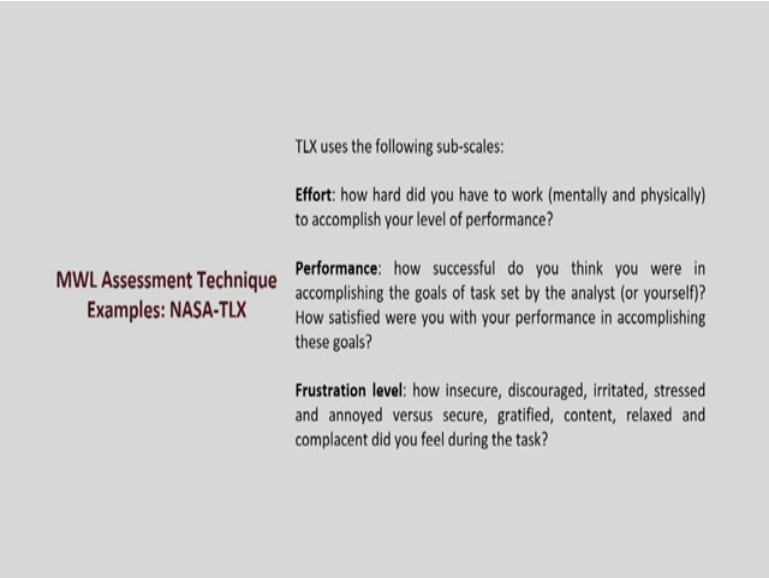

So, from NASA TLX we have mental demand, physical demand, temporal demand, effort, performance and frustration level. So, we have six variables to measure. In SWAT we had three variables we had time, mental effort and stress load, but in NASA TLX we have total sixth dimension mental demand, physical demand, temporal demand, effort, performance and frustration level. So, all these dimensions can be understood or can be clarified or evaluated or access through NASA TLX.

So, based on the research question you are going to answer, you can choose any one of them. Not only these two any other four five whatever I discussed earlier. So, only here I described this two specific tool because these two tools are very commonly used and ok. So, the popularity is very high for this two tools.

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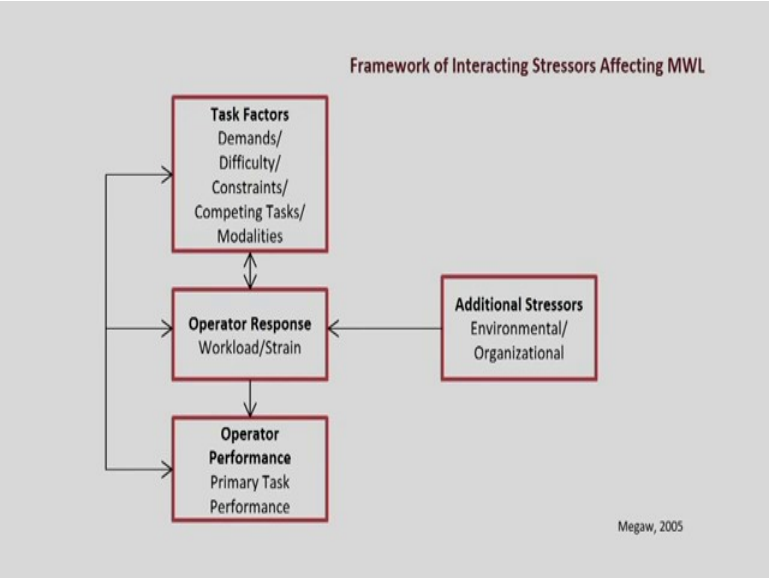

Now, when we are talking about mental workload and all those thing, it is very important to understand a particular kind of framework we should follow. So, it is developed in 2005 by Megaw. So, what it is saying that we have list of task factors. So, what is job demand or task demand, what is the intensity of the difficulty, what are the varieties of constrain we have, what is the competing task we have and what are the modalities we can do the task.

So, this can be defined in a particular group which will be calling as task factor. Further we have operator responses were workload and strain will be there and they based on the operator responses will be calculating the operators performance mainly we will be doing the primary task performance measurement. So, here all are interconnected. Here we have an influential factor that is the environmental and organizational. So, how the relations are, how the physical environment is, all these things are influential factor. So, you should understand these particular you can really follow this particular diagram or schematic representation of the mental workload, how the stresses are interacting.

So, you can explain from these, the what is the current situation of your area or of your the kind of research or kind of ergonomic workstation you are trying to evaluate so, that is possible.

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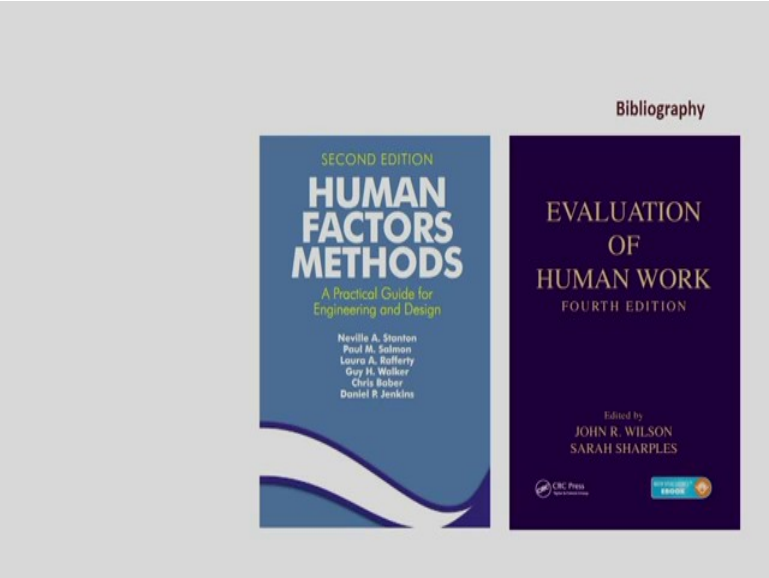

So, here I would like to refer these two books, again I think this particular book I am referring many times because this here you will get lot of basic fundamentals. So, for this today's lecture if you follow these two books probably you will get you know in detailed more elaboration. So, please read them if you have any query, again the same thing what I am going to says comeback let us know where exactly you got stuck. So, we are here and we will definitely answer them.

Thank you.