Ergonomics Research Techniques
Dr. Urmi R. Salve
Department of Design, Indian Institute of Technology Guwahati
Week 7: Lec 23- Introduction

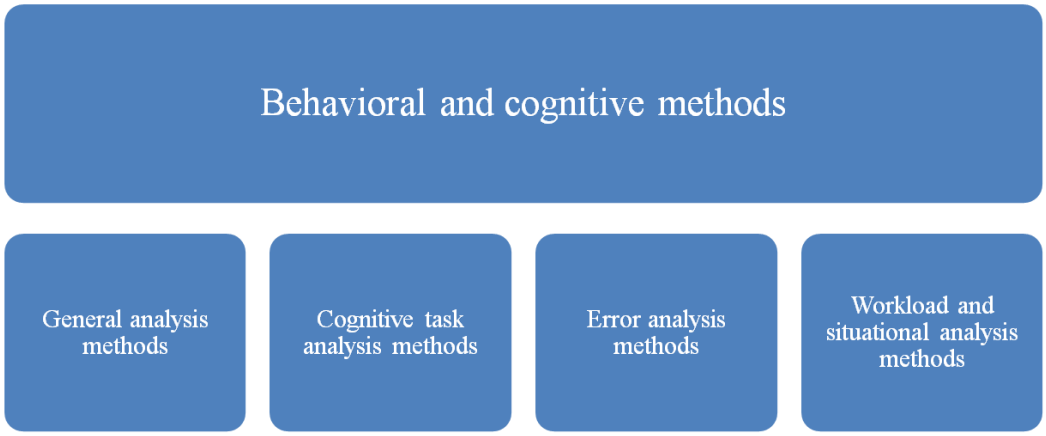
Welcome back to the class. Today we will start our cognitive portion behavioral and cognitive methods. So, today we will give a general discussion what are the varieties of way are present through which we can measure and analyze the behavioral and cognitive methods. So, let us first start with the definition of cognitive ergonomics. Cognitive ergonomics is concerned with the mental process. Ok? So, whenever we are talking about any ergonomics analysis which is connected with our mental process how do we perceive, how do we think, how do we act upon on the you know responses that we are receiving. So, all the mental process such as perception, memory, reasoning andyou knows motor responses. So, connected motor responses as they affect the interaction among human and other elements of the system. So, cognitive ergonomics mainly deal with mental workload, decision making, and skilled performance very important aspect is skilled performance. Ok? Whenever we start any ergonomics intervention you must have seen if there is some activity which is connected to skill knows craftsmanship anything which need high level of know skilled thing then it it becomes very difficult for us to go for ergonomics physical intervention. So, those cases we need to really look into from the cognitive ergonomics perspective. Human computer interaction definitely, human reliability. So, we will be talking about you know all kinds of how reliable the interaction happened between the man machine and within the particular environment and of course, work stress and training. So, these all are the topics normally we try to cover within the purview of cognitive ergonomics. However, these are not only the things we may have some we may coin some other terminology as well because these are something which we commonly use. Apart from that we can coin many other terminology which we can include in cognitive ergonomics if we follow the definition of it. So, remembering the elements of this particular cognitive ergonomics one is perception, second is memory and reasoning. These three components are very very important when we talk about cognitive ergonomics. Now, these three components how they are connected with our motor responses. So, suppose we are looking at a particular object and suppose a red it is a very common example that we try to give in when we start the cognitive ergonomics this particular area of study. If we see a red light definitely we know there is a danger or there is need to stop. How do wetake that decision, how do we assess that yes we need to stop because it is a reasoning that we do. So, we have a perception about the red color from our learning from our memory and we do a action against that particular response received from that. So, whenever we are talking about cognitive ergonomics this perception, memory, reasoning is very much important. And this mental workload, decision making, skill performance, human computer interaction, human reliability and work stress and training are the major component that we normally talk about when we try to go for cognitive ergonomics. Apart from that definitely we can coin much other terminology.

Contents

So, for this whole exercise related to as we did in physical that you know various tools techniques we try to understand, learn and practice here also for cognitive ergonomics what we will do we will try to first classify ok, classification of behavioral and cognitive methods. So, major classification we will try to do in steps and for each classification what we will do we will learn majorly available techniques. I would not say that we will be able to cover all and everything whatever is available because it is a time span is restricted. So, what we will do? Whatever possible and whatever easy to discuss in this particular platform we will do and definitely interest is commonly used or majorly used tools and techniques ok. So, first what we try to do is general analysis method under that we have several techniques, then we have cognitive task analysis method. It is a major area that we definitely need to work whenever we go for behavioral and cognitive ergonomics. Then error analysis which is also important aspect when we talk about production, productivity and all those thing. Workload and situation analysis method this is an area where we really need to put an attention or give an attention and we need to do lot of intervention when we try to do something in the system level, at the system level. Ok. So, when we are trying to improve something from the system level this particular aspect is very very important. Of course, at the end we will try to conclude or summarize the whole topic. So, in general analysis method we will try to focus mainly on the observation, interview, verbal protocol, preparatory grid and focus group. Each one we will be discussing in separate section. Today I will give the brief of them. Then in under cognitive task analysis, hierarchical task analysis commonly we know call it as HTA, cognitive allocation of functional methodology, critical decision method, applied cognitive work analysis. Ok. So, all techniques we will be learning separately. Under this, it is not only this much we may have some more techniques available. However, these are the common techniques. So, we will be discussing these. Ok. Apart from that also some some more available you based on your research interest, based on your study interest definitely you can find them out. Third we will be discussing on the error analysis method. In error analysis we will go for systemic human error reduction and prediction approach. So, this in short we call it SHERPA. So, this particular technique we will be

learning and we will be practicing. So, for all tools and technique as we did in physical ergonomics everybody should practice, everybody should collect their own data and in the discussion section maybe we can discuss it. Then task analysis for error identification. So, this is also very important when we talk about the productivity. Next part will be the workload and situational analysis method. In this particular sector we will go for multiple resources time sharing model. It is a model through which we will try to visualize or try to see our system. Multimodal critical path analysis and situational awareness global assessment technique. This situational awareness global assessment technique again it is it is very very important when we talk at the system level.

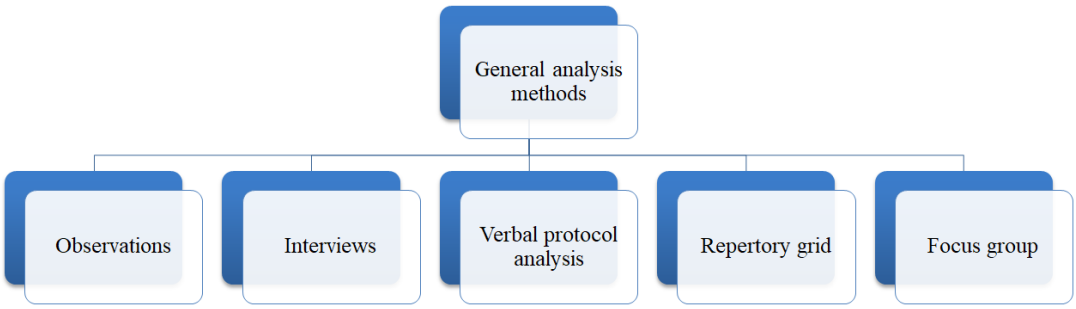
Behavioral and cognitive methods are classified into following categories-



So, let us start slowly with the general analysis. So, this is the schematic representation how do we divide them and you know in a broad classification. So, if we try to classify them. So, it is mainly the it starts with the general analysis, then cognitive task method, error analysis, workload and situational analysis. Here I would like to mention one thing it is not that each component are important for every research ok. So, depending on the requirement, depending on the type of objectives you have you can definitely pick one, you can pick two or you can follow all four. So, it is not mandatory that you should go in a sequence like this. However, whenever we start any kind of intervention it starts with general analysis method because it gives a direction to you. Whereas, cognitive task analysis method also if you start with that maybe you have a prior study or some kind of pilot study from where you have a lead and you can start directly from the cognitive task analysis. But it is it is nowhere restricted that you cannot start with you know workload and situational analysis method. Because if you have a lead that it is the requirement of your study you can definitely start with it ok. But it is it is a baby step that we try to always take, we start with general then go for the cognitive task analysis, error analysis and the situational workload and situational analysis. However, it is not mandatory ok.

General analysis methods

- General aspects of human factors are measured through following five methods:-



So, under general analysis methodas I mentioned earlier we have observation, interviews, verbal protocol, and repertory grid and focus group these are majorly used. Today we will give short description in the next class I will take you for each with example ok.

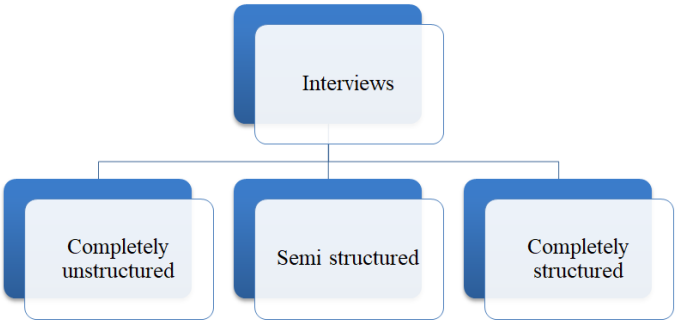
Observation

- The core approaches in the ergonomist's toolkit.
- This approaches feed data into many methods;
  - Hierarchical task analysis
  - Cognitive task analysis
  - Verbal protocol analysis
  - Human error identification methodologies
- The three main ways to collect observational data;
  - Direct observation
  - Indirect observation
  - Participant observation
- Observational data can take in many form;
  - Time and error data
  - Descriptions and frequencies of activity
  - Verbatim protocols
  - Behavioral narratives

So, in observation what it is, if we talk about observation? So, the core approaches in the in this is the ergonomist toolkit. So, it is a very basic if we talk about the observation. And for each and every study if you talk about cognitive or ergonomics or physical ergonomics this observational technique from both perspective is very very important ok. So, these approaches fit data into many method like whatever information we are getting from this particular study or particular method what will happen the interpretation of this part of your study can be the input of many other process many other techniques. Specially when we talk about hierarchical task analysis from the data received from the observational observation you can take input from there and give start

with your hierarchical task analysis. Same thing will happen with the cognitive task analysis verbal protocol and human error identification methodologies ok. So, the main three main ways to collect the observational data is the direct observe first is direct observation, indirect observation and participant observation. These all three varieties we will be describing in detail in next class. So, observational data can take in many form ok. So, depending on the type of objectives type of you knows research interest we have we can have the how do we do the analysis how do we collect the information from the observation. One is time and error data. So, for each and every element of your activity we can use you can collect the time data ok. How much time it is taken, how the person who is working is spending time, what is the you know activity time taken. So, all these are possible also it is possible to collect the error data. So, in a particular given task how many errors are happening. So, that is also possible to collect information from the observational technique. Next is description and frequencies of activity. So, whenever we are observing a particular task in detail what happens the first is important is the description of the study. So, that description can help you to get to make a blueprint of the whole work ok. So, this description actually will give you a detailed analysis detailed understanding where the cognitive obstruction or load or you know which further tool you can use to identify them. These entire thing is possible only in the if you are getting your data in the descriptive format. Also frequency of activities...frequency of activities means how frequently you are performing that particular task. Then definitely verbatim protocol will be doing this and behavioral narratives. Here also we will be describing the process in detail.

Interviews



- A structure of questioning is proposed as starting with open questions.
- After the open questioning, the probing questions are asked.
- At the end, the closed questions finish the interview.

- Completely unstructured:- Random questions are asked
- Semi structured:- Questions following an agenda, but deviating off the path to following interesting line enquiry
- Completely structured:- A verbal questionnaire with recording.

Next as I mentioned after observation within general we have observation. Second very important tool that we frequently use in the field of design, in the field of you know industrial ergonomics, occupational health and many other cases is the interview. Now, these interviews can have three major type or three major component ok. So, one will be the completely unstructured. The interview many of us definitely used it in our research life that some interviews are completely unstructured. We will discuss what it is, what should be the assumption of the completely unstructured interview, how do we analyze it

in further semi-structure and completely structured. So, what exactly it means a structured, a structure of questioning is proposed as starting with open question. After the open questioning the probing questions are always asked. This is the way how do we go ahead. At the end a closed question finish particular interview. These steps are necessary ok. So, starting and ending. So, apart from that whatever information are getting collected may not be considered as a part of data collection of interview. So, from where you are starting. So, the first question of your interview is very important as well as the ending question or ending remarks are very very important. So, when we are talking about completely unstructured it is a random questions are asked depending on the discussion. Semi-structure there will be some agenda, some questions which will follow particular agenda, but it may deviate from the path that follow some interesting line of query ok. So, it is not very much structured no single questions it is not like that. What will happen? We will we will have some agenda points and from that agenda point all questions will follow those agenda point. However, there may be a deviation from in the discussion in the you know in the question answering session depending on the interest ok. Depending what are the enquiries are coming depending on that we may divert a little bit. So, how to gather information from such cases or where we can use such you know tool for collecting information that is very important for us to know and we will be discussing it in detail. Third is definitely a complete structured. So, by nomenclature itself we can understand what do we mean by completely structured. So, it is a verbal questionnaire with recording ok. So, you have certain sets of you know questions and you are going to ask only those question. It is so starting question, second question, third question all questions are set and you have definite answer for that ok. So, that is completely structured question. So, we will be discussing all these in detail where and how we should use these tool to gather information.

Verbal Protocol

- The data from the verbal transcripts analyze the content therein.
- The transcript data come from the protocols gathered from live recording performance of the task.
- The transcript can be coded and analyzed at various levels of details from participants words to phrases, sentences or themes.

Now, next after questionnaire interview then another tool is very very important and useful tool is verbal protocol. So, the data from the verbal protocol or verbal transcript analyzed in the content ok. So, whatever we are getting information we go for the content analysis whatever content we are generating from this. So, the transcript data

come from this protocol gathered from live recording performance of that particular task. So, we do a recording and then what we do we come back to the laboratory and try to develop the content whatever was there in the whole period and try to you know collect those information. So, the transcript can be coded and analyzed at various level of details from participants word to phrases. So, it absolutely depend at what level at at which degree you want to analyze them. Depending on the objectives, depending on the area that you would would like to explore these verbal protocol detailing can be done ok. So, it is absolutely based on the researcher's interest.

Repertory grid

- A method used to elicit personal constructs from people.
- Based on personal construct theory, this methodology has three main stages;
  - The pool of artifacts (from which construct will be based) are defined.
  - Triads (three artifacts groups) are drawn from pool and asked to state the difference or similarity between one and other two groups.
  - Participants are asked to rate the all artifacts against the constructs and the matrix is analyzed.
- The result provides a set of personal constructs for product evaluation.
- This process is repeated with a large set of individuals and a large set of artifacts.
- Then some common constructs are likely to emerge.
- This method is used to examine the different sort of constructs that people hold, at the level of artifacts classes.

Then, repertory grid it is again a very what can I say it is a very important and useful tool ok. We use definitely in the field of design, in the field of occupational health, industrial engineering specially when we are about to start something very new and we need information. So, those cases this this tool is very very important. So, it is what it is a method used to elicit personal construct from the people ok which is very important when we talk about cognitive ergonomics. Because you know perception actually varies keeps on varying from person to person depending on the situation perception varies ok. So, identifying the personal construct is very important in many cases. So, based on personal construct theory this methodology has three main stages. First is the pool of artifacts and need to be defined. First first we need to identify those artifacts and we need to define them. Triads are drawn from that particular tool. So, we need to measure what we call it that three groups of artifacts. So, that is why triad ok. Then what we do? Ask to state the differences and similarities between one and other two groups that comparison kind of thing we try to build. Then participants are asked to rate all artifacts against the construct and the matrix is analyzed. So, the last portion which is very important because here you need lot of practice lot of experience. So, normally what happens for this particular case? Understanding the data and interpreting the data depends on the skill or experience that you develop ok. So, participants what they are asked to rate all the artifacts ok. So, whatever artifacts they we have gathered against the construct and a particular matrix is need to be developed and need to be analyzed. So, this analysis is very very important and critical. So, the results provide a set of personal construct for

product evaluation. This process is repeated with a large set of individuals and a large set of artifacts ok. So, it is a very this particular process can be done in iterative process ok. 1, 2, 3 you can you can repeat ok. Then some common constructs are likely to emerge because when you keep on doing it something which is very common it comes up and then you have an idea of what kind of personal construct you are getting from it. So, this method is used to examine the different sort of construct that people hold and the level of artifacts classes. So, you get at the end kind of classifications ok. So, using that maybe you can take it further how the system needs to be developed.

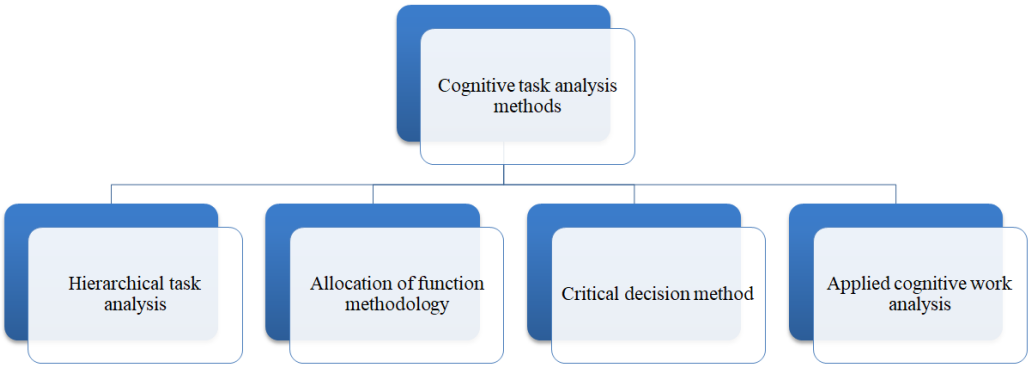
Focus group

- It is the extension of the individual interview.
- Basically it is used in market research and product design.
- Focus group people gather together to talk about individual and collective reactions to events.

This is again very commonly used tool in in the field of design; it is a focus groups study. So, it is an extension of the individual interview. So, when we talk about individual interview it is a person one person and another person is taking interval. However, it is focus group. So, basically it is used in market research and product design and focus group people gather together to talk about particular individual and the collective reaction against a event to a particular event. So, it is not an individual it is a group of people who are connected to this particular event ok. So, here it is very important for us to understand who are our focus group. So, whenever we are doing a focus group study. So, sample selection is very very important and the criteria inclusion criteria for this focus group sample are very important for us.

Cognitive task analysis method

- These methods are used for describing the knowledge and strategies required for task performance.
- Specially cognitive task analysis methods are classified into four categories:



Now, as I mentioned today we will be discussing all in brief and from next class onwards each tool will be described in detail. So, let us go for the cognitive task analysis method. So, these methods are used for describing the knowledge and strategies required for task performance ok. Specially cognitive task analysis method are classified into four major categories. One is hierarchical task analysis many of us must have done already still we will be learning this technique in detail. Allocation of function method, critical decision method and applied cognitive work analysis.

Hierarchical task analysis (HTA)

- It was initially developed in response to the need for greater understanding of cognitive tasks.
- HAT describes a system in terms of goals and sub-goals, with feedback loop in a nested hierarchy.
- This approach can be used to describe any system; inherently flexible.
- It can be used to many ends; from person specification to training requirements, to error prediction, to team performance assessment, and to system design.

So, brief description of hierarchical task analysis it was initially developed in process to need for greater understanding of cognitive task. So, initially it was for that. However, this cognitive hierarchical task analysis this is a very common tool which is being used in many other field in current days. So, HTA I think it is a printing machine HTA describes a system in terms of goal and sub goal with feedback loop in a nested

hierarchy. So, hierarchy so, we give some greedy and we try to make a nest of it right. This approach can be used to describe any system inherently flexible. It can be used to many ends ok from person specification to training requirements. So, we really do not know where the results can be used. Once we do a hierarchical task analysis with an objective it may happen it lead you to some other direction as well and your study direction may change. So, this hierarchical task analysis when we have certain things like you know step by step process we have to follow in that cases where the problems where the interventions are required is very important for us to know and this hierarchical task analysis definitely give you a result. So, also it gives the error prediction. So, we can really foresee that where that error can be ok. So, when we draw an hierarchical task analysis chart or we can we create that particular tables for hierarchical task and in that we will discuss how to how to do that. So, we will take a task and then we will practice it when we do that then what will happen we will predict the error that may possible to come and their designers has a big role that if we can predict that possible system error is going to happen we may change the design process, we may change the design or may change the element of that particular design and we can avoid it beforehand. To team performance assessment of course, if a particular task is you know performed by a particular group of people you know particular team then how how it is getting which output is acting as an input to other, how these are connected, how they are creating a nest we can understand that to a system design. Of course, it will finally, help us to design the whole system with minimum error and maximum productivity ok that we can expect from the hierarchical task analysis.

Cognitive allocation of functional methodology

- It is an extension of HTA.
- Numerous approaches has been taken which develops from the allocation of the system sub-goals in HTA.
- In this method, four basic types of sub-goal allocation are present:
  - Human only
  - Computer only
  - Shared but human in charge
  - Shared but computer in charge
- Each sub-goals can be allocated depending upon the skills and technology.
- Four criteria are applied:
  - The job satisfaction of the person
  - The potential for human error
  - The potential effect on the situational awareness
  - The resource implication of the allocations

Next part is cognitive allocation and functional methodology. Of course, it is an extension of HTA. Numerous approaches has been taken which developed from this allocation of the system sub goal which is there in HTA. In this method four basic types of sub goal allocations are present one only human, second only computer, third shared by human in charge and fourth one shared, but computer in charge ok. So, somewhere the errors or problems or the system is completely by human, completely by computer or the machines. Some cases shared with the other counterpart like machine and human a

machine or computer, but main charge is taken by the human and the fourth one just opposite where computer are the major and however, there is a you know charge which is taken by the computer ok. So, it is a shared thing however, majorly done by the computer. So, you can really start gathering information related to such type of system where only human is present, where only computer is present, where human computer both are present however, human is dominating whereas, in the next where computer is dominating it will try to get such such kind of examples and then if you do this cognitive allocation of function and methodology maybe you can try to evaluate it, it is a for your practice. So, each sub goals can be allocated depending upon the skills and technology. So, four criteria are applied the job satisfaction of a person, how satisfied a person to that particular job, the potential for human error. So, the what are the things available in the system which are the potential causes for human error, the potential effect on the situational awareness which is very very important because you if you are completely aware about the situation that is going to come maybe cognitively you are more powerful to handle that particular situation ok. So, so this is very important and the resource implication of the allocation. The next tool or technique that we we are going to discuss is the critical decision method. So, for all of you I suggest today you will learn the basic things what are the varieties available so that we are learning and in the next class we will take each and every not next one class all other next classes what we will take every detailed techniques every techniques we will we will detail it out ok. So, starting from the steps starting from the first step, second step and then how do we conclude the data ok we will do that.

Critical decision method

- It is an update and extension of the critical incident technique.
- It structures the interview in an incident analysis to review critical decision points.
- A investigation is done with detailing of the incident timeline and looking at the decision according to timeline.
- A series of questions are presented to define each decision:
  - What information cues were attended to?
  - What are the situation assessments?
  - What information was considered?
  - What options were considered?
  - What basis was used to select the final option?
  - What goals were to be achieved?
- The approach can be generate large amount of data.
- The questionnaire structure should help the analyst identify conflicts and contradictions between and within interviewee's response.

So, this is critical decision method. It is an update and extension of the critical incident technique. It structures the interview in an incident analysis to review the critical decision points ok. So, it is very important that we really understand that what are the critical decisions we need to take in a particular system when we are present when we are working ok. So, so it is it is a structures you need to follow to prepare that interview and we need to analyze that how these critical you know decisions has been taken. So, an investigation is done with detailing of the incident timeline and looking at the decision

according to the timeline. So, if an event happen then how the event happen all timeline need to fail and where which decision has been taken. So, why that decision? Why that critical decision has been taken by the operator? So, this method will give you an understanding of all these. So, you know it will help you to analyze the system thoroughly and it will give you an direction where the design interventions are really possible to enhance, where are the ergonomics intervention are really possible to enhance the system performance and total productivity of the system. So, our series of questions are presented to define each decision. So, mainly these are some you know examples what information cues were attended to then what are the situation assessments were there, what information was considered, what. So, maybe there are n number of information, but the decision maker has considered 3 or 4. Why? Which one? So, all these queries are very important when we are talking about the critical decision method. What options were considered? So, if there are 4-5 options available to choose I have chosen a particular why, why that options I have chosen, why I relied on that particular option. So, these analyses are very important ok. So, what goals were to be achieved? So, being the operator of that whole system what I was going to achieve in that particular case. So, all these type of information, all these varieties of data these are basically not information I will consider as you know data ok. So, these data will help the researcher to get a direction that where the intervention points points and how do we improve the whole system after the intervention. So, this will lead you towards the intervention. So, the approach can be generated in you know of course, as I mentioned that it is a large amount of data huge data set ok. So, the source this particular method will give you enormous data. Maybe in a particular research study we will not be able to handle so much it needs you know 2-3 objective more objectives to handle such data. So, it is very very important tool. The questionnaire structure should help the analyst identify the conflicts and contradiction between and the within interviews response ok. It is very very important. So, we will be able to identify these conflicts and contradiction once we go through this critical decision method ok.

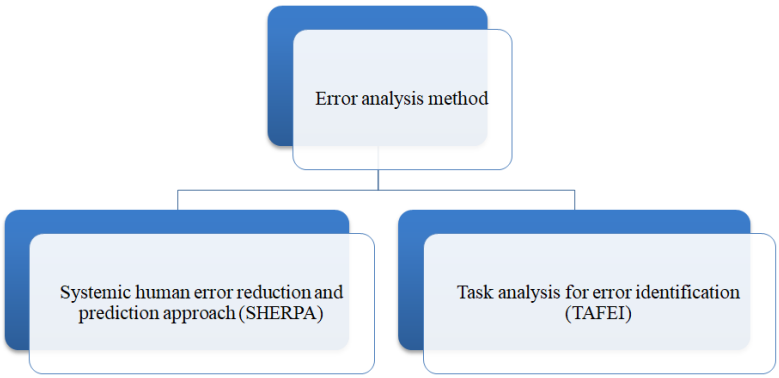
Applied cognitive work analysis (ACWA)

- It is based on the analysis of demands and constraints that are inherent in the task domain.
- It has been used in process-control and command-and-control environments.
- The aims of this methodology are to
  - Approach design holistically considering all aspects of the system (structure, procedures, training programme, automation, database design and sensors)
- The basic steps
  - Development of a functional abstraction network
  - Determining the cognitive work requirements
  - Identifying information relationship requirements
  - Representing design requirements
  - Presenting design concepts

The next is applied cognitive work analysis. It is also a very important and useful tool and frequently used tool very important thing is frequently we very frequently we use this particular tool. So, it is based on the analysis of demands and constraints that are inherent in that particular task domain ok. So, what demand we have and what are the constraints available ok in that particular inherent task domain. So, it is based on the analysis of these two components. So, how I am fulfilling it, how I am going to achieve it. It has been used in process control and command and control environment. It is very important that when there is a possibility to control the environment through some command ok. So, this particular tool is being used. The aim of this methodology is to approach design holistically considering all aspect of the system. Mainly structure, procedure, training program, automation, database design and sensor ok. So, it is it is a holistic approach as I mentioned very initially. So, it talks about demand, it talks about constraint. So, how do we manage them, how do we fulfill the objective of the system in you know taking consideration of all these thing. So, this is very very useful tool in that case and it says that it is an holistic approach then what will happen we will be able to try to visualize the whole system together and we will be able to understand where the interventions are possible. So, each and every tool it is not only this particular tool, each and every tool basically gives you an understanding that where the interventions intervention points are and if we do intervention what will be the kind of impact. So, you can really visualize it. So, every tool, but however, all tools are not similar based on the objective of your research you can choose any one of them. So, the basic steps that we follow over here is development of a functional abstraction network, determining the cognitive work requirements, identifying information relationship requirement, representing design requirement and presenting the design concepts. So, these are the basic steps. So, design concepts, still design concepts. So, it gives real indication where and how the designs can be possible.

Error Analysis Method

- These methods focus on the prediction of human error.



So, next part of this whole chapter will be the error analysis method. So, in this error analysis method we will deal mainly two components. So, these methods focus on the prediction of human error. So, till now whatever we have done we try to gather

information from the system. Whereas, in error method again we will try to get information from the system, however, it is very much connected to the human performance ok. So, first one is SHERPA. The full name of SHERPA is Systemic Human Error Reduction and Prediction approach. In recent days many research studies basically use this particular tool to get an understanding how the whole system is performing. The next is task analysis for error identification. Again kind of result will be getting quite similar, however, the variables are different, the results are little different and it gives you different indication.

Systemic human error reduction and prediction approach (SHERPA)

- It is a part based on Human Task Analysis (HTA) as a description of normative, error-free behaviour.
- SHERPA is used to analyse what can go wrong in task performance.
- At the core of SHERPA is a task and error taxonomy.
- Each task can be classified into five basic types.
- SHERPA uses hierarchical task analysis with an error taxonomy to identify credible errors.
- SHERPA is used in control room tasks, maintenance tasks, transportations tasks and command-and-control tasks.
- It is a divergent error prediction method:
  - It works associating with ten error modes with each action.
  - It is an overinclusive strategy to novice for selecting errors modes.
  - The novice users use a play-safe-than-sorry approach and predict many more errors.

So, let us start with SHERPA. So, what exactly it does? It is a part based on human task analysis ok. So, SHERPA is used to analyze what can go wrong in task performance ok. So, what is possible way where we we being an operator may go wrong ok. So, it may happen that when we design a particular system we are expecting that the system to perform a certain manner or certain way. However, if we go for this particular analysis we may predict that while following this process where the human may go wrong ok. So, again it is a prediction, it is a prediction. So, when we do a prediction we can improve the system before we meet any accident ok. So, to prevent any hazard, to prevent any accident we may analyze the system using SHERPA. At the core of SHERPA is a task and error taxonomy. So, we will giving different nomenclature, different you know counting of those type of error. So, each task can be classified into five basic types that we will be discussing. So, SHERPA uses hierarchical task analysis with an error taxonomy to identify credible errors. SHERPA is used in control room task, maintenance task, transportation task and command and control task. So, these cases definitely we can use SHERPA. It is very clear identification where we can use SHERPA as a tool of tool to identify your error. So, if you have such situation definitely you can pick this particular tool to analyze your situation or analyze your error. So, it is called divergent error prediction method. It works associating with 10 error method with each action, every action associated with 10 error. It is an over inclusive strategy to novices for selecting error method and the novice user like many of us when we start our research work we are really not really expert. So, for those cases play safe than sorry approach like you

know let us do it. If we go wrong we can come back again redo it ok some kind of. So, if we are in that particular phase SHERPA definitely will help you to get better data, better information ok. So, SHERPA definitely is a is an useful tool for any learner if they have cases like maintenance task, control room task, transportation task and command control task ok.

Task analysis for error identification (TAFEI)

- It is based upon a theory of human-product interaction; called rewritable routines.
- The idea of rewritable routines- Transitory, either becoming completely overwritten or modified.
- Based on this theory, TAFEI predicts, represent and analyses the dialogue between people and products.
- TAFEI has two forms of output
  - Predicted errors from human interaction with a device (based on analysis of transition matrices)
  - A model of task flow based on mapping human action onto state-space diagrams.
- The task flow model is used as a part of an analytical prototyping procedure to assess a virtual product.
- It is a convergent error-prediction technique:
  - Identifying the possible transitions between the different states of a device
  - Uses the normative descriptions of behaviour to identify potentially erroneous actions.
  - The novice prevent the individual generating too many false alarms.

Then next is task analysis for error identification. So, it is based upon a theory of human product interaction called rewritable routine. Very important very commonly used term you know rewritable routine. So, if we are following a routine how do we rewrite and improve our performance. It is very you know general information however, it is very scientific and we we coined this terminology to you know to use as a tool and use as a data in in this in this particular field. So, it is very very important and again as I mentioned it is it it gives you a direction to where you can start your intervention. So, that the idea of rewritable routine is transitory of course, it is very important either becoming completely overwrites or somewhere you modify. So, wherever you find this is not really going to work you rewrite it completely whereas, it may happen some parts are quite ok. You find you the data say this is feasible you keep them whereas, those parts are not feasible you change and rewrite that particular portion. So, based on this theory this task analysis for error identification represents and analyze the dialogue between people and product. So, this particular tool has two forms of output. First is predicted errors from human interaction with a particular device. So, when you are interacting so, what are the predicted error and the second component what you get as an output is a model of task flow based on the mapping human action onto state space diagram ok. It is very important in a in a form of state space diagram. So, how the information is processing. So, it is a mapping of human action. So, the task flow model is used as a part of an analytical prototyping procedure to assess a virtual product. So, if you are creating a virtual product then you can do this particular task. It is a convergent error prediction technique this particular method that task analysis for identification we call it TAFEI. This TAFEI can be and you know convergent error prediction technique. So, what it does identifying the possible transition here it is very important it is a possibility it is not the

confirm ok there are possibilities. So, from these possibilities you have to choose where exactly the interventions can be done. So, identifying the possible transition between the different state of a device, uses the normative description of behavior to identify potentially erroneous action. So, here also we have n number of errors whereas, which one is more potential. So, we have to remove them we have to rewrite them right. So, we really need to identify them and describe them and eliminate them. So, the novice do not know prevent the individual generation too many false alarm. It may happen when you do not know you are not aware in about that particular situation in a small error also you may raise a big alarm which is which may cause a problem to the whole system. So, this particular method will help you to stop to such kind of action. So, this is very very important. So, before you go for in any kind of design intervention or ergonomics intervention this will help you to give a gradation that where exactly you should start. It may not then each and every step the intervention is required. Somewhere you need to identify which one is more which one is less right. So, this will help you to do that.

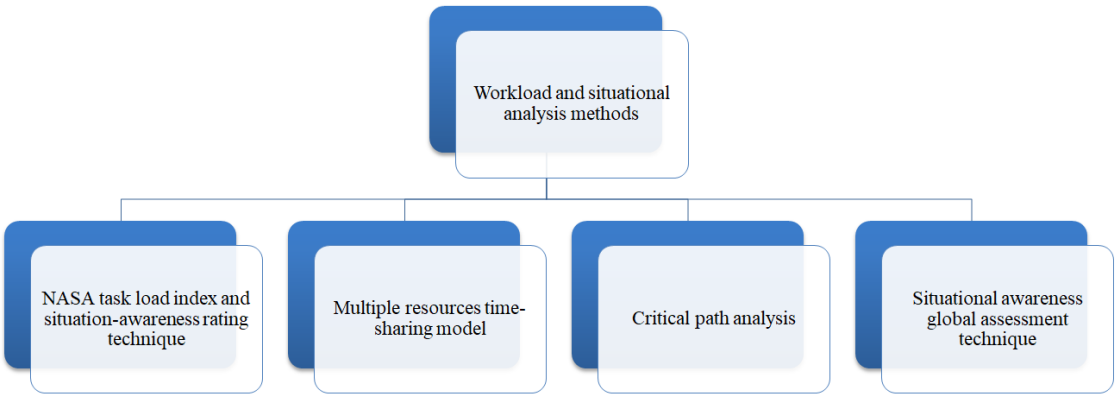
Workload and Situational Analysis Methods

- Mental workload: A multidimensional concept incorporating task and performance demands together with operator skill and attention.
- Task design is challenged with keeping mental workload within a optimal performance zone, where workload is neither too high or too low.
- Measures of mental workload:
  - Primary and secondary task performance
  - Physiological measures
  - Subjective measures

The next is workload and situational analysis method. So, again let us understand what is mental workload a multidimensional concept incorporating task and performance demands together with operator skill and attention ok. So, it is a multidimensional concept. It is a multidimensional concept. So, now from many dimension we can really try to understand what this particular situation is, what this particular concept is. So, multidimensional concept incorporating task. First is task and then performance demand. Together how how the operators skill and attention is connected with the whole activity we need to understand that and then we analyze the mental workload. So, task design is challenged with keeping mental workload within a optimal performance zone where workload is neither too high or too low. So, here if workload goes too high then maybe there is an error, there is a hazard, there is a problem in the whole system. If it is too low then again the similar not similar, but problem may happen. So, how do we optimize? You know in my earlier course also I always try to or being a practitioner of ergonomics we always try to optimize the system. So, it is not about maximum, it is not about always high, it is all about how we optimize our productivity in comparison with the input, input

resources, human health and all those things. So, here also basic concept is optimization, okay, optimization. How do we optimize it? So, what if the workload is very high or workload is very low then definitely the total performance of the system, the productivity of the system will fall, right. So, how do we optimize it? It is very very necessary. So, this tool will give you a direction, how do you do that? So, measures of mental workload, primary and secondary task performance, physiological measure and subjective measure. So, these are the components that you need to do in this particular case.

Workload and Situational Analysis Methods



Now, workload and situational analysis method, this is a topic which is you know emerging and many system designer, many design practitioner, many ergonomist, industrial engineers really try to go for these tools nowadays and many research papers are coming out with the concept of this situational awareness and situational analysis method, okay. So, we will have four major area that we will be discussing here. One is NASA task load index and situation awareness rating technique. Second is multiple resources time sharing model. Third is critical path analysis and finally situational awareness global assessment technique. These four types or four varieties we will be discussing.

Multiple resources time-sharing model (MRTSM)

- Based on Wicken's multiple resources theory (MRT)
- According to MRT, "there is more than one commodity in the human processing system that may be assigned resourcelike properties (allocations, flexibility and, sharing)
- The important relationship in MRT:
  - Two tasks require separate attentional resources, they will be time shared efficiently
  - Two tasks require common attentional resources, the performance on the tasks will depend on resource allocations.
  - When additional resources are needed for performance, the task difficulty is increased.
- It predicts the workload in situations where multiple tasks are performed concurrently.
- This model distinguishes between perceptual modalities, processing stages, processing codes and responses.
- It can be used for heuristic and computational evaluation

So, let us start with multiple resources time sharing model. So, this particular model based on Wickel's multiple resource theory, okay. See everything I will not be able to describe in this particular class. However, you should pick up these keywords like here Wixon multiple resource theory, okay. I will not be, I do not have scope to discuss it here. However, you can know study yourself. If you have question, you can definitely come back to us, okay. So, according to this particular theory, there is more than one commodity in the human processing system that may be assigned resources like you know properties, okay. So, allocation, flexibility, sharing and all those things. So, we need to understand in a system how these are being placed, okay. Once we understand then we can make the connections. So, the important of this particular relationship in this particular model are mainly three direction. So, two tasks require separate attentional resources and they will be time shared efficiently. So, maybe we identify two. So, two task where it the time you know equally or time shared by them and they may need separate attentional resources. Whereas, two task require common attentional, somewhere separate, somewhere it is common. The performance on the task will depend on the resource allocation. Whatever resources is being allocated by the system, based on that you may decide and when additional resources are needed for the performance, the performance, the task difficulty is increased. So, if additional resources are there to enhance that particular performance, definitely there will be an increased difficulty in that particular task. So, we may get this information. So, it predicts the workload in situation where multiple tasks are performed concurrently, okay. So, multiple tasks are performed concurrently. So, we may predict the workload in such situation using this particular method. So, this model distinguishes between perceptual modalities, processing stages, processing codes and responses. So, three things perceptual modalities, what it does this particular model distinguish between the perceptual modalities, processing stages, processing codes and responses, okay. So, how these things are connected? So, it is basically establishing the relationship, establishing the connection between each. It can be used for heuristic and computational evaluation.

Multimodal critical path analysis (mmCPA)

- CPA is based in project management literature, whereas multimodality of people is based in a human factors literature
- Traditional methods for modeling human response:
  - Time; not representing multimodality
- The mmCPA uses the approach of multimodality to model task time with claims for greater accuracy.
- If two or more tasks occupied the same modality, then they must be performed in series.
- But if two or more tasks occupied different modalities they could be performed in parallel.

Next that we are going to do is the multimodal critical path analysis. What it is? Definitely we will discuss in detail. However, here it is a small description. So, CPA is based in project management literature. So, you know it is not very commonly used tool in design. However, nowadays in the field of design management, in the field of industrial management we use this particular tool. Whereas, it is a multimodality of people is based in a human factors literature, okay. So, if we go back to earlier days where there was a particular you know human factors are described in different way and the way how we define we may get an input for this particular tool. So, traditional method for modeling the human responses time not responding to the multimodality. So, this MMCPA why we say multimodal, okay. Actually it is a critical path analysis. Basically it is a critical path analysis method. However, as this is very specific to the multimodal because you know nowadays systems are like this. So, multimodal critical path analysis uses the approach of multimodality to model task time with claims for greater accuracy, okay. So, we want to achieve the level of accuracy you know very fine system. So, those cases it is important. If two or more tasks occupied the same modality then they must be performed in series. So, these information so which one to be performed after which like now the sequence specification how do we do that. So, using this type of analysis this type of tool we may get an idea. But if two or more task occupied different modalities they could be performed in parallel. So, if the whole system needs to be built what are the things can be done in sequence, what are the information, what are the process to be done in parallel, how do we decide. So, the whole system flows. Now designing this whole management so system, service for all those cases this MMCPA is very very multimodal critical path analysis is very very you know helpful. So, it actually help us to save the whole execution time, it help us to understand the you know interactions between the activities which is happening in the system. Also it help us to understand where the possible errors come, where are the possible error, the sources of error. So, using this tool we can get all this information. So, when it is a requirement to design the whole system this type of tool is definitely a big help.

Situational awareness global assessment techniques (SAGAT)

- This methods present recall-probe questions when the task is interrupted to measure the awareness.
- It measures three levels of awareness:
  - Perception of elements
  - Comprehension of the situation
  - Prediction of future status
- The recall-probes are developed using a HTA-type technique to elicit the operator goals.
- Questions at each awareness level can be developed.
- This method can be used in aviation, questions about perception of elements (air speed, altitude, fuel status, location, engine revolutions)

Then is situational awareness global assessment technique. Again it takes information, it takes data from few of the earlier tools that we discussed. So, this method presents recall probe questions when the task is interrupted to measure the awareness. It measures three levels of awareness. First is perception of element very important you know. If we do not perceive the elements whatever present in our workstation, in our workplace it becomes very difficult for someone to react on it right. So, how I am perceiving the elements present in the workstation each and everything how I am perceiving it, how I am getting influenced of it, it is very very important. So, and it keeps on varying person to person, position to position, situation to situation. The same light source can have different impact when we are in different situation. So, how do we perceive, how it help us to take this critical decision. So, these this particular process will help us to understand that. Then comprehension of the situation, how I am comprehending that particular situation in a particular cases ok and then prediction of the future status. Of course, my decision will help to act something and how do I predict and how do I act because my prediction will lead me the the lead me means I mean to say the operator lead the operator to take some action right. So, here it is very very important how they are perceiving the element, how they are comprehending the particular situation and how they are force how they foresee the situation, how they take the status ahead ok. So, the recall probes are developed using the HTA type technique to elicit the operators goal. Questions at each awareness level can be developed because you know it has different stage. So, you can really develops 1, 2, 3, 4 something like that. This method also can be used in aviation questions about the perceptions of elements and all those things. So, air speed, altitude, fuel state. So, basically you know when there is an air accident. So, how and why it happen? So, it may have sequential error. So, how do we analyze it and how the design can prevent such incident further? So, these type of tool will give you such data. So, this is very very useful in many critical situations. So, it is not only aviation industry, in much industry where lot of parallel information and cross connecting information is going on and it is going to affect the system. For those cases these types of tools are very helpful.

		Output						
	Methods	Time	Errors	Tasks	Goals	Decision	Workload	Usability
General analysis methods	Observation							
	Interview							
	Verbal protocol							
	Rep. Grids							
	Focus group							
Cognitive task analysis	HTA							
	Function Alloc.							
	CDM							
	ACWA							
Error analysis	SHERPA							
	TAFEI							
Workload and situation analysis	Workload							
	MRTSM							
	CPA							
	SAGAT							

Analysis of the Behavioural and Cognitive methods by Form of Data Output — Primary form of output — Secondary form of output

So, you know it is an I can say it is a overall chart that you can see. It is a just a data representation that where and how you can use them, what is possible possibilities. So, using this particular form you can may choose which one is useful for your objective and which one to be chosen for your objective. So, you can choose to fulfill your object. So, this is just a representation of that you can use for your own, but it is not only this. Apart from the based on your specific objective you can have some changes here and there. It is not only fixed, you can have your own modification, but this is basic. This you can use it.

Conclusion

- Most project would require using multiple methods in order to provide a comprehensive picture of cognitive and behavioral demands and constraints.
- Some methods have very general coverage, in which cases a primary form of output is not identified.
- Most ergonomics studies are likely to involve a combination of methods.
- Application of methods will benefit from a pilot study to determine the data regarding data about human cognitive and behavioral demands.

So, today I would like to conclude with all these tools that we are going to discuss, already discussed today. However, each and every tool we will be discussing in detail in further classes. So, already I think I mention always that you know although somebody is telling this tool is beneficial for this, this tool is beneficial for that, this technique we

should use for this, this technique we can be used for that. However, it is absolutely the researcher's decision that which tool to be chosen because the researcher is the only owner of his or her objectives. So, based on his or her objectives what data or what deliverable they are visualizing based on that they can pick the tools and techniques available in the literature, ok. So, from whatever tools I have discussed till now you can use any one of them or in combination based on your objectives, ok. So, in from the next class onwards what we will do? We will go for the detailing. So, starting from the history majorly and then how do we collect data, how do we analyze the data and what can be the possible interpretation of such data. If possible in some cases I will give some example which I have with me then you may practice it at your end and if you have any question or any query definitely you can discuss it in the discussion board or in the you know interaction session. Thank you for today. Thank you.