

**Ergonomics in Automotive Design**  
**Prof. Sougata Karmakar**  
**Department of Design**  
**Indian Institute of Technology, Guwahati**

**Module - 1**  
**Part - II**  
**Lecture - 02**

(Refer Slide Time: 00:34)

**Driver Information Acquisition and Processing**

Driving – complex task

- Physical demand
- Cognitive demand

Time constrained decision making

Selection of response

Execution of response (e.g. neuro-muscular action for control operation)

Courtesy: Swaroop Roy and Shiv Kumar

Average time taken by driver:

- 0.5-1.0 sec: Viewing analog speedometer (Rockwell et al., 1973)
- Typically two to four glances (each 1 sec duration): Operation of radios, climate controls etc. (Bhise, 2002; Jackson et al., 2002)
- 0.8 -2.0 sec glances: viewing through side-view mirror

During an off-road glance of 1 sec duration, vehicle travels 28 m on the roadway (if speed is 100 km/h)

Now, we are going to the last topic of module one; that is driver information acquisition and processing. So, all of we know; the driving is a complex task which deals with physical demand and cognitive demand. If you look at the various scenario, where the driver has to take decisions within fraction of second; 0.5 to 1.0 second is required for viewing analog speedometer. Typically, 2 or 4 glances are required and each of 1 second duration while they are operating different types of controls - in little bit complex task; where they are operating radio button or climate control, means, AC control; for that purpose, they at least require two to four glances and each of the glance requires 1 second.

On the other hand; if you look at for viewing side-view mirror – left-side or right-side view mirror; then it is taking point eight to two seconds. So, while driver is doing these types of in-vehicle activities; then his primary attention from the road, it is shifted to inside the vehicle. Then, what is happening? If we consider that vehicle speed is 100

kilometer per hour, so within this 1 or 2 second time; in 1 second time; the vehicle travel 28 meter and within this distance driver is actually not looking at the road; he is looking inside the vehicle for performing different types of operations.

So, what happens; while drivers are doing this type of complex decision-making task and followed by that selecting a particular response and executing that response; then various information they receive, they process, and they execute.

(Refer Slide Time: 02:22)

**Driver Information Acquisition and Processing**

**Why is information required?**

For efficient and save navigation of vehicle, drivers need to perform numerous tasks/ activities which continuously require different information received through different sensory channels.

**Accidents in India due to act of talking over mobile phones while driving (year 2016)**

- 4976 – road accidents
- 2138 – deaths
- 4746 – injuries

**Negative consequences?**

- The information may have negative impact on drivers such as annoyance, fatigue, and interference or masking of other useful information.
- Mental fatigue due to cognitive overloading leading to delayed in decision making and response execution.
- Distractions of driver's attention from primary task of driving are the major causes of accidents and near-accidents.

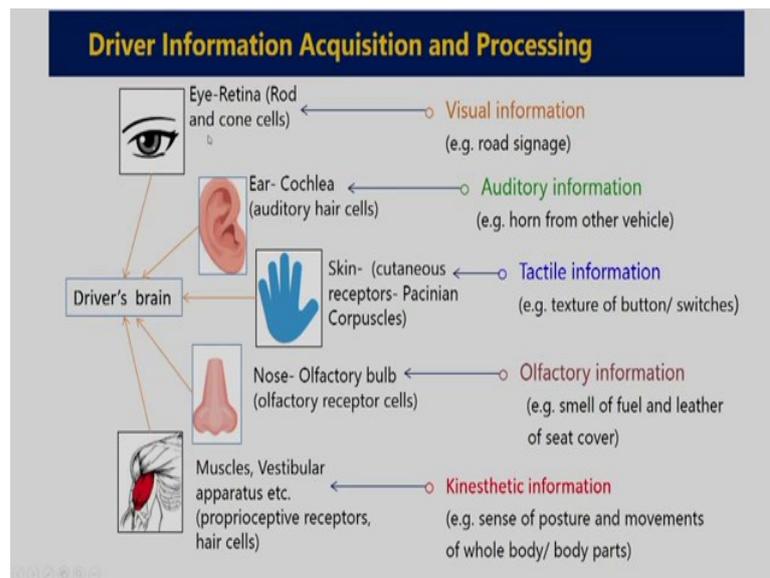
Source: Ministry of Road Transport and Highways, 2016. ROAD ACCIDENTS IN INDIA 2016. New Delhi.

Now, why this information is required; different types of information is very important for the driver's safe and effective navigation. On the one hand, it is important that various information is required for driving; on the other hand, if information overloading is there, there are also different types of driver errors, which happens.

The information may have a negative impact on drivers, such as annoyance, fatigue, interference or masking of other useful information. There is also mental fatigue due to cognitive overloading and which leads to delayed decision making and response execution, distracted driving also leads to accident. If we look at this report by Ministry of Road and Transport and Highways (2016). So, according to their accident report (2016), 4,976 road accident happened; out of that 2,138 deaths occurred, and 4,746 people injured.

Why all these accidents happened? Only due to the drivers distracted behaviour while they were talking over mobile phones. So, from that, it is very clear that while drivers are distracted or performing different types of activity, means, while they are not concentrating on their primary task (that is navigating the vehicle) and based on the information received from the road; then this types of accidents may happen.

(Refer Slide Time: 03:49)



Drivers receive information through various sensory channels. In various sense organs (like eye, ear, skin, nose) various types of muscles and different types of receptors are there (proprioceptive receptors are there); through that they are receiving the various information.

What type of information are they receiving? They are receiving visual information; for example - road signages; auditory information from horn of other vehicles; tactile information, for example - the texture of button/switches; olfactory information - smell of fuel or leather from the seat cover. Similarly, there is kinesthetic information; for example - sense of posture and movements of whole body or body parts.

So, this type of different information; like visual information, auditory information, tactile information, olfactory information as well as kinesthetic information; all these types of information is being received by the driver while they are driving. And this information is received by various sense organs like eye; in eye there are rod and cone

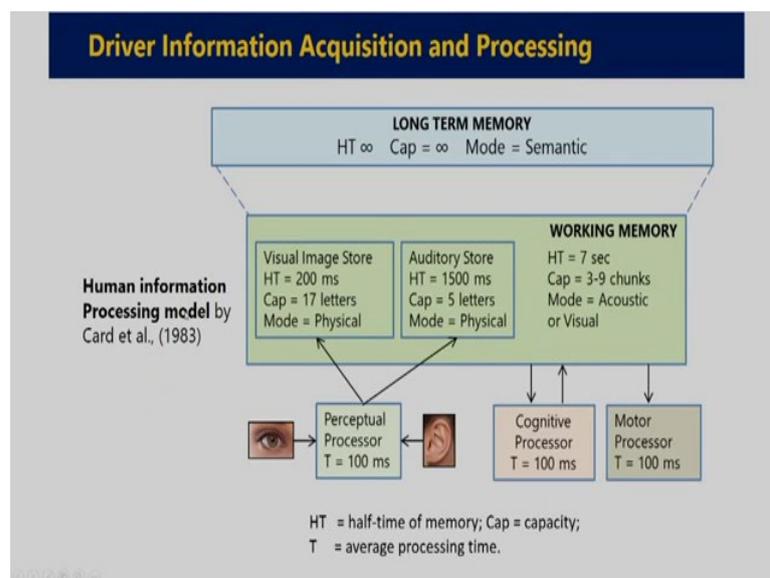
cells; these are the receptors cells those are activated and then the electrical signal is reaching to the brain.

Similarly, in ear there is cochlea. In cochlea there are hair cells; those hair cells are activated, and it sends the signal. If we consider the skin; there are various cutaneous receptors; for example - Pacinian corpuscles, Meissner corpuscles; those receptor cells are getting activated and they are sending the signal to the brain. Similarly, for nose, there is olfactory bulb; inside that olfactory bulb, there are olfactory receptor cells. Due to various type of smell that is coming to nose and it is activating olfactory receptor cells; then signal is reaching to the brain.

Various kinesthetic information, as I mentioned earlier; senses of posture, movements of whole-body parts or individual body part; then that information is actually perceived by various types of receptors located in muscles, located in vestibular organ of inner ear. So, there are proprioceptive receptors in muscles, and in case of vestibular operators, there are hair cells.

So, these receptor cells, while activated they send signals to brain, and then brain interprets the signals to take the decision. So, driver receives so many information from various sensory channels and while that information reaches the driver's brain, they get the perception about the stimuli and then further process for decision making.

(Refer Slide Time: 06:31)



Now, we are moving to the human information processing model. In human information processing model, there are various aspects of human brain and various types of processors. So, there is perceptual processor, you can see at the bottom, it is written half time of the memory, means, after a certain time the memory decays to its half of the original amount. Capacities - 'Cap', this 'Cap' is for capacity and 'T' for average processing time.

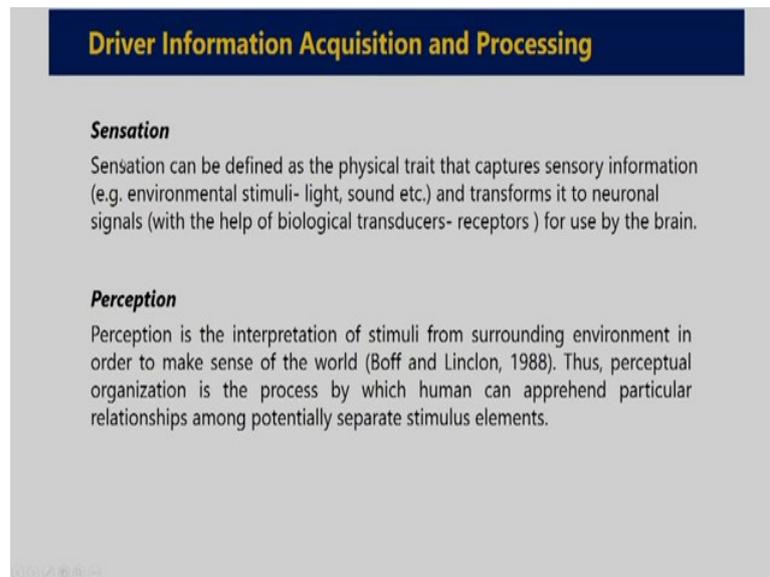
Now, while if you look at them, while the driver is receiving some visual information or auditory information, it is going to perceptual processor. In perceptual processor, the average time is 100 milliseconds for the processing. Now, that information goes to the working memory, and it is stored as visual information or auditory information. Half time of visual information is 200 milliseconds, and its capacity is 17 letters and mode - physical. Similarly, in case of auditory; half time is 1,500 milliseconds.

So, while from the perceptual processors, these visual and auditory information or any other information is reaching to brain and it is stored in working memory. So, average half time of working memory is 7 seconds, and its capacity is 3-9 chunks of information and mode – mainly acoustic or visual.

So, now that information further travels from the working memory; it may reach to long term memory. And in long term memory; the half time is infinite, means, once it is stored in long term memory, it is stored there permanently, and its capacity is infinite and the memory is stored as (information is stored as) semantic memory. Now, from the working memory; the information comes to cognitive processor and cognitive processors with the help of working memory; ultimately guide motor processor and motor processor executes the motor response.

Now, to understand this human information process model, we need to understand individual components. So, for individual components, we will discuss in detail.

(Refer Slide Time: 08:38)



**Driver Information Acquisition and Processing**

**Sensation**  
Sensation can be defined as the physical trait that captures sensory information (e.g. environmental stimuli- light, sound etc.) and transforms it to neuronal signals (with the help of biological transducers- receptors ) for use by the brain.

**Perception**  
Perception is the interpretation of stimuli from surrounding environment in order to make sense of the world (Boff and Linclon, 1988). Thus, perceptual organization is the process by which human can apprehend particular relationships among potentially separate stimulus elements.

So, first, one is the sensation. So, what is sensation? Sensation can be defined as the physical trait that capture sensory information from the environment or ambient soundings. And that information; whatever information or sensory information we are perceiving from the environment; our sense organ where there are neuronal receptor cells, which acts as the biological transducer, it converts to the electrical signal.

So, in brief, what is sensation? Sensation is the process by which our various biological transducers, that is the receptor, convert the physical stimuli to electrical signals and that electrical signals further travel towards the brain through the neurons or nerve fibres. Now, next is perception, what is perception?

Perception is the interaction of stimuli from the surrounding environment in order to make the sense of the world; thus, perceptual organization is the process by which human can apprehend a particular relationship among potentially separate stimulus. So, through the sensation, information is reaching to brain. And in brain there are perceptual processors which help in discriminating what type of information, how is its intensity and how its magnitude? Thus various information we perceive.

(Refer Slide Time: 10:03)

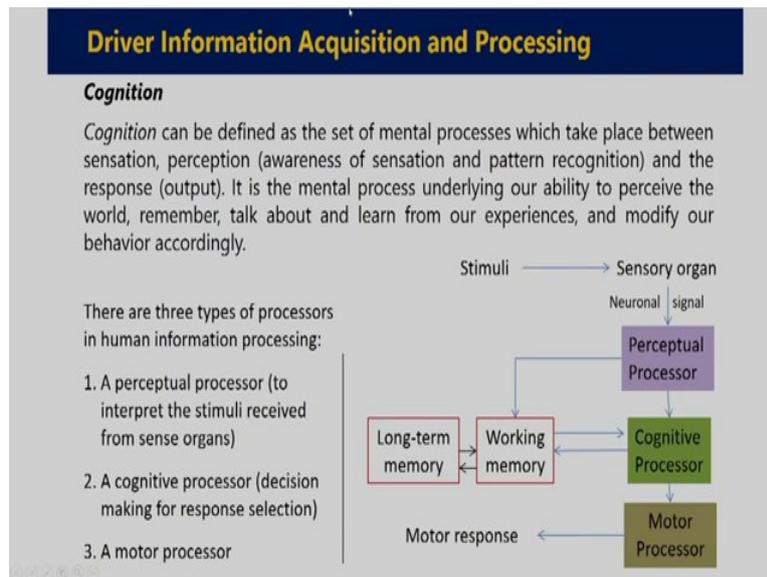
Driver Information Acquisition and Processing	
Types of perception	Examples
Visual perception	<ul style="list-style-type: none"><li>▪ Colour perception of product</li><li>▪ Form perception of product</li><li>▪ Size, depth perception</li></ul>
Auditory perception	<ul style="list-style-type: none"><li>▪ Pitch perception (frequency of sound wave)</li><li>▪ Loudness perception (amplitude of sound wave)</li><li>▪ Sound localization (location and direction of sound source)</li></ul>
Smell perception	<ul style="list-style-type: none"><li>▪ Noxious smell of ammonia.</li><li>▪ Sweet smell of a fragrance.</li></ul>
Touch perception	<ul style="list-style-type: none"><li>▪ Smoothness or roughness of the product surface</li><li>▪ Softness of seat-cover</li></ul>
Kinesthetic perception	<ul style="list-style-type: none"><li>▪ Vibration frequency, amplitude, duration, direction etc.</li><li>▪ Body balance, spatial orientation</li></ul>

Now, various types of perception. There is visual perception; here are some examples - colour perception of the product, form perception of product, size and depth perception, so these are the various types of visual perception. Similarly, there is also auditory perception, while the information from the hair cells of the ear, those electrical signals are reaching to brain, then in brain there is auditory perception related to pitch perception, loudness perception, sound localization, location and direction of the sound source. So, this type of various perception is perceived in our brain.

There is smell's perception - the noxious smell of ammonia, sweet smell of fragrance; this type of information is also reaching to our brain. Touch perception; so as we have discussed earlier; there is skin where there is cutaneous receptors, those receptors actually convert the stimulus (which we, as earlier mentioned as the sensation) and that sensation as electrical signal is reaching to our brain, where we are getting the touch perception; we are getting the information like softness of the seat cover or smoothness or roughness of the product surface.

So, this type of information we perceive. There is also kinesthetic perception. For example, vibration, frequency, amplitude, duration, direction, etcetera. Body-balance, spatial-orientation of different body parts that information is perceived by (actually sensed) our kinesthetic sensors and ultimately it reaches to brain for kinesthetic perception.

(Refer Slide Time: 11:38)

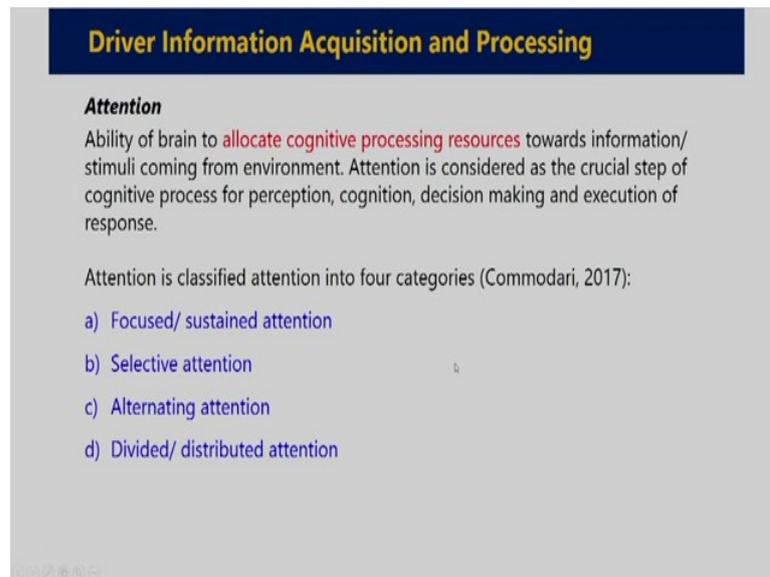


Now, the next topic is cognition, cognition can be defined as the mental process which takes place between sensation (that is the first step), and then perception, and finally, response selection. So, cognition is the process which is actually happening or taking place between these activities - in between sensation, perception and response. It is the mental process underlying our ability to perceive the world (remember, talk about and learn) from our experiences and modify our behaviour accordingly.

So, while once any stimulus is coming to our sensory organs and sensation happening as a neuronal signal, which is reaching to perceptual processor. From the perceptual processor it is going to cognitive processor, and from cognitive processor it is reaching to motor processor. And finally, motor processor is executing the motor response; while there are various type of neuro-muscular functions.

So, mainly, there are three types of processor - perceptual processor, cognitive processor and the motor processor. This cognitive processor is actually making the decision based on the working memory and working memory is again taking the help of long-term memory.

(Refer Slide Time: 12:55)



**Driver Information Acquisition and Processing**

**Attention**  
Ability of brain to allocate cognitive processing resources towards information/ stimuli coming from environment. Attention is considered as the crucial step of cognitive process for perception, cognition, decision making and execution of response.

Attention is classified attention into four categories (Commodari, 2017):

- a) Focused/ sustained attention
- b) Selective attention
- c) Alternating attention
- d) Divided/ distributed attention

Now, for understanding the relationship between sensation, perception, cognition and motor response; we also need to understand attention.

What is attention? Attention is the ability to allocate cognitive resources (cognitive processing resources) towards information or stimuli coming from the environment. So, this is the allocation of cognitive processing resources, means, how much cognitive resources we can allocate for a particular task.

Attention is considered as the crucial step for the cognitive process; for perception, cognition, decision-making and execution of the response. So, there are four types of attention, means; you can categorize attention into four categories; first one - focused or sustained attention, second - selective attention, next - alternating attention and the last one is a divided or distributed attention. Now, we will discuss each of these categories; one by one.

(Refer Slide Time: 13:54)

**Driver Information Acquisition and Processing**



- a) **Focused/ sustained attention** – ability to respond discretely to specific stimulus/ task for certain amount of time without distraction
- b) **Selective attention** – focusing on a specific stimuli by filtering others (inhibiting interference of distracting stimuli and suppress inappropriate response)
- c) **Alternating attention** – rapid shifting of the attention back and fort between stimuli/ tasks that require different cognitive demand
- d) **Divided/ distributed attention** - processing two or more stimuli simultaneously and concerns the allocation of resources among different sets of input

So, if you take the vehicle example where the driver is driving a vehicle, at that time, how the driver is allocating different types of cognitive resources for decision making? So, in that case; he has different types of attention. Focused or sustained attention - in this type of attention, you can define as the ability to respond discretely to specific stimulus or task for certain amount of time without distraction.

In case of driving; we can take the example; while the driver is driving and his primary focus is on the visuals of the road; while visual information is coming from the road and driver is focusing his attention on the road and based on that visual information, he is driving. So, this type of attention allocation, we call as focused attention.

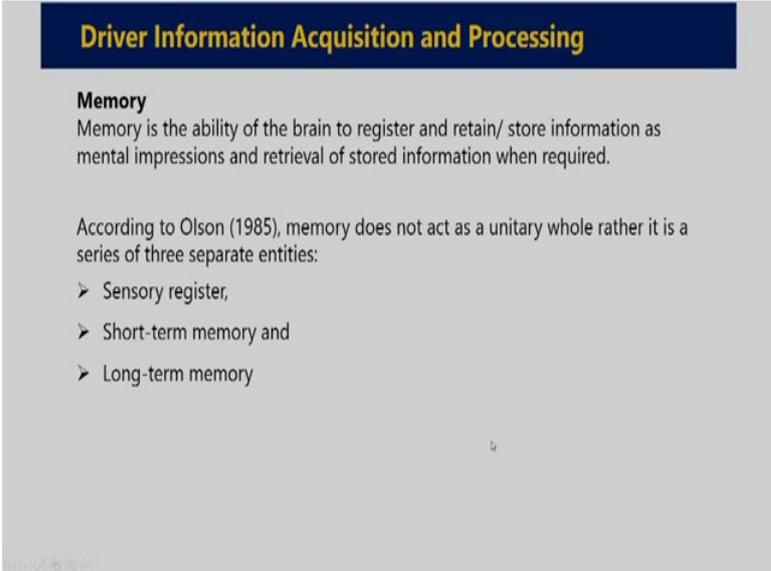
There is another type of attention that is selective attention; where focusing on a specific stimulus by filtering others (inhibiting interference or disturbing stimuli), hence suppress inappropriate response. So, in case of selective attention; driver is actually selectively attending some stimulus, where he is suppressing or not attending to other sort of stimulus coming from the environment. For example, while the driver is driving; his primary or focused attention is on the road, at the same time he is selectively attending other visual information; for example, road signage or he is searching a particular shop on roadside. So, his attention is selectively going to that direction.

Alternating attention - rapid shifting of attention (back and forth) between stimuli task that requires different cognitive demand. In this case; there is rapid shifting, say, for

example, there is another co-passenger, he is talking with the driver. So, the driver is performing both the task; he is talking with the co-passenger, and at the same time he is looking at the road in front; for driving. So, he is rapidly shifting his attention between these two tasks. So, this is an example of alternating attention.

There is another sort of attention, that is divided or distributed attention. Driver is performing two or more tasks simultaneously; those tasks or stimuli may be similar or maybe of different nature. For example, driver is talking with co-passenger, at the same time he is controlling different types of controls and at the same time perceiving or receiving information from the road. So, for a particular time, he is distributing his attention in so many activities. So, this type of attention distribution is called distributed attention.

(Refer Slide Time: 16:38)



**Driver Information Acquisition and Processing**

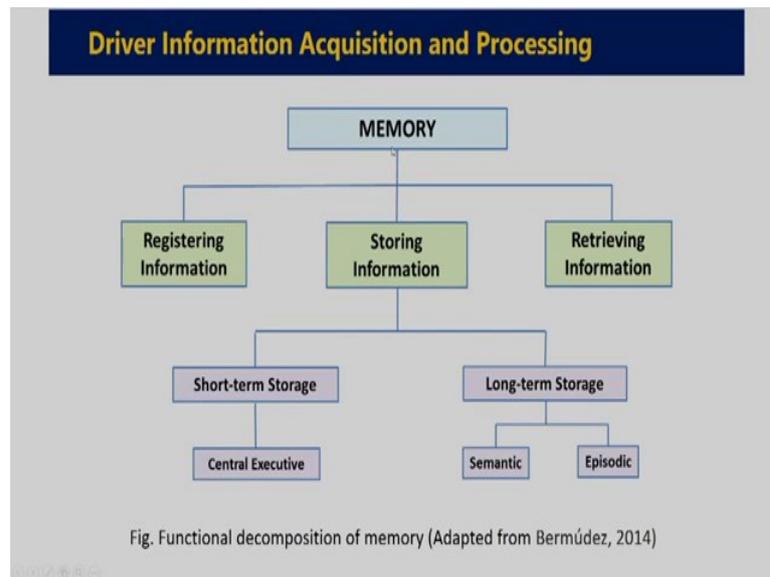
**Memory**  
Memory is the ability of the brain to register and retain/ store information as mental impressions and retrieval of stored information when required.

According to Olson (1985), memory does not act as a unitary whole rather it is a series of three separate entities:

- Sensory register,
- Short-term memory and
- Long-term memory

Now, for understanding the human information processing; we should also know about the memory. Memory - how we can define memory? Memory is the ability of the human brain to register and retain or store the information as mental impression and retrieval of stored information whenever it is required. So, not only the storing but at the same time, retrieval of that information. According to Olson (1985), memory does not act as unitary whole; rather it is a series of three separate entities. So, first one - sensory register, second - short term memory and third one is the long-term memory. So, these are the main three categories of memory.

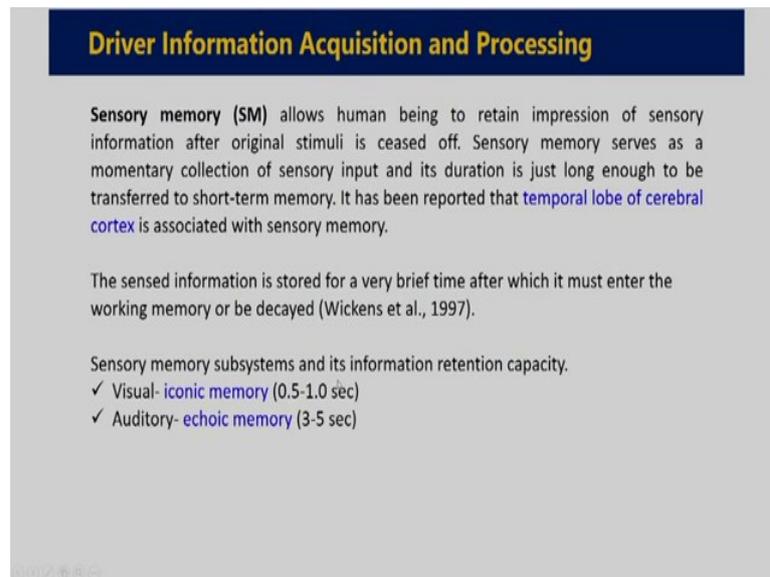
(Refer Slide Time: 17:21)



Now, from this schematic diagram; you can see; based on the function, memory can be divided into three parts; one is registering information, generally, we call it as sensory register or sensory memory. The second is the storing of information, where there is short-term storage or short-term memory and long-term memory. And there is also another function of brain, that is modular function related to memory; that is the retrieving of information.

Now, in storing information; as we mentioned; short-term memory is there as well as long-term memory. Short-term memory then acts as the central executive for making the decision; obviously, with the help of long-term memory. Long-term memory can be further divided into semantic and episodic memory.

(Refer Slide Time: 18:08)



**Driver Information Acquisition and Processing**

**Sensory memory (SM)** allows human being to retain impression of sensory information after original stimuli is ceased off. Sensory memory serves as a momentary collection of sensory input and its duration is just long enough to be transferred to short-term memory. It has been reported that **temporal lobe of cerebral cortex** is associated with sensory memory.

The sensed information is stored for a very brief time after which it must enter the working memory or be decayed (Wickens et al., 1997).

Sensory memory subsystems and its information retention capacity.

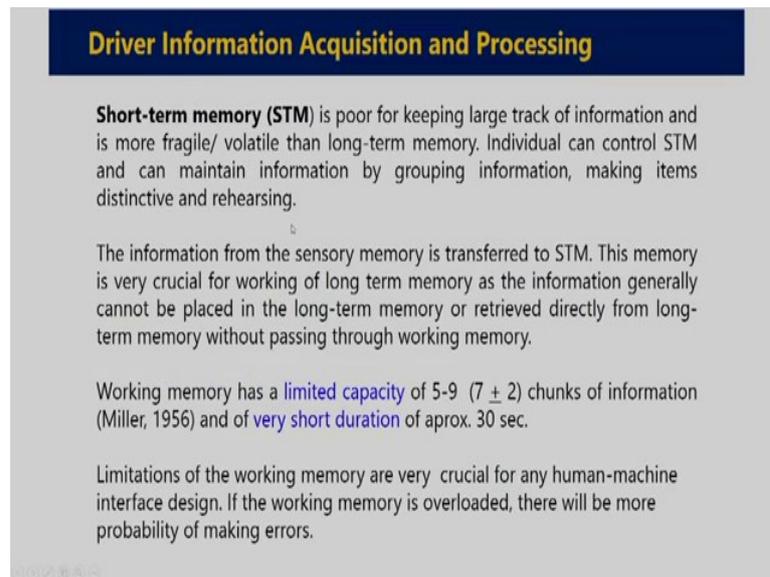
- ✓ Visual- **iconic memory** (0.5-1.0 sec)
- ✓ Auditory- **echoic memory** (3-5 sec)

Now, we want to discuss about sensory memory. So, sensory memory allows a human being to retain impression of sensory information after original stimuli is withdrawn. Sensory stimuli serve as momentary collection of sensory input, and its duration is just enough to be transferred to short-term memory. It has been reported that temporal lobe of the cerebral cortex is associated with this sensory memory. So, sensory memory; it has huge capacity, but its duration is very short, its time is just enough for converting that information from sensory memory to short term memory (if it is required); otherwise it will be decayed or it will be destroyed, there will be no storage of sensory memory.

The sensed information is stored for a very short time, after which it must enter the working memory, or it will be decayed. Sensory memory sub-system and its information retention capability also varies based on which type of information. If it is visual information; it is stored as an iconic memory, and its duration is 0.5 to 1 second; after that it decays.

On the other hand; auditory memory, which is auditory information, which is stored as the echoic memory, its duration is 3 to 5 seconds.

(Refer Slide Time: 19:28)



**Driver Information Acquisition and Processing**

**Short-term memory (STM)** is poor for keeping large track of information and is more fragile/ volatile than long-term memory. Individual can control STM and can maintain information by grouping information, making items distinctive and rehearsing.

The information from the sensory memory is transferred to STM. This memory is very crucial for working of long term memory as the information generally cannot be placed in the long-term memory or retrieved directly from long-term memory without passing through working memory.

Working memory has a **limited capacity** of 5-9 ( $7 \pm 2$ ) chunks of information (Miller, 1956) and of **very short duration** of approx. 30 sec.

Limitations of the working memory are very crucial for any human-machine interface design. If the working memory is overloaded, there will be more probability of making errors.

Now, short-term memory is poor for keeping large track of information, and it is more fragile/volatile than the long-term memory. Individual can control short-term memory and can maintain information by grouping information, making items distinctive and by rehearsing. The information from the sensory memory is transferred to the short-term memory, this memory is very crucial for working of the long-term memory as the information generally cannot be placed in the long-term memory or retrieved directly from the long-term memory without passing through the short-term memory.

So, short-term memory actually works as the gateway. From long-term memory, the information comes to short-term memory; then it helps in decision making. On the other hand; while some information is coming from the sensory organs and it is reaching to brain. So, first it reaches to; from sensory memory to short-term memory and from short-term memory to long-term memory. Working memory has a limited capacity. So, generally, 5 to 9 chunks of information and have very short duration - approximately 30 seconds. Limitations of the working memory are very crucial for any human-machine interface design. If the working memory is overloaded there will be a probability of more mistakes or errors.

(Refer Slide Time: 20:48)

### Driver Information Acquisition and Processing

**Long-term memory (LTM)** is generally stored in semantic, episodic-visual, auditory and abstract formats. LTM has **large capacity** and is **virtually permanent** i.e. usually through the entire life span of an individual. Human gains control over LTM by encoding information into rich meanings and linking/ associating items together and by being clever at finding items that appear to be lost (Olson, 1985).

So, in comparison to short-term memory, long-term memory is generally stored as the information in semantic and episodic format. Long-term memory has large capacity, and it is virtually permanent. It means; usually, it is stored throughout the entire life span of an individual. Human gains control over long-term memory by encoding information into rich meanings and linking or associating items together, by being clever at finding items that appear to be lost. So, they can also find out the information stored in the brain by some tricks or by associating or linking with other items stored in the brain.

(Refer Slide Time: 21:29)

### Driver Information Acquisition and Processing

Characteristics of different memories

Feature	Sensory register	Short-term memory	Long-term memory
What it takes to get information in?	Attended or unattended stimulation	Requires attention and cognition	Repetition, rehearsal or coding
How information is maintained?	Not possible	Continued attention or rehearsal	no effort or capacity is required
How long unmaintained trace lasts?	0.25 to 2 seconds	Up to 30 seconds	Minutes to years
What format information is in?	Literal copy of the input	Visuospatial and phonological	Semantic, episodic - auditory/ visual, abstract
How much information can be held?	Very high capacity	Small: 7 +/- 2 Chunks	No known limit
Rate of forgetting	Rapid decay Overwriting from successive inputs	Decay, or overwriting from successive attended inputs	Possibly no loss until damage in the brain parts associated with the long term memory

Adapted from: Olson (1985)

Now, after discussing these three types of memory - sensory register, short-term memory and long-term memory. If we summarize; that, what are the differences of these three types of memory (based on various features), as it is mentioned on the left side panel; that what it takes to get information in; how information is maintained. So, the first point - what it takes to get information in. Attended or unattended stimulus - that may be sensed by the sense organ, and it is reaching to sensory register or our sensory memory.

In the case of short-term memory, it requires the attention and cognition to save that memory. Long-term memory; (repetition, rehearsal or coding) is required to convert the short-term memory to long-term memory. How information is maintained in this type, means, various types of memories? So, in case of sensory memory; information cannot be maintained. In case of short-term memory; it is possible; for that purpose, continuous rehearsal or attention is required. In the case of long-term memory; generally, no effort or capacity is required for this purpose.

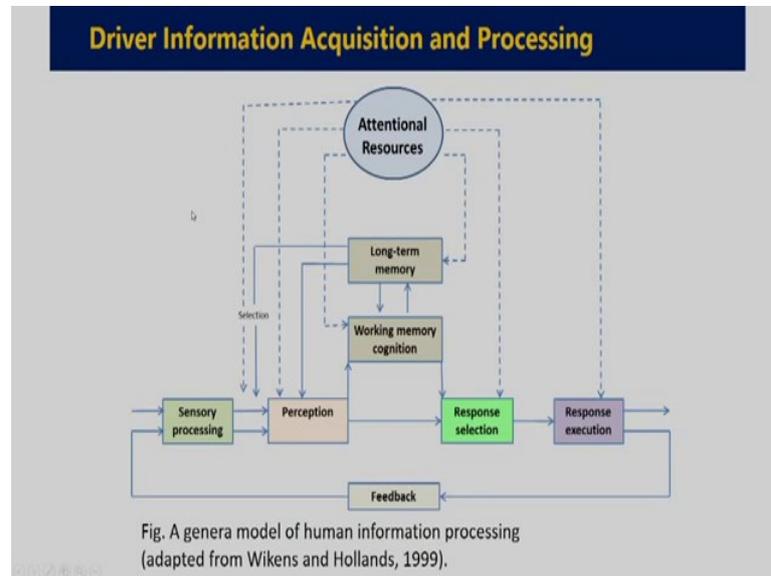
Then, how long this information last in that brain? In the case of a sensory register, it is 0.25 second to 2 seconds. In case of short-term memory, it is up to 30 seconds that short-term memories stay, and in case of long-term memory it is a lifetime; it is from minutes to years. What is the format of the information which is stored in sensory memory or short-term memory or long-term memory? So, in case of sensory memory, the information is stored as the literal copy of the input or the visual or auditory or any other tactile information.

In the case of short-term memory, it is stored as visuospatial and phonological information. In case of long-term memory; semantic/episodic, that may be auditory and visual, or in abstract format, it is stored. In terms of capacity; sensory register has high capability, it can store huge information, but in case of short-term memory, it is very small, only 7 plus minus 2 chunks of information; in case of long-term memory, again it is, there is no limit, infinite amount of information can be stored. Rate of forgetting. So, rapid decay happens in case of sensory memory; it keeps overwriting from successive inputs; if the next input comes, then the previous information is erased.

In case of short-term memory, it decays, or overwriting happens, from successive attended inputs. So, in that case it also decays first. So, as we mentioned; its duration is only 30 seconds, but in case of long-term memory possibly no loss, until there is damage

in the brain or brain parts which are associated with the long-term memory. So, these are the overall differences between these three types of memories.

(Refer Slide Time: 24:17)



Now, following discussing various aspects of the cognitive process and human information processing, we found that sensation is important. Then from sensation, it is reaching to perception, then there is cognition is happening and based on the cognition, we are making various decisions and that decision is ultimately helping in the selection of motor response and execution of the motor response.

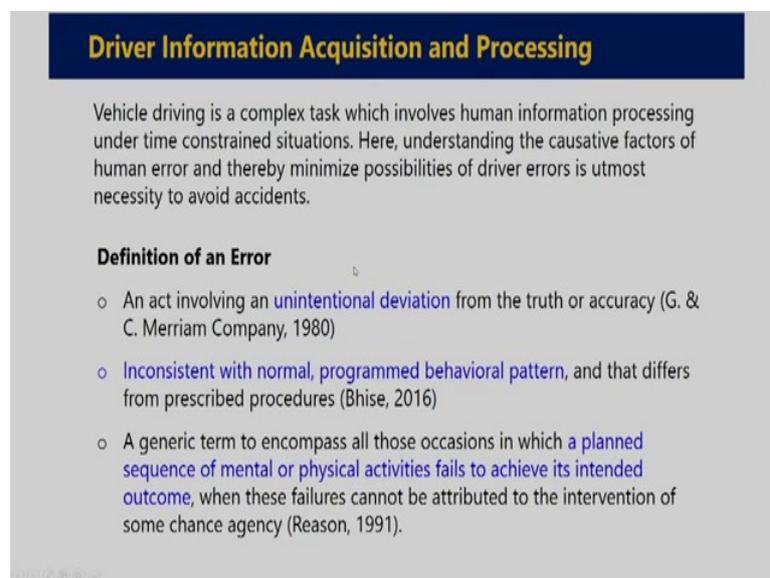
So, if we look at this schematic diagram of the general model of human information processing. So, you can see, while that any sort of information or stimuli is coming from the environment and it is reaching to the sense organs; from the sense organs that sensation is reaching for sensory processing and that is from sensory processing, it is reaching to the brain for perception.

So, from sensory processing or sensory memory, it is going for the perception. And from perception, it is reaching to working memory, and from working memory, it is reaching to long-term memory, or working memory is guided by long-term memory.

So, with the help of working memory, cognition is happening, and that cognition is ultimately helping in response selection, while the response is selected then there is response execution through neuro-muscular actions and that response is ultimately

providing feedback to the sensory processing. So, while this type of step by step activities are happening and there is also this type of feedback loop; then attentional resources play a very important role; you can see attentional resources has influence on all these areas - sensory processing, perception, long-term memory, short-term memory as well as response selection. So, attentional resources; how information will be processed, it will be stored and how/what type of response will be selected; in all these activities, actually how much attention is being provided in each of these steps, it plays a crucial role. So, attention is very important in the case of information processing and response execution.

(Refer Slide Time: 26:20)



**Driver Information Acquisition and Processing**

Vehicle driving is a complex task which involves human information processing under time constrained situations. Here, understanding the causative factors of human error and thereby minimize possibilities of driver errors is utmost necessity to avoid accidents.

**Definition of an Error**

- An act involving an **unintentional deviation** from the truth or accuracy (G. & C. Merriam Company, 1980)
- **Inconsistent with normal, programmed behavioral pattern**, and that differs from prescribed procedures (Bhise, 2016)
- A generic term to encompass all those occasions in which **a planned sequence of mental or physical activities fails to achieve its intended outcome**, when these failures cannot be attributed to the intervention of some chance agency (Reason, 1991).

Now, moving to the next topic; that is related to human error and how this is relatively important for driving. Vehicle driving is a complex task which involves human information processing under time-constrained situation. Here understanding of causative factors of human error is important, and thereby we can minimize the possibilities of driver errors by various design modifications. So, what is error or human error?

There are various definitions of human error. So, it can be defined as an act of involving an unintentional deviation from the truth or accuracy. It can also be defined as the inconsistency, any act or activity which is inconsistent with normal or programmed behavioural pattern and that differs from prescribed procedures.

Reason (1991), he defined an error as a generic term to encompass all those occasions in which a planned sequence of mental or physical activities fails to achieve its intended outcome when these failures cannot be attributed to the intervention of some chance agency. So, this type of planned sequence of; while there is deviation from or those occasions in which planned sequence of mental and physical activities fails to achieve its intended action that is defined as the error. So, there are various definitions of human error.

(Refer Slide Time: 27:52)

**Driver Information Acquisition and Processing**

Three different causes of human error (Nemeth, 2004):

- **Task complexity**- complex task sequences can overburden the limited capacity short-term memory and the recall capability of long-term memory
- **Error-likely situations**- situations incompatible with human abilities, limits, experience or expectations are likely to induce errors
- **Behavioral Characteristics**- human characteristics like demographic traits, skills, training, experience, emotional state and stress can induce error

Types of human error depending on behaviors of omission and commission  
(Adapted from Swain and Guttman, 1980):

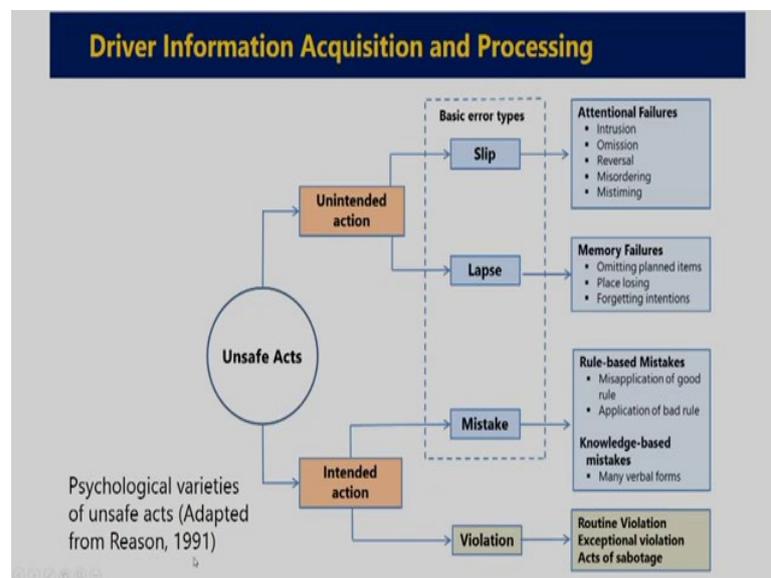
<b>Omission</b>	Portion of a task is skipped
<b>Commission</b>	performing a function that should not have been performed
<i>Extraneous act</i>	Task that should not have been performed, as it diverts attention from the system
<i>Sequential act</i>	Task is performed out of sequence
<i>Time error</i>	Task performed too early, too late, or outside of time allowed

And this human error actually happens due to various reasons. What are those reasons? So, one is task complexity; there is also error-like situations and behavioural characteristics. In task complexity; complex task sequence can overburden the limited capacity of short-term memory and recall capability of the long-term memory. As a result, due to the task complexity, different type of human error happens. Moreover, if there are error-like situations incompatible with the human capabilities, limitations and experience or expectation, there is also chance of error and thereby accident.

Human behavioural characteristics like demographic traits, skills, training, experience, emotional state and stress can also induce error. So, these are the main reasons for which different types of human error happen. Types of human error depend on the behavioural pattern of omission and commission. So, this is actually adapted from Swain and Guttman (1980).

So, the first one is the omission. What is Omission? Omission is the portion of the task that is skipped; on the other hand; commission is the performing of additional task or performing some task which is actually not required to be performed. Further commission can be categorized into three - extraneous act, sequential act and time error. Extraneous act, means, additional task or additional step, which is performed, which is actually not required. Sequential act; due to sequential act while you are not following the proper sequence of task performance, then there is also error. There is also time error; the task which is performed not at the appropriate time, due to that also, error happens.

(Refer Slide Time: 29:41)



According to Reason (1991), psychological varieties of unsafe acts. So, Reason in 1991 divided unsafe acts which are actually leading to error into main two categories; unintended action and intended action. In unintended action, we can further categorize; slip, lapse. Under unsafe act, that intended action can further be categorized into - mistake and violation. Out of all these types of errors; slip, lapse and mistake; these three are considered as the basic error type; while violation is not considered as the error because violation is mainly an act of sabotage, exceptional violation and routine violation.

So, while these types of violation; it is actually intended activity, and this is not actually an error. So, in terms of error; we can consider these three - slip, lapse and mistake. In case of slip; attentional failures happen, where there is intrusion, omission, rehearsal,

misunderstanding, mistiming. So, this type of (different types) error occurs. Memory failures; in case of lapse, it is mainly associated with memory failures, omitting planned items, place losing, forgetting intentions. So, these are coming under lapse. In mistake; rule-based mistakes; there is rule-based mistakes as well as knowledge-based mistakes.

In rule-based mistakes; misapplication of good rule or application of bad rule. Knowledge-based mistake; many verbal forms. So, actually; that mistake is happening due to mistake in the interpretation of the information or applying the (whatever) knowledge; whatever knowledge that person has; he applied in a wrong way. So, mainly from this schematic diagram; we understand the basic three types of errors; that is the slip, lapse and mistake.

(Refer Slide Time: 31:46)

Driver Information Acquisition and Processing			
Different types of human errors in driving activities (Bhise 2016):			
Sl. No.	Types of human errors	Description	Example
1	Detection error	failure to detect a signal or a target	a driver fails to see a pedestrian
2	Discrimination error	failure to discriminate between signals	stop lamps were perceived as tail lamps
3	Interpretation error	failure to recognize a situation, a signal etc.	a tachometer reading was interpreted as the speed reading
4	Omission error	failure (or forgetting) to perform a required action	forgetting to look in the side-view mirror before changing lane
5	Commission error a) Extraneous act error, b) Sequential error, and c) Time error	performing a function that should not have been performed	(e.g., changed radio station while turning on the windshield defrost function)

(Adapted from Bhise, 2016)

Now, if we take the example of automobile driving. In automobile driving, drivers also create different types of errors during their information processing. So, these errors may be related to detection, maybe related to discrimination. So, first; detection related error is called detection error. Failure to detect a particular target; then this type of error happens, if we take one example, the driver fails to see pedestrian because there is no proper detection, that may be due to low illumination, maybe due to information overloading, so there maybe various reasons and during that situation driver may fail to detect a particular stimulus.

Then discrimination error; failure to discriminate between signals. If we take one example, the stop lamp is perceived by the driver as the tail lamp. So, the driver is actually failing to discriminate the two stimuli. So, in case of discrimination error, there is failure to discriminate between two signals; first one; here one example, stop lamps were perceived as the tail lamp. So, driver fails to discriminate between these two; whether that is a stop lamp, or it is a tail lamp, so he is unable to discriminate.

Similarly, there may be interpretation error; failure to recognize a stimulus or a signal. A tachometer reading was interpreted as the speedometer reading. Now, this type of interpretation error may also happen; there is also omission error. In omission error; failure or forgetting to perform required action. For example, forgetting to look into the side-view mirror before changing the lane; there is also commission error. Commission error; as we mentioned earlier, there is extraneous act, sequential error and time error.

So, in commission error; performing a function that should not have been performed. For example, changing the radio station while turning on the windshield defrost function. So, this type of commission error may happen.

(Refer Slide Time: 33:48)

Driver Information Acquisition and Processing			
Sl. No.	Types of human errors	Description	Example
6	Substitution error	using or substituting another item instead of the desired one	pressed accelerator pedal instead of the brake pedal
7	Reversal error	reversing the direction of activation or interpreting a displayed signal in opposite direction	increased temperature instead of decreasing
8	Inadequate response error	error in judgment or estimation of signal magnitude, distance, speed, etc.	insufficient force application during brake pedal movement for stopping
9	Legibility error	error related to not being able to read a display	Difficulty in clarify in visualizing due to factors such as small font size, insufficient light, excessive glare etc.

(Adapted from Bhise, 2016)

In substitution error; using or substituting another item instead of the desired one. For example, in case of driving, if the driver by mistake press the accelerator pedal instead of pressing the brake pedal; that type of error we can categorize under substitution error.

Reversal error; reversing the direction of activation or interpreting a displayed signal in the opposite direction.

So, this type of error happens; for example, while driver instead of increasing the temperature, he is decreasing the temperature, means, rotating that control knob in the opposite direction. Inadequate response error; error in judgment or estimation of signal magnitude, distance, speed etcetera. During driving, insufficient force application on brake pedal for stopping. So, if driver is unable to exert sufficient force or if he is unable to decide that how much force is to be applied on the brake pedal to stop the vehicle then this type of inadequate response error happens.

Then legibility error; error related to not being able to read a display, there may be a different reason. So, driver may have difficulty in clarity of visualization due to factors such as small font size, insufficient light, excessive glare etcetera. So, due to these various factors, there may be a difficulty in legibility of the display and display elements.

(Refer Slide Time: 35:20)

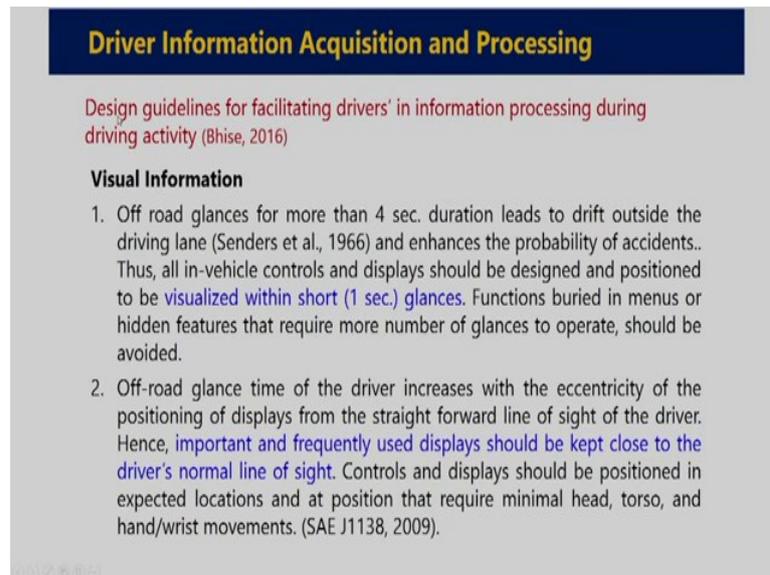
Driver Information Acquisition and Processing			
Sl. No.	Types of human errors	Description	Example
10	Recovered error	an error has occurred, but the operator could correct the error after some elapsed time	It is possible to reduce the loudness of music system while it is too high
11	Unrecovered error	an error that the operator fails to correct (or will not or cannot correct).	Once the driver takes a wrong turn in a one-way road, it is difficult to correct the action.

(Adapted from Bhise, 2016)

Recovered error; an error occurred, but the operator could correct the error after some elapsed time. So, while that error happens, but the driver, still the driver has the possibility or the opportunity to correct that error; e.g. it is possible to reduce the loudness of music system while it is too high. So, by mistake if driver has increased the music loudness, he still can reverse it. It can be recovered.

There is also a scenario where unrecovered error occurs. It is an error that the operator fails to correct or will not or cannot correct it again. Once the driver takes the wrong turn in one-way road, it is difficult for him or her to correct that action because the road is one way. So, this is coming under the category of unrecovered error.

(Refer Slide Time: 36:15)



**Driver Information Acquisition and Processing**

Design guidelines for facilitating drivers' in information processing during driving activity (Bhise, 2016)

**Visual Information**

1. Off road glances for more than 4 sec. duration leads to drift outside the driving lane (Senders et al., 1966) and enhances the probability of accidents.. Thus, all in-vehicle controls and displays should be designed and positioned to be visualized within short (1 sec.) glances. Functions buried in menus or hidden features that require more number of glances to operate, should be avoided.
2. Off-road glance time of the driver increases with the eccentricity of the positioning of displays from the straight forward line of sight of the driver. Hence, important and frequently used displays should be kept close to the driver's normal line of sight. Controls and displays should be positioned in expected locations and at position that require minimal head, torso, and hand/wrist movements. (SAE J1138, 2009).

Now, after understanding various aspects of human information processing, now we have to see; how that information processing is applicable in case of driving activity or how we can provide design guidelines for facilitating driver's information processing during various driving activities. So, first; we are discussing about visual information; that how visual information processing can be facilitated by the various type of design intervention.

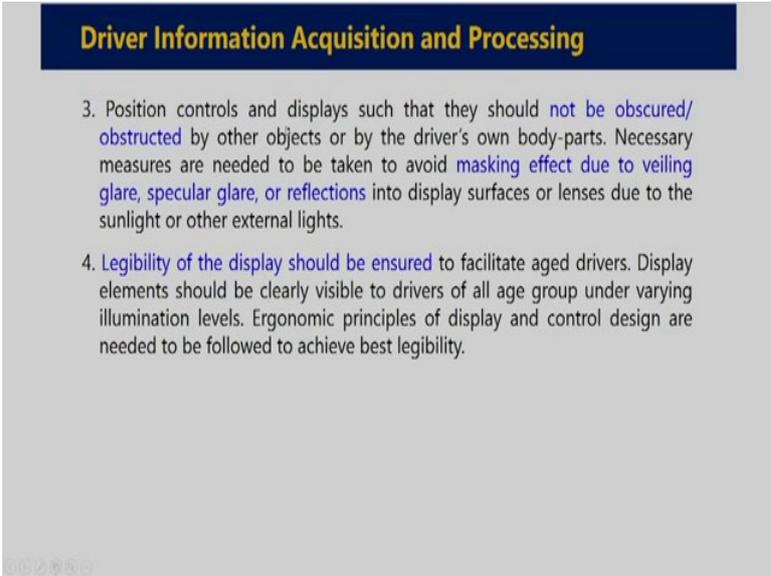
Off-road glances for more than 4-second duration leads to drift outside the driving lane if the driver is not looking at the road for more than 4 seconds then; obviously, he will be drifted from the driving lane.

And it enhances the probability of accident. Thus, all in-vehicle controls and display should be designed in such a way; and should be position in such a way that it should be visualized within a short glance of 1-second duration; just he or she will look only for 1 second after that, again he will focus his attention on the road. Functions buried in menus or hidden features; that requires more number of glances to operate, that should be avoided. While, drivers are operating any controls or there is an infotainment system or

any display where there are various menus and sub-menus, most frequently used menus needs to be directly provided on the screen, it should not be buried under menus or sub-menus, so that time for operating those menus or tools can be reduced.

Off-road glances time of the driver increases with the eccentricity of the positioning of the display from the straightforward line of sight of the driver. Hence, important and frequently used displays should be kept close to the driver's line of sight, means, straight forward, at line of sight. Controls and display should be positioned in the expected location and at the positions that require minimal head, neck and torso movement or hand or wrist movement. So, for that purpose, Society of Automotive Engineers (SAE J1138, 2009) this standard can be considered.

(Refer Slide Time: 38:27)



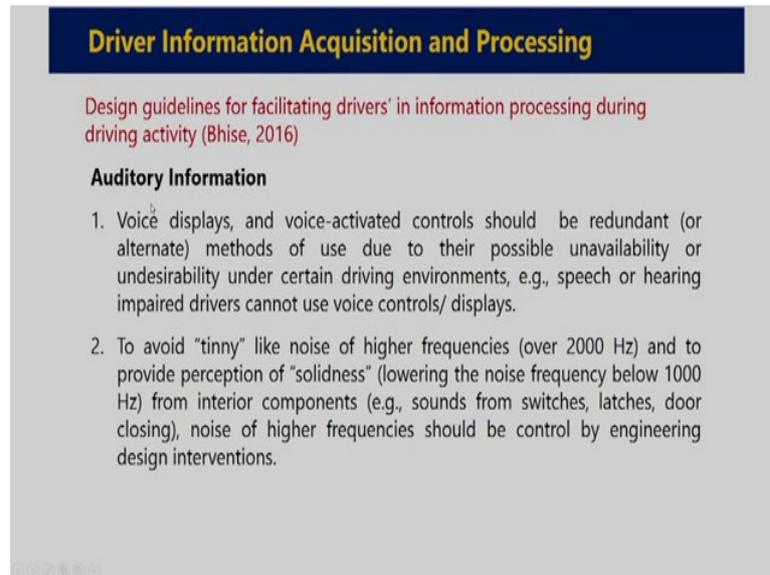
**Driver Information Acquisition and Processing**

3. Position controls and displays such that they should **not be obscured/obstructed** by other objects or by the driver's own body-parts. Necessary measures are needed to be taken to avoid **masking effect due to veiling glare, specular glare, or reflections** into display surfaces or lenses due to the sunlight or other external lights.
4. **Legibility of the display should be ensured** to facilitate aged drivers. Display elements should be clearly visible to drivers of all age group under varying illumination levels. Ergonomic principles of display and control design are needed to be followed to achieve best legibility.

Position of controls and display should be such that, they should not be obscured or obstructed by other objects or by drivers own body parts. Necessary measures are needed to be taken to avoid masking effect due to veiling glare, specular glare or reflection into display surfaces or lenses due to the sunlight or any other external lights.

Legibility of display should be ensured to facilitate aged drivers. Display element should be clearly visible to the drivers of all age group under varying illumination level. Ergonomics principles of display and control design are needed to be followed for this purpose to achieve the best legibility.

(Refer Slide Time: 39:14)



**Driver Information Acquisition and Processing**

Design guidelines for facilitating drivers' in information processing during driving activity (Bhise, 2016)

**Auditory Information**

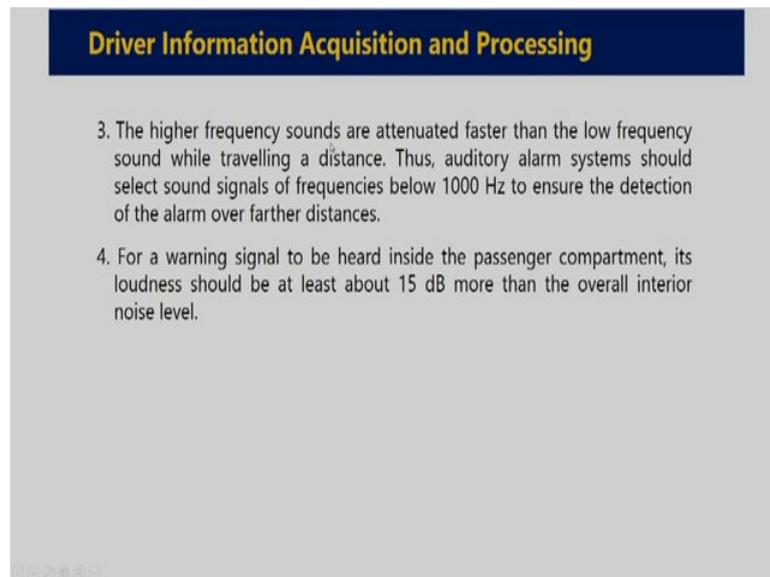
1. Voice displays, and voice-activated controls should be redundant (or alternate) methods of use due to their possible unavailability or undesirability under certain driving environments, e.g., speech or hearing impaired drivers cannot use voice controls/ displays.
2. To avoid "tinny" like noise of higher frequencies (over 2000 Hz) and to provide perception of "solidness" (lowering the noise frequency below 1000 Hz) from interior components (e.g., sounds from switches, latches, door closing), noise of higher frequencies should be control by engineering design interventions.

Now, design guidelines related to auditory information. Voice displays or voice-activated controls should be redundant (or alternate) methods of use due to their possible unavailability or undesirability under certain driving scenario. So, it should be alternate one, not the single one; there should be other options also.

Otherwise, if it is unavailable or it is undesirable in certain conditions, for example, speech or hearing-impaired drivers cannot use voice control or display. So, for them, the alternative arrangement should be there.

To avoid tinny like noise of higher frequencies and to provide perception of solidness (lowering the noise frequency below 1000 Hertz from interior components) like, a sound from the switches, latches, door closing. So, these sounds should not be tinny like, and the frequency of that sound should be reduced below 1000 Hertz to give the feel of solidness. So, for that purpose, engineering design interventions are required.

(Refer Slide Time: 40:22)



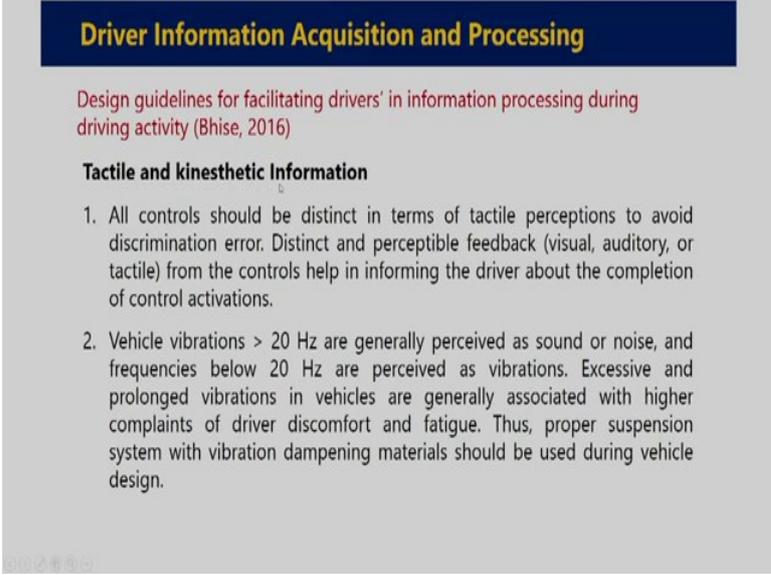
**Driver Information Acquisition and Processing**

3. The higher frequency sounds are attenuated faster than the low frequency sound while travelling a distance. Thus, auditory alarm systems should select sound signals of frequencies below 1000 Hz to ensure the detection of the alarm over farther distances.
4. For a warning signal to be heard inside the passenger compartment, its loudness should be at least about 15 dB more than the overall interior noise level.

The higher frequency sounds are attenuated faster than the low-frequency sound while travelling a distance. Thus, auditory alarm systems should select sound signal of frequencies below 1000 Hertz. So, during auditory display design, while we are selecting a frequency range; it should be below 1000 Hertz to ensure the detection of that alarm over further distances.

For a warning signal to be heard inside the passenger compartment, its loudness should be at least 15 decibels more than the overall interior noise level. So, while designing the warning signal this has to be taken into consideration.

(Refer Slide Time: 41:05)



**Driver Information Acquisition and Processing**

Design guidelines for facilitating drivers' in information processing during driving activity (Bhise, 2016)

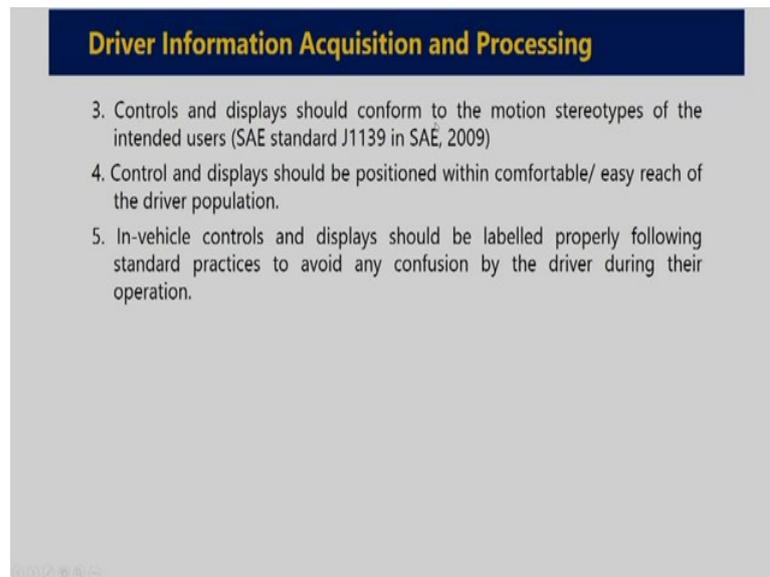
**Tactile and kinesthetic Information**

1. All controls should be distinct in terms of tactile perceptions to avoid discrimination error. Distinct and perceptible feedback (visual, auditory, or tactile) from the controls help in informing the driver about the completion of control activations.
2. Vehicle vibrations > 20 Hz are generally perceived as sound or noise, and frequencies below 20 Hz are perceived as vibrations. Excessive and prolonged vibrations in vehicles are generally associated with higher complaints of driver discomfort and fatigue. Thus, proper suspension system with vibration dampening materials should be used during vehicle design.

Then design guidelines related to tactile and kinesthetic information. All controls should be distinct in terms of tactile perceptions to avoid discrimination error. Distinct and perceptible feedback (visual, auditory or tactile) from the controls help in informing the driver about the completion of control activations.

Vehicle vibrations greater than 20 Hertz are generally perceived as sound or noise. And frequencies below 20 Hertz are perceived as the vibration. Excessive and prolonged vibration in vehicles is generally associated with higher complaints of driver discomfort and fatigue. Thus, proper suspension system with vibration dampening materials should be used during vehicle design.

(Refer Slide Time: 41:54)



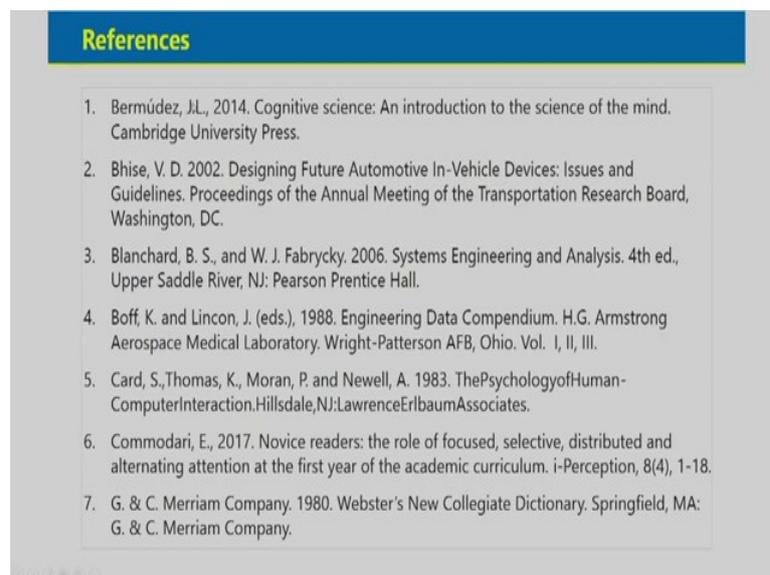
**Driver Information Acquisition and Processing**

3. Controls and displays should conform to the motion stereotypes of the intended users (SAE standard J1139 in SAE, 2009)
4. Control and displays should be positioned within comfortable/ easy reach of the driver population.
5. In-vehicle controls and displays should be labelled properly following standard practices to avoid any confusion by the driver during their operation.

Controls and display should conform with the motion stereotype of the intended user. So, for that purpose again, we can consult SAE J1139 standards. Control and display should be positioned within the comfortable or easy reach of the driver population.

So, that driver can easily operate various controls without more physical effort. In-vehicle controls and display should be labelled properly, following standard practices to avoid any confusion by the driver during their operations. So, these are the various design guidelines which help in information processing by the drivers.

(Refer Slide Time: 42:32)

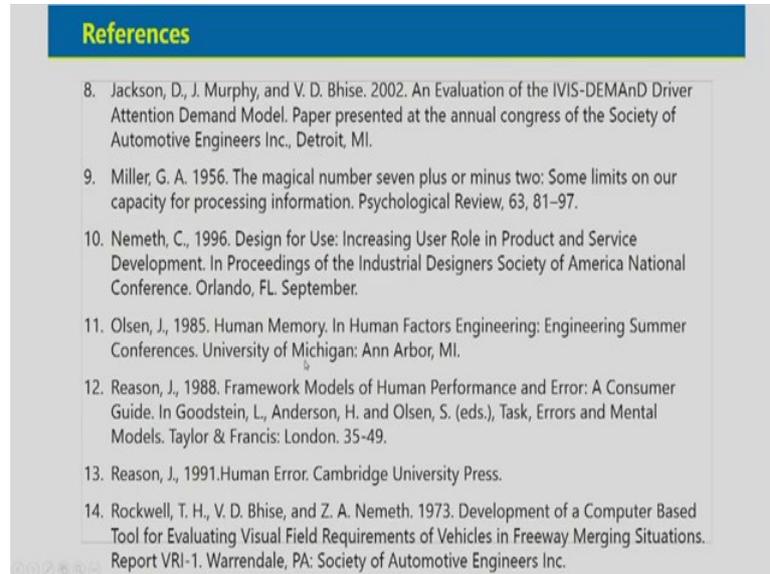


**References**

1. Bermúdez, J.L., 2014. Cognitive science: An introduction to the science of the mind. Cambridge University Press.
2. Bhise, V. D. 2002. Designing Future Automotive In-Vehicle Devices: Issues and Guidelines. Proceedings of the Annual Meeting of the Transportation Research Board, Washington, DC.
3. Blanchard, B. S., and W. J. Fabrycky. 2006. Systems Engineering and Analysis. 4th ed., Upper Saddle River, NJ: Pearson Prentice Hall.
4. Boff, K. and Lincon, J. (eds.), 1988. Engineering Data Compendium. H.G. Armstrong Aerospace Medical Laboratory. Wright-Patterson AFB, Ohio. Vol. I, II, III.
5. Card, S., Thomas, K., Moran, P. and Newell, A. 1983. The Psychology of Human-Computer Interaction. Hillsdale, NJ: Lawrence Erlbaum Associates.
6. Commodari, E., 2017. Novice readers: the role of focused, selective, distributed and alternating attention at the first year of the academic curriculum. i-Perception, 8(4), 1-18.
7. G. & C. Merriam Company. 1980. Webster's New Collegiate Dictionary. Springfield, MA: G. & C. Merriam Company.

Now, these are the list of references which has been consulted for preparing this presentation.

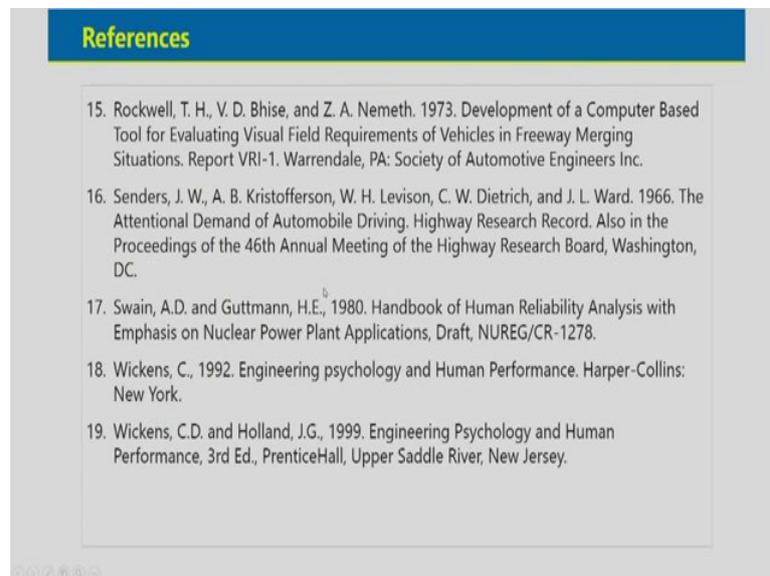
(Refer Slide Time: 42:39)



**References**

8. Jackson, D., J. Murphy, and V. D. Bhise. 2002. An Evaluation of the IVIS-DEMANd Driver Attention Demand Model. Paper presented at the annual congress of the Society of Automotive Engineers Inc., Detroit, MI.
9. Miller, G. A. 1956. The magical number seven plus or minus two: Some limits on our capacity for processing information. *Psychological Review*, 63, 81–97.
10. Nemeth, C., 1996. Design for Use: Increasing User Role in Product and Service Development. In Proceedings of the Industrial Designers Society of America National Conference. Orlando, FL. September.
11. Olsen, J., 1985. Human Memory. In Human Factors Engineering: Engineering Summer Conferences. University of Michigan: Ann Arbor, MI.
12. Reason, J., 1988. Framework Models of Human Performance and Error: A Consumer Guide. In Goodstein, L., Anderson, H. and Olsen, S. (eds.), *Task, Errors and Mental Models*. Taylor & Francis: London. 35-49.
13. Reason, J., 1991. *Human Error*. Cambridge University Press.
14. Rockwell, T. H., V. D. Bhise, and Z. A. Nemeth. 1973. Development of a Computer Based Tool for Evaluating Visual Field Requirements of Vehicles in Freeway Merging Situations. Report VRI-1. Warrendale, PA: Society of Automotive Engineers Inc.

(Refer Slide Time: 42:40)



**References**

15. Rockwell, T. H., V. D. Bhise, and Z. A. Nemeth. 1973. Development of a Computer Based Tool for Evaluating Visual Field Requirements of Vehicles in Freeway Merging Situations. Report VRI-1. Warrendale, PA: Society of Automotive Engineers Inc.
16. Senders, J. W., A. B. Kristofferson, W. H. Levison, C. W. Dietrich, and J. L. Ward. 1966. The Attentional Demand of Automobile Driving. *Highway Research Record*. Also in the Proceedings of the 46th Annual Meeting of the Highway Research Board, Washington, DC.
17. Swain, A.D. and Guttman, H.E., 1980. *Handbook of Human Reliability Analysis with Emphasis on Nuclear Power Plant Applications*, Draft, NUREG/CR-1278.
18. Wickens, C., 1992. *Engineering psychology and Human Performance*. Harper-Collins: New York.
19. Wickens, C.D. and Holland, J.G., 1999. *Engineering Psychology and Human Performance*, 3rd Ed., PrenticeHall, Upper Saddle River, New Jersey.

So, students can go through these references for more understanding and detailed information.

(Refer Slide Time: 42:46)

Useful online resources

Sources	Webpage
International Ergonomics Association (IEA)	<a href="http://www.iea.cc/project/index.html">http://www.iea.cc/project/index.html</a>
Human Factors and Ergonomics Society	<a href="https://www.hfes.org/Web/links/links.html">https://www.hfes.org/Web/links/links.html</a>
Indian Society of Ergonomics (ISE)	<a href="http://www.ise.org.in/links.shtml">http://www.ise.org.in/links.shtml</a>
Foundation for Professional Ergonomics (FPE)	<a href="http://www.ergofoundation.org/">http://www.ergofoundation.org/</a>
Humanics Ergonomics	<a href="http://www.humanics-es.com/">http://www.humanics-es.com/</a>
Chartered Institute of Ergonomics & Human Factors	<a href="http://www.ergonomics.org.uk/">http://www.ergonomics.org.uk/</a>
Association of Canadian Ergonomists	<a href="https://www.ace-ergocanada.ca/resources/national_conferences/useful_links/index.html">https://www.ace-ergocanada.ca/resources/national_conferences/useful_links/index.html</a>
Ergonomics in Design	<a href="http://ergonomicsindesign.com/">http://ergonomicsindesign.com/</a>
Ergoweb	<a href="https://ergoweb.com/">https://ergoweb.com/</a>
Ergonomics laboratory, Dept. of Design, IIT Guwahati	<a href="http://www.iitg.ac.in/erglab/">http://www.iitg.ac.in/erglab/</a>

Further, here is the list of useful online resources which you can also explore for getting more idea about human factors and ergonomics from different websites.

(Refer Slide Time: 42:58)



And here, these are the various books which you can further go through for more understanding of this subject related to automotive ergonomics in vehicle design.

Thank you.