Engineering Psychology

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Week-05

Lecture-12

Multitasking - 2

Namaskar. In the previous class, we examined the phenomenon of multitasking. I defined multitasking and discussed its nature, followed by an overview of the information processing framework responsible for handling information. I explained how understanding the principles of information processing can aid in effective multitasking. Additionally, I covered the concepts of sensory register and short-term memory, which are essential for comprehending how information is processed.

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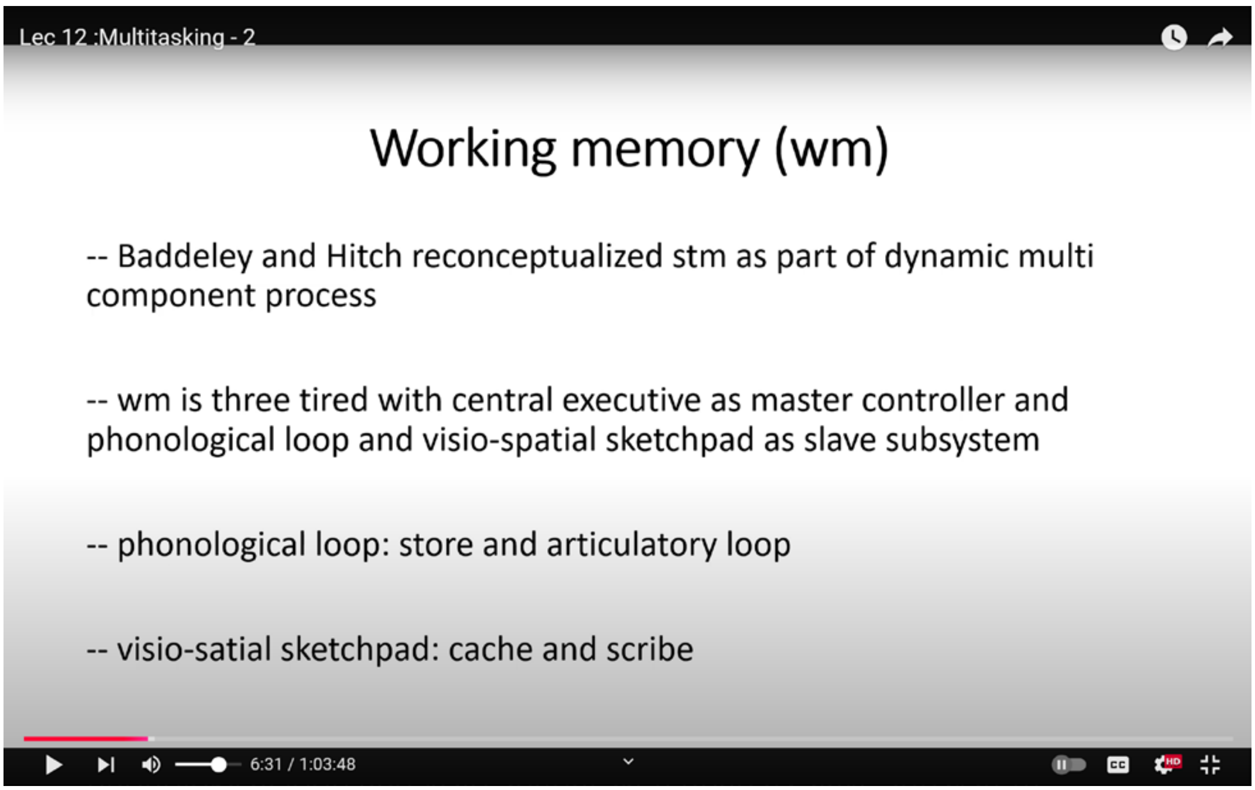

To summarize, multitasking involves performing multiple tasks simultaneously. To succeed in managing several tasks at once, it is crucial to understand how information is processed in the human mind. With this perspective, I attempted to elucidate the information processing mechanism. In the last class, I explained how sensory receptors manage the vast amounts of information directed toward them. I also discussed how sensory registers temporarily hold all accessible information and how attention serves as a filter, allowing some information to pass while blocking out others. We examined and tested the claim that all information is available in the sensory register, albeit for a very brief period.

Furthermore, we explored different types of sensory registers, such as the icon for visual information and the echo for auditory information. When information transitions from the sensory register, it enters a store that temporarily holds data for a longer duration; however, this store has a limited capacity. We discussed the concept of short-term memory, and I explained its functionality and limitations. In the context of engineering psychology, whether you are designing a website, an interface, or a machine intended to assist humans, understanding the nature of short-term memory and its retention duration is vital. This knowledge can guide you in creating better designs that support human activity rather than hinder it.

One question I posed in the last class was: if short-term memory is merely a temporary store that passively retains information, how do complex activities such as driving or reading occur? For reading or driving to happen, individuals must continually update information. For instance, while driving, one needs to constantly check the speedometer, observe street signs, and not only retain this information but also update it according to driving requirements. You need to be aware of changing traffic lights, the various signs on the road, and how to maneuver based on those signs. Furthermore, comprehending a signboard requires accessing stored information. Thus, if short-term memory is merely a passive store, how can we drive effectively?

Alan Baddeley and Graham Hitch addressed this question with their concept of working memory. Recent research indicates that the structure of short-term memory can be more accurately described through working memory, which I will briefly outline. This model helps to resolve some issues that short-term memory could not adequately explain.

So, what does this conceptualization entail? Baddeley and Hitch reconceptualized short-term memory as part of a dynamic, multi-component process. They propose that rather than a singular short-term memory dependent solely on acoustic or verbal coding, with a limitation of 7 plus or minus 2 chunks and a duration of approximately 20 seconds without rehearsal, memory plays a role in complex tasks by actively engaging with stored information.

Active information not only resides in short-term memory but also communicates with long-term storage, borrowing necessary rules and information in real time to address problems. Taking the reading example, when you read a text, you are not merely producing sounds or decoding words; you are also interpreting their meanings. Each word carries significance that is stored in your long-term memory, which is then accessed by working memory through a two-way communication system.

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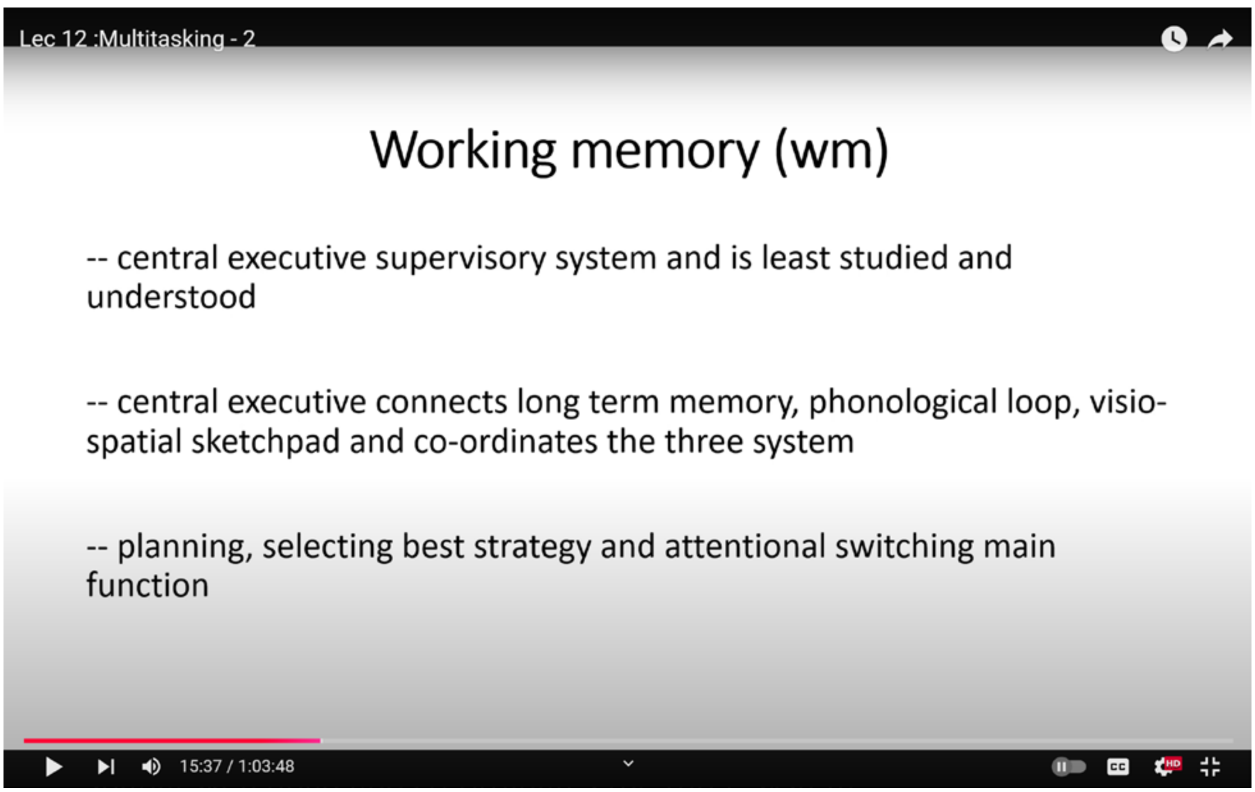

When reading a sentence, you strive to comprehend the meaning of each word and how they combine to convey a larger idea. To accomplish this, you require not only a store for incoming information, such as the words present and their arrangement, but also an understanding of their meanings. To illustrate this, Baddeley and Hitch devised a model that includes not only storage components but also a supervisory system that facilitates communication with long-term memory.

The working memory system is designed to bring forth the information necessary for understanding the meaning of stimuli originating from the sensory register. So, what does working memory look like? It comprises a three-tiered structure with a central executive at the top, which acts as the master controller, and two secondary systems, the phonological loop and the visual-spatial sketchpad, which serve as subordinate systems or storage units. The central executive is responsible for managing the incoming information from the sensory register as well as inputs from the temporary storage of the phonological loop and the sketchpad. It facilitates a two-way communication channel with long-term storage.

Long-term storage contains meanings, rules, and facts. Utilizing these stored facts, the central executive can extract meaning from incoming information as well as from the information temporarily held within its subordinate systems. The phonological loop is divided into two parts: the store and the articulatory loop. The visual-spatial sketchpad consists of two components: the visual cache and the scribe.

So, how does this system function? Briefly, the sensory register collects various pieces of information from the external environment. Through the process of attention, it filters and sends limited information, let's assume four pieces, to the central executive. The central executive operates as an attentional system, similar to a supervisor or manager in a company whose role is to manage work rather than perform the tasks themselves. It directs the filtered information to the two subordinate systems: the phonological loop and the visual-spatial sketchpad.

The phonological loop receives all auditory information from the sensory organs. It acts as a temporary buffer, storing auditory information for short periods. When a person speaks, all the words uttered must remain active for a brief duration to ensure comprehension. Therefore, all words entering the central executive are channeled into the phonological loop. The phonological loop then transfers this information to the phonological store, which retains fundamental details about the auditory stimuli, such as identifying nouns, verbs, and objects, essential for understanding the meaning of sentences. Meanwhile, the articulatory loop continually rehearses this information.

In a similar manner, the visual-spatial sketchpad processes visual and spatial information. The cache retains temporary visual and spatial data, while the scribe organizes this information in a coherent manner. When the central executive requires this data, both the visual-spatial sketchpad and the phonological loop return the information. The central executive also features an episodic buffer, which serves as a connector between itself and long-term memory.

Thus, the central executive temporarily holds information in these two loops while simultaneously communicating with long-term memory via the episodic buffer. By integrating information from the sensory register, long-term memory, and the temporary storage systems, it creates meaning from incoming data. This illustrates the design and function of working memory.

As I previously mentioned, the central executive functions as a supervisory system and is one of the least understood components of this model. Its role resembles that of a manager; it gathers information, organizes it, extracts meaning, and occasionally modifies the data. The central executive maintains a connection to long-term memory, allowing it to retrieve information needed to derive meaning from inputs received from the phonological loop and the sketchpad.

Now, what exactly is long-term memory? This will be the next topic of our study. Long-term memory represents the conventional understanding of memory as a space where information is stored. The central executive connects to long-term memory, retrieving information to construct meaning from the data supplied by the phonological loop and the sketchpad. The central executive is tasked with planning and determining the most effective strategy.

Reflecting on the example I provided in the last class, consider a scenario where a child unexpectedly jumps in front of your car. Your response will depend on the child's position. If the child is on the periphery and has not reached a distance that poses a risk of being struck, you can maneuver the car to avoid the child. Conversely, if the child is directly in front of you, you would need to brake abruptly or employ alternative measures to stop the car. Deciding which action to take is the responsibility of the central executive, which evaluates what should be done and selects the best strategy.

If the child jumps into your path but there is sufficient space to maneuver the vehicle, the central executive would likely opt to steer the car rather than brake, as stopping a vehicle with higher momentum is generally more challenging than executing a maneuver.

Another function of the central executive is attentional switching, akin to the role of a moderator in a discussion forum. In such a setting, the moderator facilitates discussions, allowing participants to share their ideas, and at the end, briefly summarizes the conversation. This mirrors the central executive's role, as it shifts attention to decide which system should be active at any given time.

In the driving example, the central executive gathers information from visual inputs, proprioceptive cues from your hands, and other visual stimuli from the road and the vehicle. Additionally, you may receive auditory signals from passengers, such as a warning shout. The central executive's task is to integrate these various inputs and switch between them, all while also consulting long-term memory to determine the appropriate response. Thus, this encapsulates the role of the central executive within the working memory system.

We previously discussed long-term memory, describing it as a repository that retains all information. To clarify, long-term memory can be defined as follows: information that is rehearsed in short-term memory or deemed valuable by the central executive is transferred from working memory to long-term memory through processes of repetition and elaboration.

There are two primary methods of storing information in long-term memory. The first method is passive repetition, akin to rote memory. An example of this type of memory includes the recitation of mantras, slokas, or the Hanuman Chalisa. If someone interrupts you while reciting these verses, you may forget everything from the point of interruption and have to start over. This illustrates rote memory: you have not learned the content by comprehending its meaning but rather have memorized it through repetition.

The second method involves assigning meaning to the information. For instance, if I see a tulip, I might associate it with a significant memory, such as the first time I visited the Netherlands during a student exchange program. In this case, tulips, which are abundant in the Netherlands, become a symbol representing that experience. This process of elaboration involves taking information and connecting it to personal meanings.

Both rote repetition and the assignment of meaning are ways to store information in long-term memory, which can retain this information indefinitely. A notable feature of long-term memory is that it does not lose information; rather, the connections to that information may fade. While information remains stored, retrieval failures can occur due to a lack of encoding, meaning the information was never adequately attended to and transferred to long-term memory, or due to lost connections, similar to misplacing a key that prevents access to a locked door. Thus, information is never genuinely lost from long-term memory; instead, failures in retrieval can make it seem unavailable.

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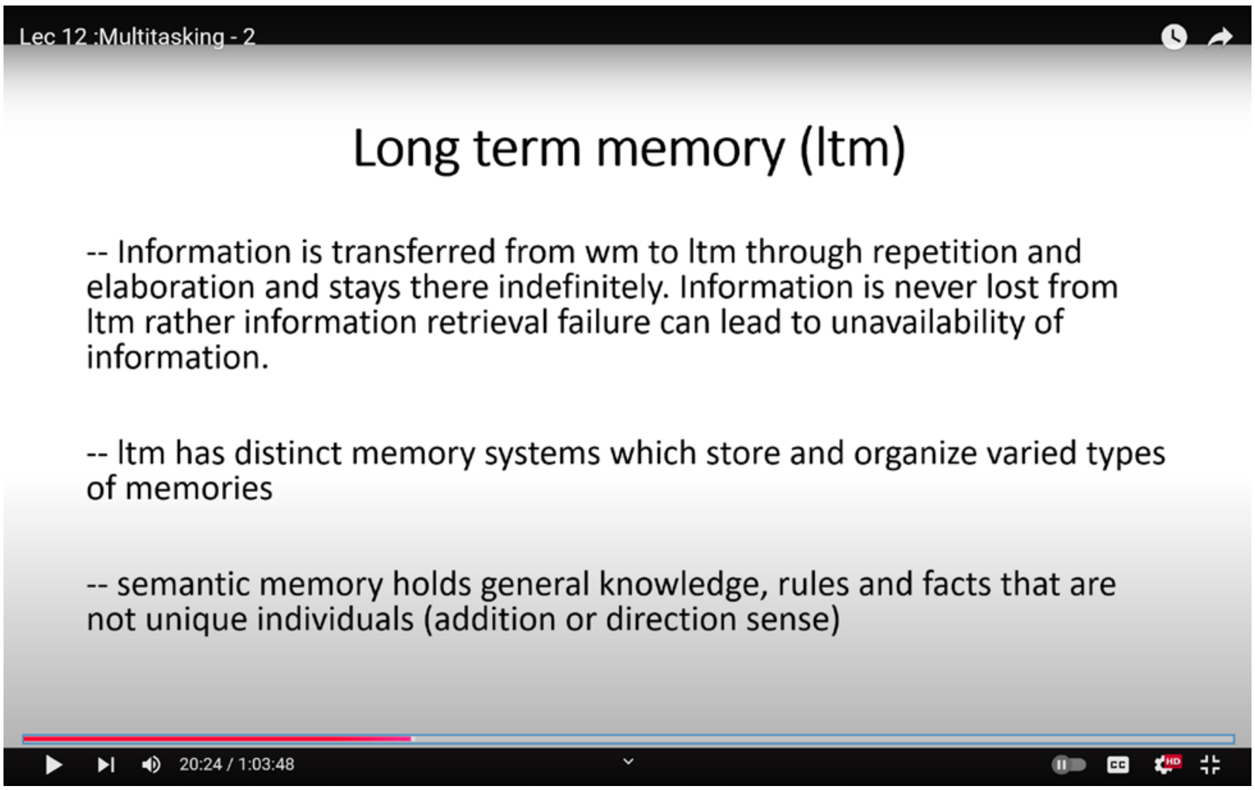

Additionally, long-term memory is characterized by a distinct memory system that organizes various types of memories. Tulving proposed an organizational structure for long-term memory, indicating that it can be divided into two main categories: conscious memory and non-conscious memory. Conscious memory is known as declarative memory, while non-conscious memory is referred to as procedural memory.

Declarative memory encompasses memories that can be explicitly defined, such as your experiences visiting a park or attending a party. In contrast, procedural memory pertains to skills or habits performed without conscious awareness, such as riding a bicycle. You might execute these actions without being fully aware of why you are doing them. Conscious memory involves awareness of the action being performed, while non-conscious memory occurs without such awareness.

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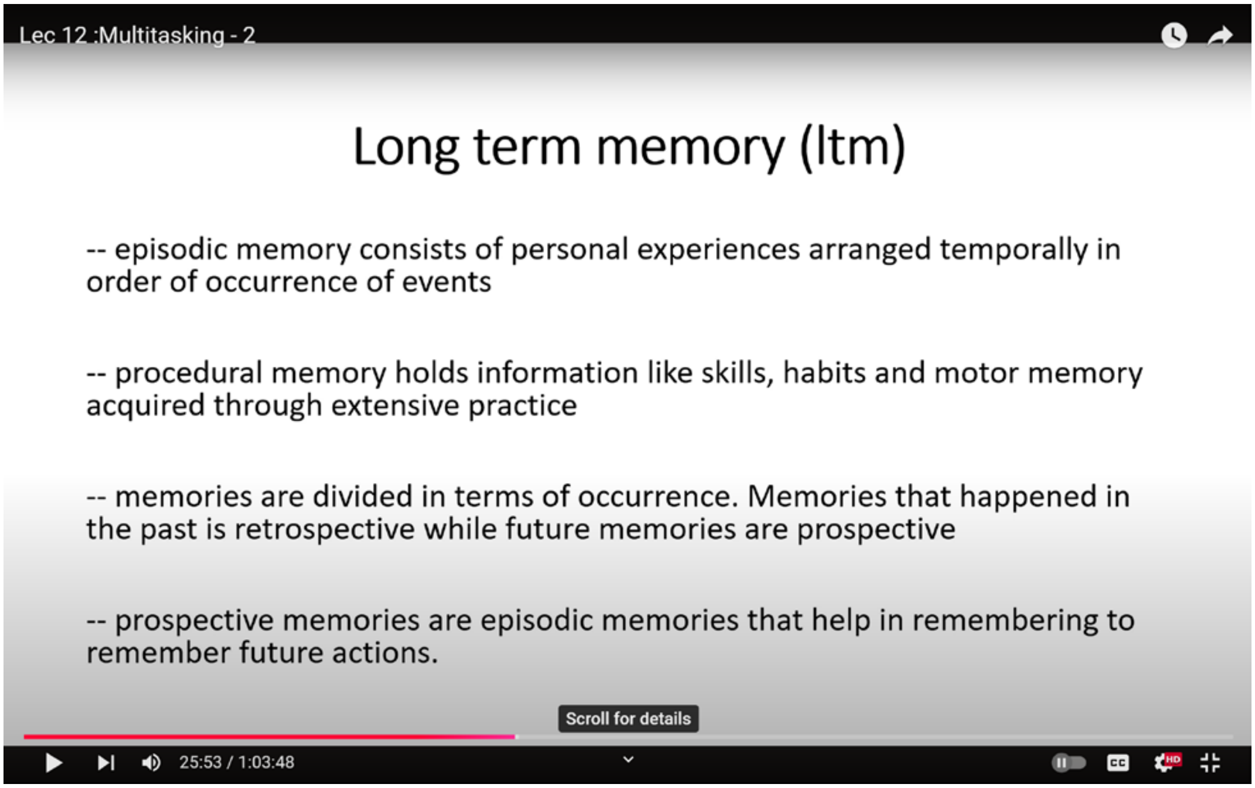

Within the conscious form of memory, there are two types: semantic memory and episodic memory. Semantic memory relates to general knowledge, including information about concepts, facts, and rules. For example, it encompasses knowledge about directions (e.g., south, north), geographic locations (e.g., the countries of America or Africa), and various currency systems. Semantic memory also includes rules, such as mathematical operations (e.g., how to add or subtract numbers) and principles governing chemical reactions (e.g., balancing electron exchange in a chemical equation). Facts that are universally acknowledged, such as "the sun rises in the east" (assuming the Earth is rotating at a specific speed), fall under semantic memory. These facts are publicly available and not unique to individuals.

On the other hand, episodic memory consists of personal experiences arranged temporally according to when they occurred. This form of memory captures unique experiences and events in a person's life.

Episodic memory retains information regarding the timing of events. For instance, consider attending a birthday party. The entire event is structured chronologically, detailing when you arrived, what you did afterward, and the sequence of activities until the party concluded. Various events occur during this time, and this organization is characteristic of episodic memory.

Another form of memory is procedural memory, which I previously described. This type of memory is non-conscious and contains information about skills, such as how to play the guitar or ride a bicycle. It also encompasses certain habits; for example, some individuals may touch their heads or move their legs while seated on elevated surfaces, or engage in nail-biting. These behaviors are habits and motor memories that are developed through extensive practice. Skills such as playing the guitar and driving are examples of procedural memories.

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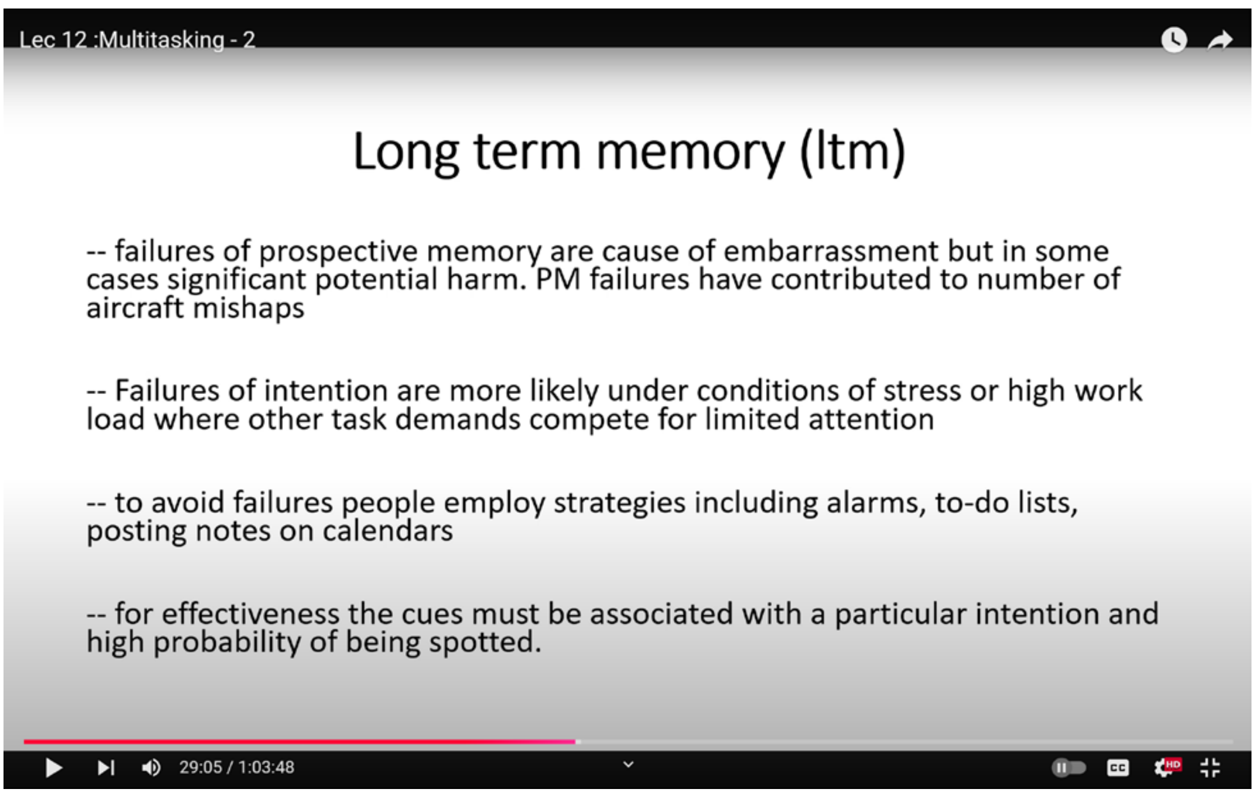

Memories can be categorized based on their timing. Memories that refer to past experiences are termed retrospective memories, while those related to future events are called prospective memories. For example, recollections of your farewell in the 12th grade are retrospective, whereas memories of taking medication at 6 p.m. today or tasks you plan to complete later this evening are prospective memories. Thus, memories can be differentiated into retrospective and prospective categories.

Prospective memories are a subset of episodic memories that assist in remembering future actions, such as taking medicine at a specific time, picking up a child from school, or visiting the market for particular items. These types of memories are labeled as prospective memories. It is important to note that prospective memories consist of two components: one, a factual intent, remembering a future action, and the other, a retrospective element, what needs to be done in the future is stored in the retrospective part of memory. Failures in prospective memory can lead to embarrassment or, in some cases, significant potential harm. For instance, forgetting whether you have taken medication and subsequently taking it again could result in an overdose. Similarly, forgetting to pick up your child from school may leave the child waiting, which could lead to unsafe situations.

Consequently, failures in prospective memory can cause embarrassment or present serious issues. Such failures have been implicated in numerous aircraft mishaps. When piloting an aircraft, the pilot must remember specific actions to take in the future, such as lowering the landing gear and raising the flaps, actions that occur after takeoff. If a pilot forgets to execute these steps, it can result in a dangerous situation.

Failures of intention are more likely to occur under stress or high workload conditions, where competing task demands strain limited attention resources. These failures can result from the pilot or operator experiencing stress or managing multiple tasks simultaneously. When attempting to accomplish numerous tasks, it is natural for one to forget future actions.

To mitigate these failures, people employ various strategies. For example, they may set alarms, create to-do lists, or post reminders on calendars. These tools help individuals remember what they need to do and when to do it in the future. For effectiveness, cues should be closely associated with a specific intention and have a high likelihood of being noticed. For instance, if you create a list or reminder for an upcoming task, it should be placed in a visible location, such as on the refrigerator, where individuals typically see it while retrieving food. Alternatively, it could be displayed on a computer screen, a location where people spend considerable time. By using such aids, failures in prospective memory can be avoided.

We have examined memory as one aspect of managing information; however, for information to transition from the sensory register to working memory, attention is required. But what is attention?

Attention is the cognitive process that allows us to determine which information to process and which to disregard. One of the primary functions of attention is to prioritize information. The term "attention" is commonly used in everyday language; however, it often leads to confusion regarding its precise meaning. This confusion arises for two main reasons. First, attention is described in various ways, resulting in no universally accepted definition. Second, measuring attention presents challenges. For example, if you instruct someone not to pay attention to a task, they will likely focus on it anyway. Thus, measuring a situation with "no attention" can be problematic.

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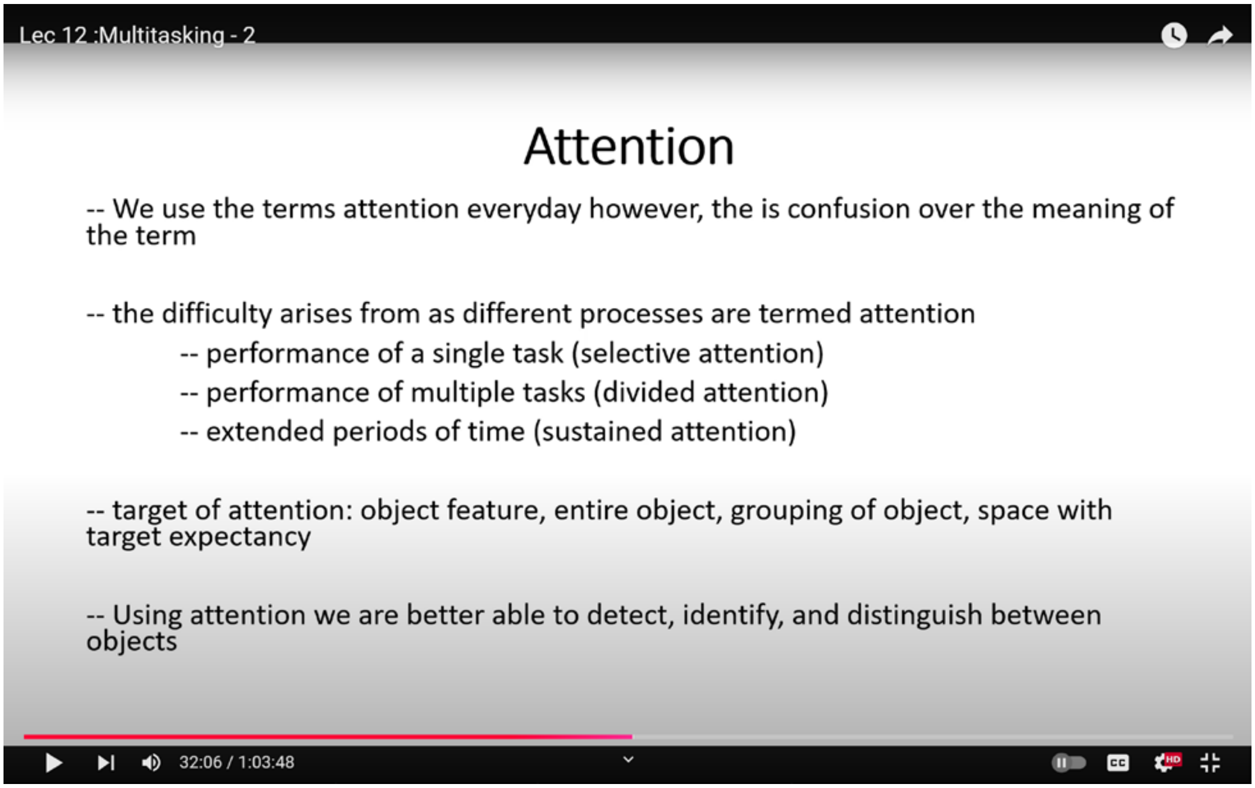

Next, we will explore one of the features of attention: its various definitions. The difficulty in defining attention stems from the different terminologies used to describe it. One type of attention is called selective attention, which refers to focusing on a single task. Attention can also facilitate the performance of multiple tasks, known as divided attention. A third type, sustained attention, involves maintaining focus on an object or task over an extended period.

Thus, there are three types of attention: selective attention, which involves focusing on a single job or extracting a single object from multiple objects; divided attention, which encompasses multitasking; and sustained attention, which pertains to concentrating on one task for longer durations. For instance, reading exemplifies selective attention.

Driving and talking are examples of divided attention, while focusing on coloring, painting, or creating art exemplifies sustained attention. The target of attention is always related to a specific object feature; it may be an entire object, a group of objects, or a space that holds a target expectancy. For instance, when I say "pay attention," I could be referring to a particular feature of an object, such as the upper or lower part of a cup, or to an entire object, like a clock. Additionally, one might focus on a grouping of objects, such as paying attention to a cluster of trees rather than the background. Furthermore, attention may also be directed towards spaces with target expectancies, like focusing on a display that is likely to present a warning. Displays are known to serve as visual warning cues, making them another important target of attention.

What does attention accomplish? It assists us in detecting certain stimuli and warnings. Not only does it aid in detection, but it also facilitates identification. When you pay attention, you are quicker to recognize and identify where a particular stimulus belongs. This property of attention relies on working memory, which is managed by the central executive, responsible for identifying and distinguishing between different objects. Therefore, attention not only enhances our ability to detect stimuli but also aids in the identification and differentiation of objects.

Several factors influence attention. Certain task-related demands can affect where we direct our attention. For instance, when using a sewing machine, the movement of the fabric requires more attention than the hand mechanism that controls the machine. If you do not focus on the fabric, the sewing process may go awry. Thus, specific task-related characteristics dictate where attention should be allocated.

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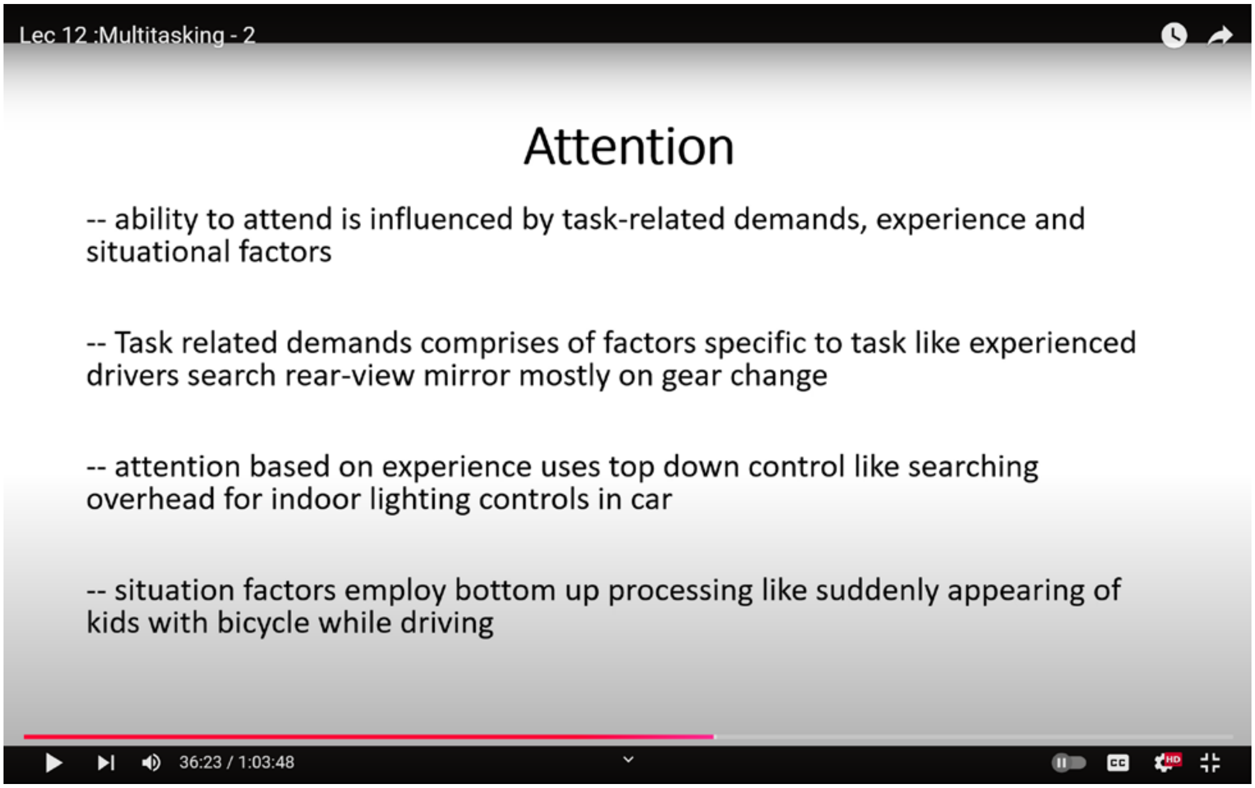

Experience also plays a significant role in determining where to direct attention. For example, if I mention that there is a bird in the room, your past experiences tell you that birds generally fly. Consequently, you are more likely to look up at the ceiling rather than down at the floor in search of the bird. Thus, experiences guide attention allocation.

Situational factors can also influence attention. For example, if you are sitting in a quiet room reading and hear a ding from the microwave oven indicating that your coffee is ready, this sound will capture your attention, drawing you away from your reading. Such situational factors can divert your focus from the task at hand. Task-related demands encompass factors that are specific to the task, including experience, driving, and checking rearview mirrors, particularly during gear changes.

I have previously provided examples, but I will reiterate them. Task-related factors include elements specific to task experiences. One such example is the act of shifting attention to the rearview mirror to assess the proximity of other vehicles. This becomes particularly important during gear changes, as shifting speeds may affect how nearby drivers perceive your actions. If you suddenly decrease or increase speed, it is essential to communicate this change to the driver behind you. Looking at the rearview mirror helps determine whether there is a vehicle behind you; if the space is clear, you can change lanes easily. Conversely, if there is a vehicle in close proximity, you may need to signal your intentions to change lanes, allowing the driver behind you to pass or take appropriate action.

Attention based on experience employs top-down control, as demonstrated when searching for indoor lighting in a car. Past experience suggests that lights are usually located on the roof, prompting you to feel around for the light switch. An example of a situational factor is the sudden appearance of a child on a bicycle while driving, which can shift your attention dramatically.

The focus on a single activity, such as reading, exemplifies selective attention. We have discussed three different types of attention: selective, divided, and sustained (or vigilance). Now, let us explore each type of attention individually to understand its meaning and nature.

The first form of attention is selective attention, where individuals concentrate on just one activity. A good example of selective attention is reading. What does selective attention accomplish? It filters out irrelevant information, thereby freeing cognitive capacity. For instance, when you are reading and thoughts about what food will be served in the hostel intrude, selective attention helps you disregard these distracting thoughts and concentrate solely on the material you are reading.

If your mind is free of distracting thoughts, you will possess a significant amount of cognitive capacity, which can then be utilized for reading and comprehending the meaning of the text. Selective attention is a critical property of behavior, as cognitive capacity is limited while the volume of available information is vast. Attention involves the selection of relevant information, and the importance of selective attention becomes evident when considering that sensory organs receive a tremendous amount of data from the external world. With this influx of information, it is necessary to filter and identify the relevant details needed to accomplish any given task. Selective attention is essential for this process, as it blocks out irrelevant information and focuses solely on pertinent data.

Consider a scenario in a control room of a nuclear power plant. A substantial amount of information is available to you, but your primary responsibility is to monitor the various controls. In this context, you would concentrate on the controls that indicate system-critical situations. By focusing on these critical indicators, you can effectively fulfill your role. Other incoming information, such as colleagues conversing or the air conditioning unit operating, can be filtered out. Utilizing selective attention, you can concentrate on the panels and displays that provide information regarding system-critical functions.

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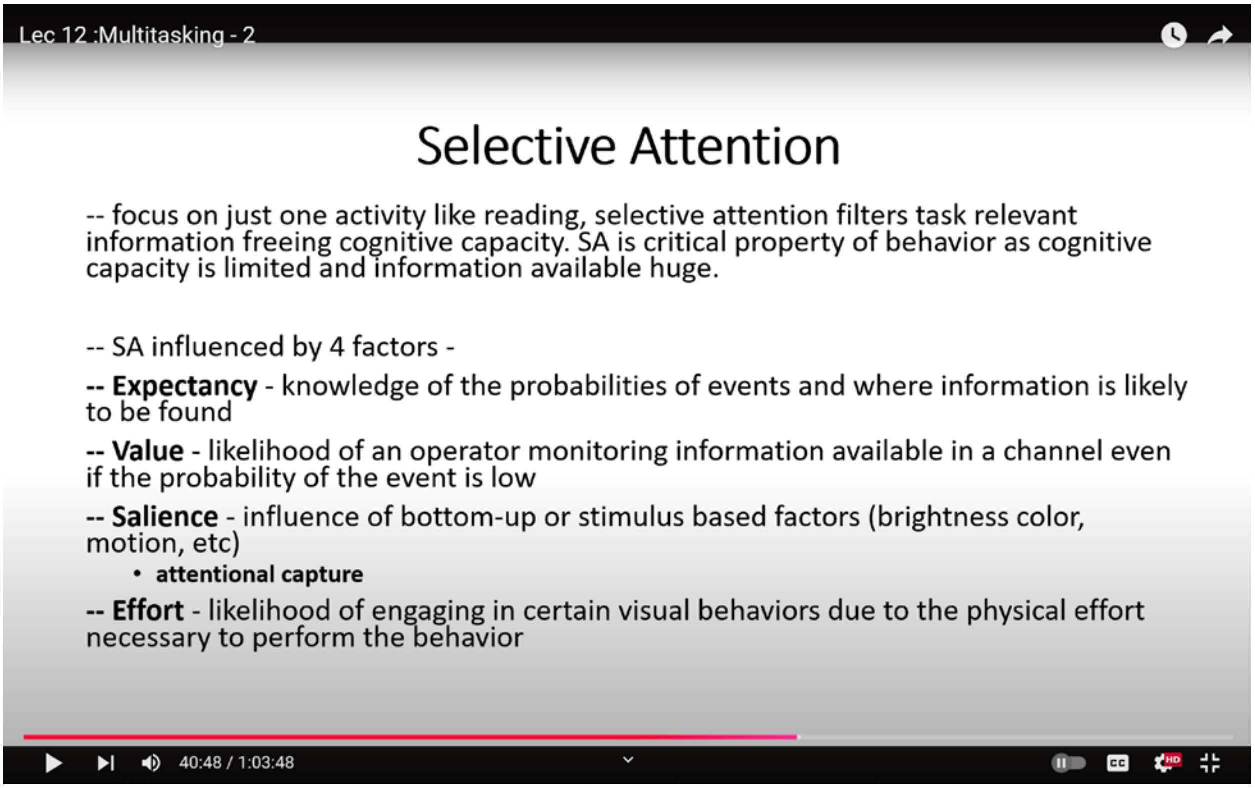

Selective attention is influenced by four factors. The first factor is expectancy, which refers to the knowledge of the probability of an event and the locations where information is likely to be found. People's expectations are shaped by how frequently certain occurrences happen and where they can be located. For instance, when working in the control room of a power plant, experience tells you that critical system information is available on a display located above the controls. You know that this display will only activate or change color when it is necessary to perform an action, such as shutting down the plant or halting a specific function.

Therefore, expectancy enables you to disregard that display if everything is functioning normally. However, when the display does light up, you will cease processing other information and concentrate exclusively on the relevant displays rather than sifting through all the other data. Thus, expectations and the probabilities of events define the mechanisms of selective attention.

The second factor is value, which refers to the likelihood of an operator monitoring information available in a channel, even if the probability of the event is low. In wartime scenarios, when operators are monitoring radars for enemy aircraft, even the slightest blip will prompt the air traffic controller to alert defense forces to investigate and potentially neutralize the threat. Conversely, during peacetime, the air traffic controller can afford to relax and allow information to flow for longer periods before deciding on any course of action. Alerting the Air Force to a non-existent threat, such as a bird or some other object causing the radar blip, would be both costly and time-consuming. Therefore, the value of the decision significantly influences selective attention.

The third factor is salience, which pertains to certain stimulus features that are novel and capable of capturing your selective attention. The influence of bottom-up stimulus-based factors includes attributes such as brightness, color, and motion. For example, on a website, you may notice text that blinks or changes color rapidly, effectively capturing your attention due to its high refresh rate. This phenomenon exemplifies salience.

The fourth factor is effort, which relates to the likelihood of engaging in specific visual behaviors based on the physical effort required to perform those actions. The amount of effort involved in a certain task can also influence your selective attention. If a button or knob must be manually pushed to perform an action, it is likely to attract more of your attention compared to an automated system that requires no physical input. Expectancy and value, considering the probability of a specific event occurring and how important that stimulus is, are top-down factors influencing attention. In contrast, salience and effort represent bottom-up influences because effort determines how much information you can access. If all necessary information is presented on a single display, there may be no need to turn your head to gather additional details. However, if the information available on your display is insufficient, you will need to exert more effort to understand the situation. In such cases, salience and effort are classified as bottom-up processes.

The effectiveness of the selective attention process relies on two mechanisms. Selective attention, or the act of focusing on a single object, depends on two features: a perceptual process that filters out irrelevant information under conditions of high perceptual demand, and a cognitive top-down process that filters irrelevant stimuli based on expectancies and knowledge of target properties. The selection of one piece of information from a multitude relies on this perceptual process, determining how you differentiate between what to focus on and what to disregard. Additionally, there is a cognitive process involved, which is guided by expectations. An example illustrating the perceptual process in selective attention is the flanker compatibility test.

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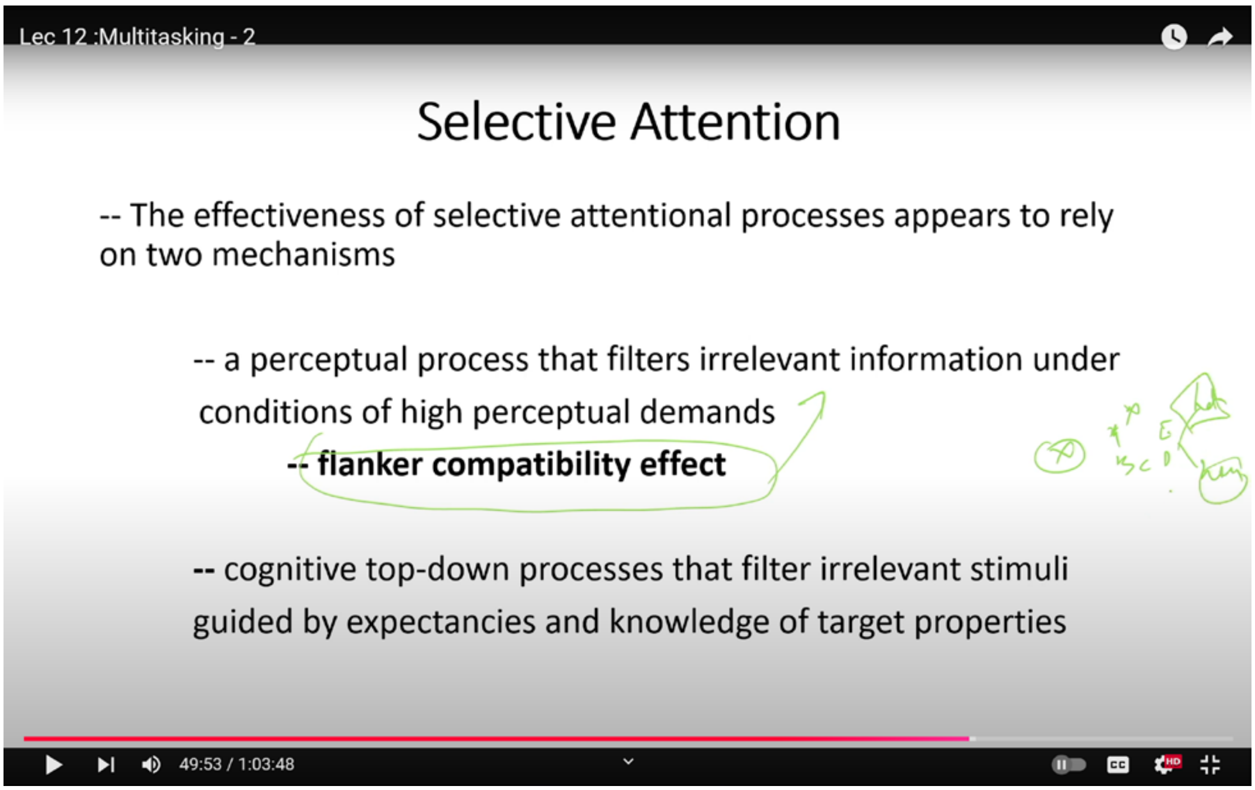

The Flanker task is quite simple. In this task, a series of letters is presented to you, accompanied by a distractor positioned next to these letters. You will see a group of letters, with a distractor included, and there are two conditions to consider: the heterogeneous condition and the homogeneous condition. In the homogeneous condition, all the letters are similar, whereas, in the heterogeneous condition, the letters presented, referred to as non-targets, are dissimilar. Your objective is to identify a target letter and determine whether this target is present among the letter strings, despite the presence of a distractor that may divert your attention.

Results from the Flanker task indicate that if you become highly focused on the task of lateral identification, specifically, determining whether the target letter appears in the letter string, distractors may go unprocessed. However, if the targets and non-targets are relatively simple, the distractor can interfere with processing. In simple terms, if you are matching a target letter to a set of different letters, the task will require more effort. Consequently, you will have fewer attentional resources available to process the distractor. Conversely, if most letters in the string are similar, you can easily ascertain whether the target is present, allowing your attention to spill over to the distractor. This distractor may then hinder your performance, which illustrates the Flanker task.

Regarding the cognitive top-down process, it suggests that knowing the properties of stimuli or having certain expectations about them will aid in focusing attention. For example, if I ask you where a bird might be, your expectation is that birds fly and are typically found above, leading you to focus your attention on the ceiling rather than the floor. While it is possible for a bird to be on the floor, it is far more likely to be located above, so you direct your attention accordingly.

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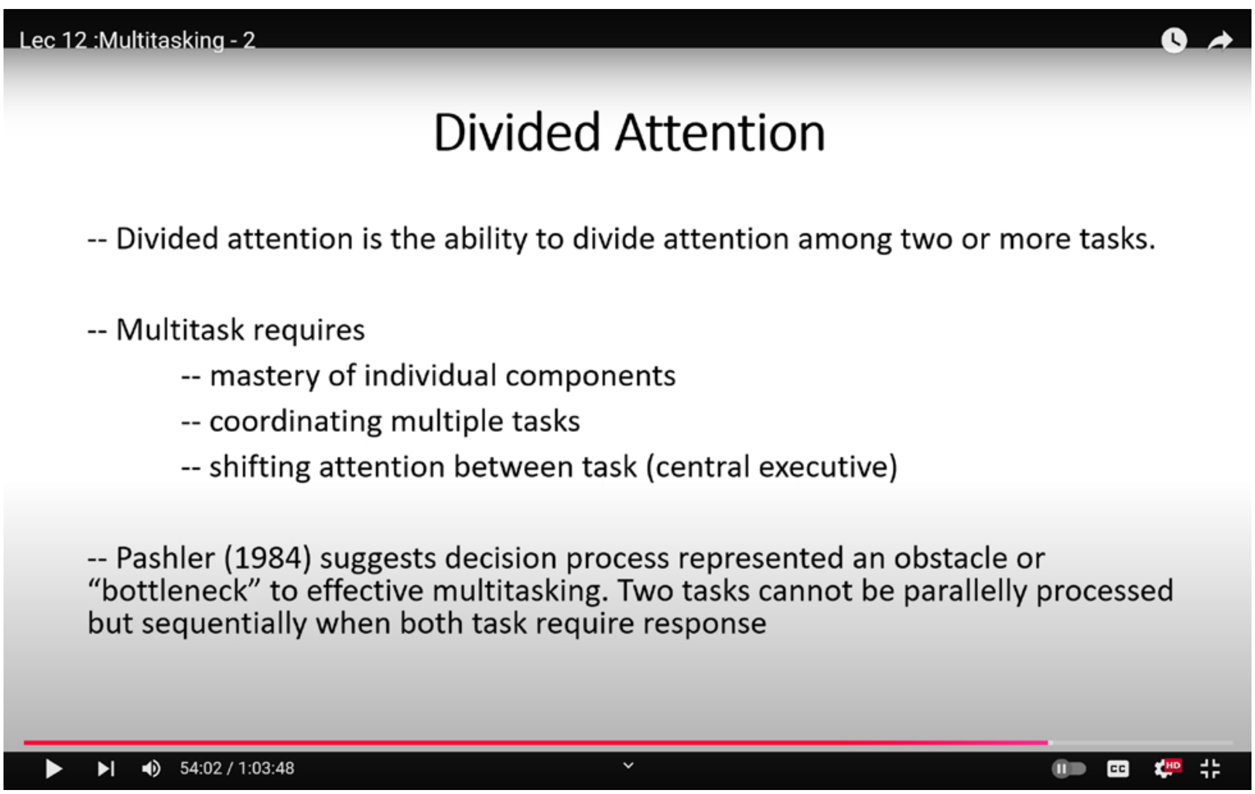

The second category of attention is known as divided attention. This refers to the ability to distribute attention across two or more tasks, commonly exemplified by multitasking. When engaging in multitasking, several factors should be taken into account. First, you must have mastery over the individual components of each task. To successfully multitask, familiarity with all components is essential. Second, you must be able to coordinate between tasks. If two tasks are equally demanding, coordinating between them becomes challenging. For instance, when driving and talking simultaneously, if you are not an experienced driver, it is difficult to engage in conversation. However, if you are proficient at driving, you can manage to talk while driving.

Shifting attention between tasks is primarily governed by the central executive function. If both tasks are easy, you can easily shift your attention back and forth. However, if both tasks are difficult, shifting attention becomes nearly impossible as each task competes for your focus. For example, if you are involved in an important discussion while navigating through a busy city, it becomes challenging to concentrate on both driving and the conversation. In such cases, it is not feasible to manage both tasks effectively.

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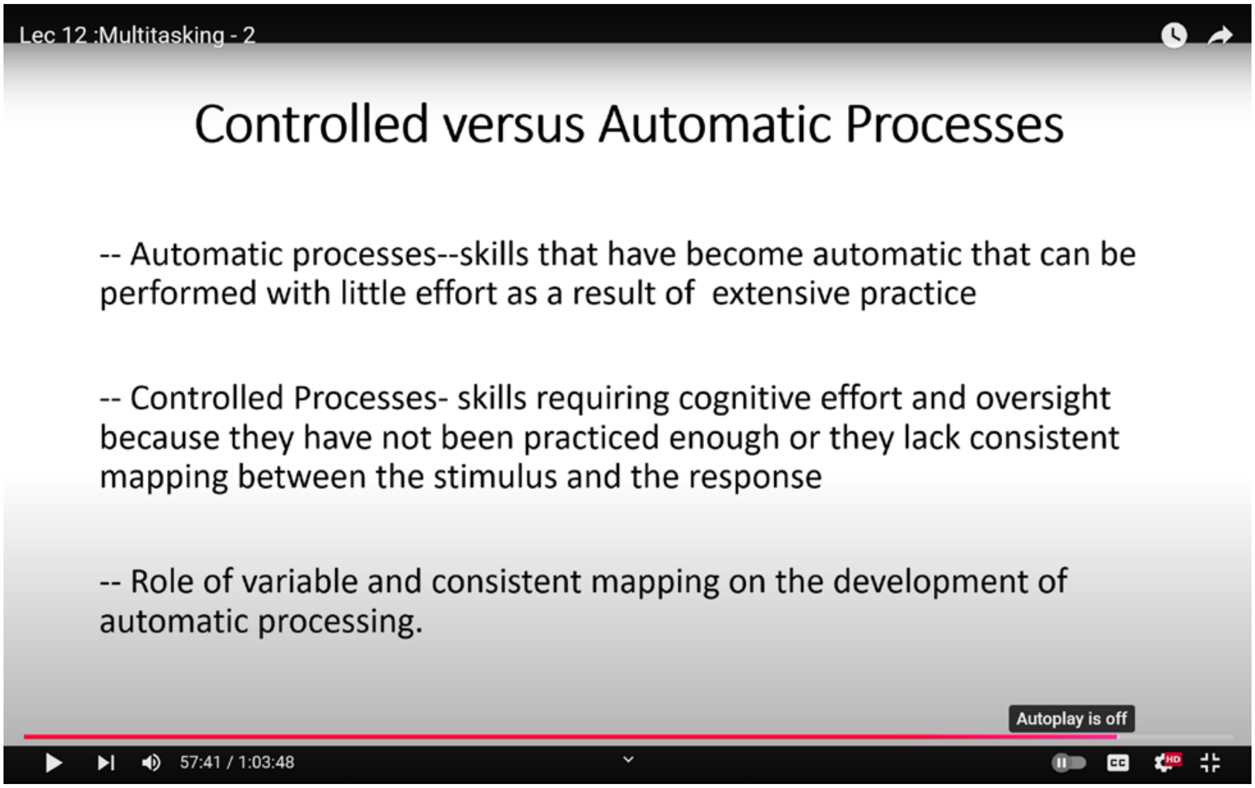

On the other hand, if one task is automatic, such as driving on a highway with minimal distractions, you can engage in a deep conversation and respond to questions. The parser model suggests that the decision process presents a bottleneck that hinders effective multitasking. According to this model, multitasking encounters difficulties when two stimuli require attention simultaneously. When both tasks are equally challenging, they compete with each other, making parallel processing impossible; instead, they must be processed sequentially.

There is a phenomenon in psychology known as the Psychological Refractory Period (PRP). Simply put, it refers to a situation where two individuals approach a bank teller and both start providing their bank account numbers in order to receive some information. The teller can retain one number in his working memory and communicate the information related to that account.

Let us consider a scenario where the first person arrives first, provides their account number, and the teller begins processing the information associated with that number. Subsequently, a second person arrives and gives their account number to the bank teller while requesting information about their account as well. At this point, the bank teller cannot perform both tasks simultaneously. While he is engaged in selecting a response regarding the first person's bank account information, he cannot also focus on the second account number provided by the second person to retrieve that information.

However, if both individuals were to arrive simultaneously, or if both were present at the moment the response is being executed, multitasking becomes manageable. In simpler terms, multitasking is feasible only when one task is automatic and the other is straightforward. If one of the tasks occurs automatically, the second task can receive attention. However, if both tasks demand your attention, they cannot be processed in parallel; instead, they will undergo sequential processing.

One way multitasking can occur is through the distinction between control processing and automatic processing. Automatic processing implies that skills have become automatic due to extensive practice and can be performed with minimal effort. For instance, if you are an expert driver, you can drive automatically, allowing you to engage in important conversations within the vehicle or adjust the radio. Control processes, on the other hand, involve skills that require cognitive effort and oversight because they have not been practiced sufficiently, resulting in inconsistent mapping between stimulus and response.

This means that control tasks are those that cannot be performed automatically. For example, driving is an automatic task, but conversing about an unpredictable event requires you to respond based on what is being discussed, making it a controlled response rather than an automatic one. Therefore, more attention must be devoted to that task, as it requires specific input.

I have previously mentioned consistent mapping between stimulus and response. This indicates that if the stimulus and response share consistent mapping, meaning the stimulus closely resembles the response, it becomes easier to manage. Conversely, if the stimulus differs from the response, controlled processing becomes more challenging. For instance, if someone is talking to you, responding verbally is straightforward. However, if someone asks you to show them a map, the command is verbal, but your response necessitates a motor action. In this scenario, the stimulus and response involve different types of actions, making control processing more difficult to execute.

There is a significant relationship between variable and consistent mapping in the development of automated processing. The more consistent the mapping between stimulus and response, the more automatically a specific task can be performed. Conversely, if the stimulus and response are disparate, controlled processing becomes necessary. Thus, multitasking is simpler when the stimulus and the response correspond closely to what is being requested and the action required. However, if multitasking involves dissimilar stimuli and responses, it becomes increasingly difficult.

Lastly, we should discuss the concept of sustained attention, also known as vigilance. Vigilance refers to the ability to maintain attention over an extended period. This was tested using a classic clock test. In this test, a clock was presented to participants, and the clock would move in such a manner that it completed two movements, referred to as jumps, within a one-hour timeframe, occurring a total of thirty times. Participants were tasked with identifying the specific time frames in which the clock made these two jumps. Generally, the clock advances one unit for each time frame.

Sometimes, this clock will jump two units, meaning it will move two distances. The task for the participants in this test was to notice how many times this occurred. Reports from this test indicate that, after a period of time, individuals were unable to accurately describe what was happening, which relates to the concept of vigilance. So, why does vigilance decline? Why is it challenging for people to maintain their attention on a task for extended durations?

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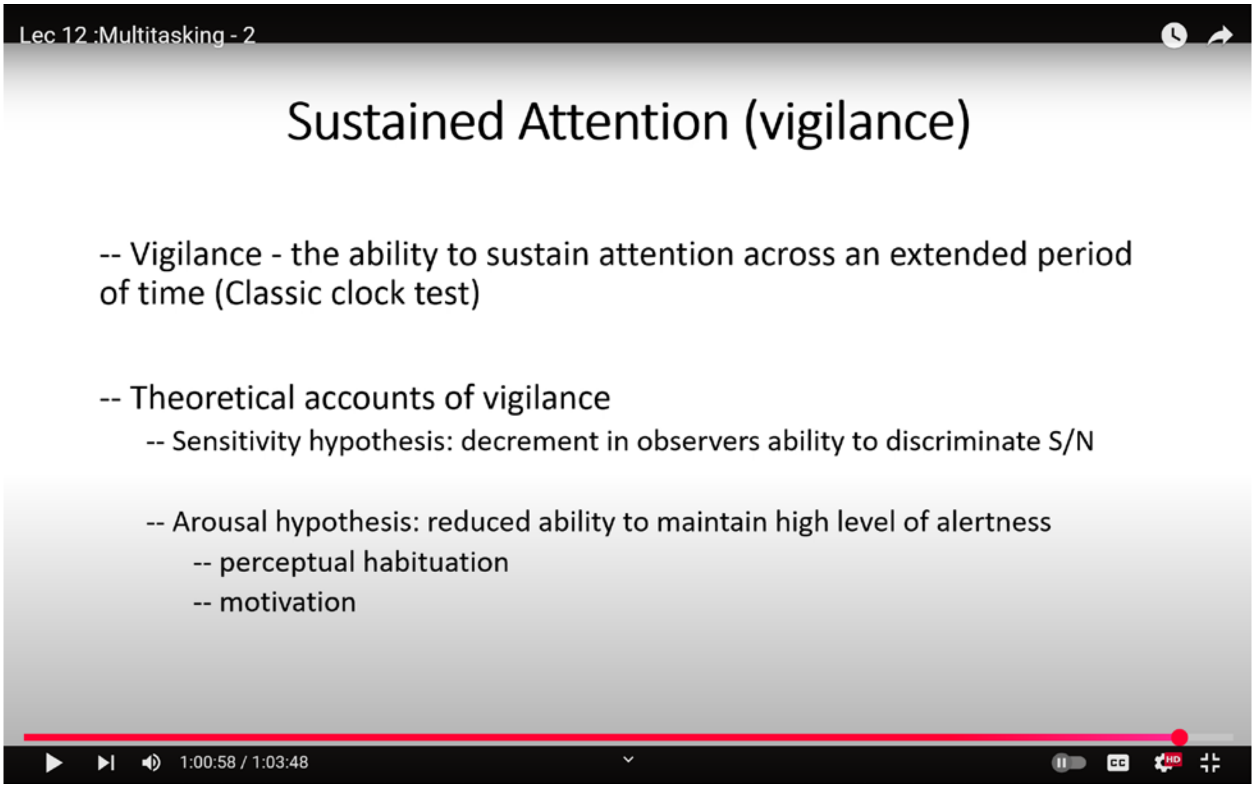

There are two theories that address this issue. The first is the sensitivity hypothesis, which posits that there is a decrease in the observer's ability to distinguish between signal and noise. As time elapses, individuals become less adept at identifying which particular object requires their focused attention and which does not. Consider the act of reading: initially, you can maintain your focus, but eventually, distracting thoughts intrude, diverting your attention and diminishing your vigilance.

The second hypothesis is the arousal hypothesis, which suggests that the diminished capacity to sustain high levels of alertness is caused by perceptual habituation. When you observe a stimulus for an extended period, your perceptual system becomes overburdened and habituated, leading it to rely on shortcuts to process information. For instance, when tasked with identifying differences between two figures, the first three discrepancies may be easily recognizable, but locating the fourth and fifth differences becomes increasingly difficult due to the prolonged exposure to the same image. As a result, your eyes and cognitive processing become habituated to the stimulus.

Another factor related to the arousal hypothesis is motivational decline. As time progresses, individuals may become demotivated, which further hinders their ability to sustain attention and maintain vigilance while scanning for information over extended periods. Thus, the two hypotheses, sensitivity and arousal, explain why individuals lose focus when observing a stimulus for long durations.

In this chapter, we explored the concept of multitasking, the roles of memory and attention in facilitating multitasking, and the factors that should be considered to promote effective multitasking. Thank you, and goodbye. Namaskar. Amen.