Engineering Psychology

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Week-05

Lecture-13

Decision Making - 1

Namaskar. In this lecture and the subsequent one, we will examine another crucial aspect of cognition that is beneficial to human factor psychologists and human factor engineers. In the last class, we covered information processing, memory, and attention, during which I explained how memory and attention contribute to multitasking. Multitasking is a vital element when studying individuals who interact with systems, as it enables individuals to perform one or more tasks simultaneously. In this section, we will focus on decision-making.

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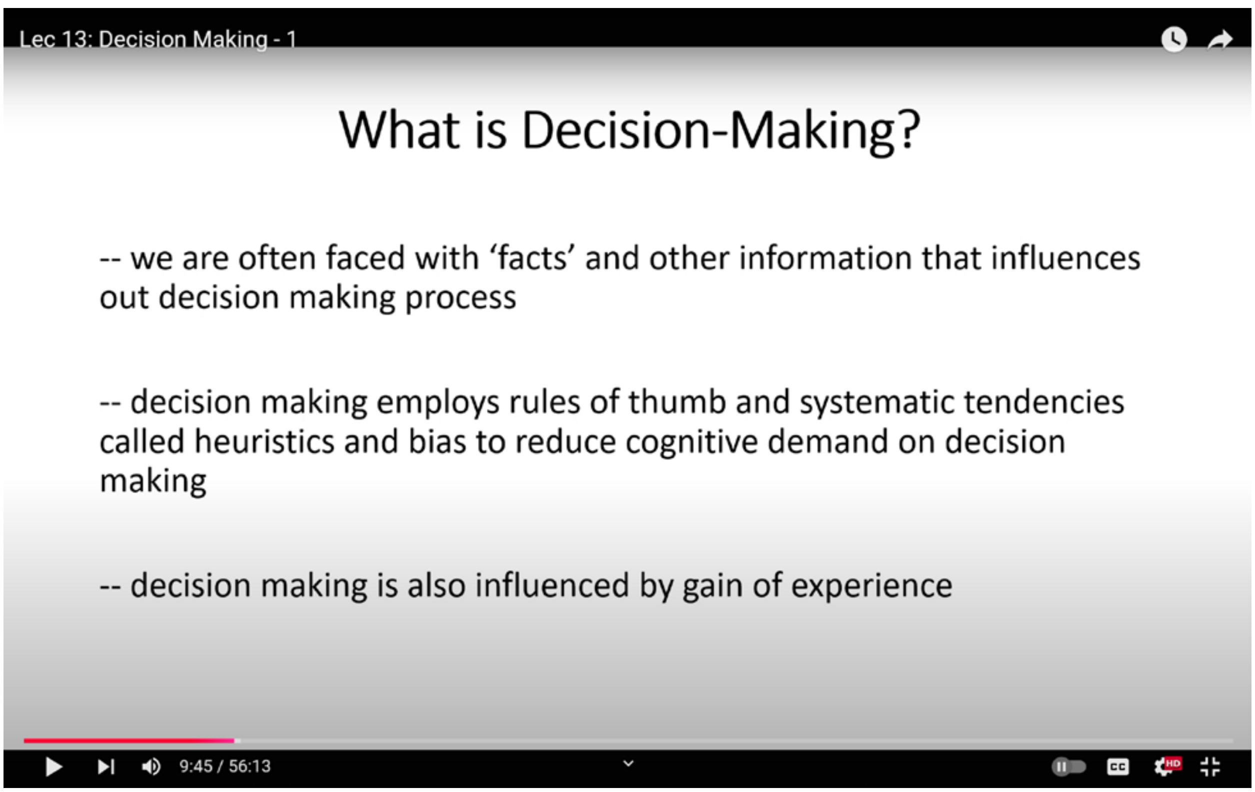

At times, people possess facts and other relevant information about a particular event, and there may be multiple events that present possible solutions to a problem. The question arises: how do operators decide which option to choose over the others? This question lies at the core of this lecture. What information should an operator consider? How should he reason through the evidence for and against each option in order to select an optimal alternative for solving the problem? Moreover, what does it mean to have an optimal solution to a problem? We will explore various decision-making methods and further investigate real-life decision-making scenarios. Additionally, we will examine several shortcuts that individuals use when making decisions, and towards the end, I will address the challenges associated with decision-making.

To initiate our discussion, let me present a scenario. Imagine a truck driver tasked with transporting goods from point A to point B. As he travels from point A to point B, he must navigate various types of roads, which may include flat terrain, hills, and other natural obstacles. These conditions can both aid and hinder the driver's performance in terms of navigation. The driver is currently at a midway point, designated as point C. From point C to point D, the driver must ascend a valley, and it is already nighttime. While he could choose to climb the valley at night, as you may know, mountain roads present their own challenges and are best avoided after dark. There are potential safety concerns and environmental factors, such as landslides or other hazards, that may impede the driver's progress, necessitating heightened caution during the drive.

However, there is a twist to the situation: the goods the driver is transporting belong to a client who is persistently calling him and requesting a quick delivery. The driver contemplates that if he can navigate the valley during the night, he will complete the task on time and have a few hours to rest before embarking on his next trip. Nevertheless, he is also aware of the dangers associated with nighttime driving, including the possibility of vehicle breakdowns or natural disasters that could prevent him from completing the journey. The worst-case scenario would be an accident. The driver weighs the pros and cons of driving at night and ultimately decides to proceed.

My question for you is: was this decision to drive at night to reach his destination a good one? On one hand, if he drives at night, he will arrive at his destination more quickly and have some time to rest between drives. On the other hand, navigating the mountain road at night is risky and could lead to a fatal accident. What should the driver have done? Is his decision to drive at night a wise one or a poor one?

This question is central to this lecture and the next. How do people make decisions? Decision-making is crucial for operators, manufacturers, and developers as it leads to optimal solutions for problems. But what constitutes the best solution? As we progress through this chapter, you will learn about the nature of decision-making, the reasons for engaging in it, the various models of decision-making, the challenges that arise in this process, and the types of solutions that can improve decision-making skills.

Let us begin to explore these points. So, what is decision-making? In real-life situations, we often encounter facts and information that inform our decisions. We must consider what actions will yield certain responses and what actions to avoid to achieve other responses. In addition to this, various other information sources can influence the decision-making process.

Reflecting on the example I presented, the facts relate to the driver's knowledge of the dangers of nighttime driving and how, if he drives at night, he might achieve his goal and secure some moments of rest between trips. Other information pertains to the pressure from the individuals whose goods he is transporting, including their expectations regarding his timely arrival and the quality time they hope to spend together when he reaches his destination, as well as other information that is not directly related to the decision at hand.

While the driver makes a decision, he must consider the facts available to him, as well as other information that, while not directly related to the facts, plays a significant role in his driving. Decision-making primarily involves rules of thumb and systematic tendencies known as heuristics and biases, which help reduce cognitive demands during the decision-making process. This indicates that when we make decisions, we do not function like computers; we do not calculate the mathematical probabilities and utilities of various available options. Instead, we employ shortcuts and specific rules of thumb.

Utilizing these shortcuts and rules of thumb allows us to make decisions more efficiently and quickly, without placing excessive strain on our cognitive capacity. If we were to evaluate all possibilities and compute mathematically the optimal decision for certain problems, it would be quite challenging to arrive at the best choice. Thus, people often rely on tricks that have proven effective in the past to guide their decisions.

Decision-making is also influenced by the accumulation of experience. Experts tend to be better decision-makers because they possess extensive experience. With each repetition of a task, individuals learn the nuances and intricacies involved, thereby gaining valuable experience. This experience informs them about what actions to take and what to avoid, facilitating more effective decision-making. Consequently, these decisions not only improve future performance but also enhance their ability to cope with new and unfamiliar situations.

Decision-making can be defined as the process in which an individual must choose among several alternatives, often with some uncertainty regarding which choice is optimal. In decision-making, individuals are required to select between alternatives. The alternatives available in decision-making stem from the judgment process, wherein people employ reasoning and judgment to generate options. These alternatives must then be utilized to achieve a specific goal. The objective of decision-making is to choose one of the alternatives provided by judgment.

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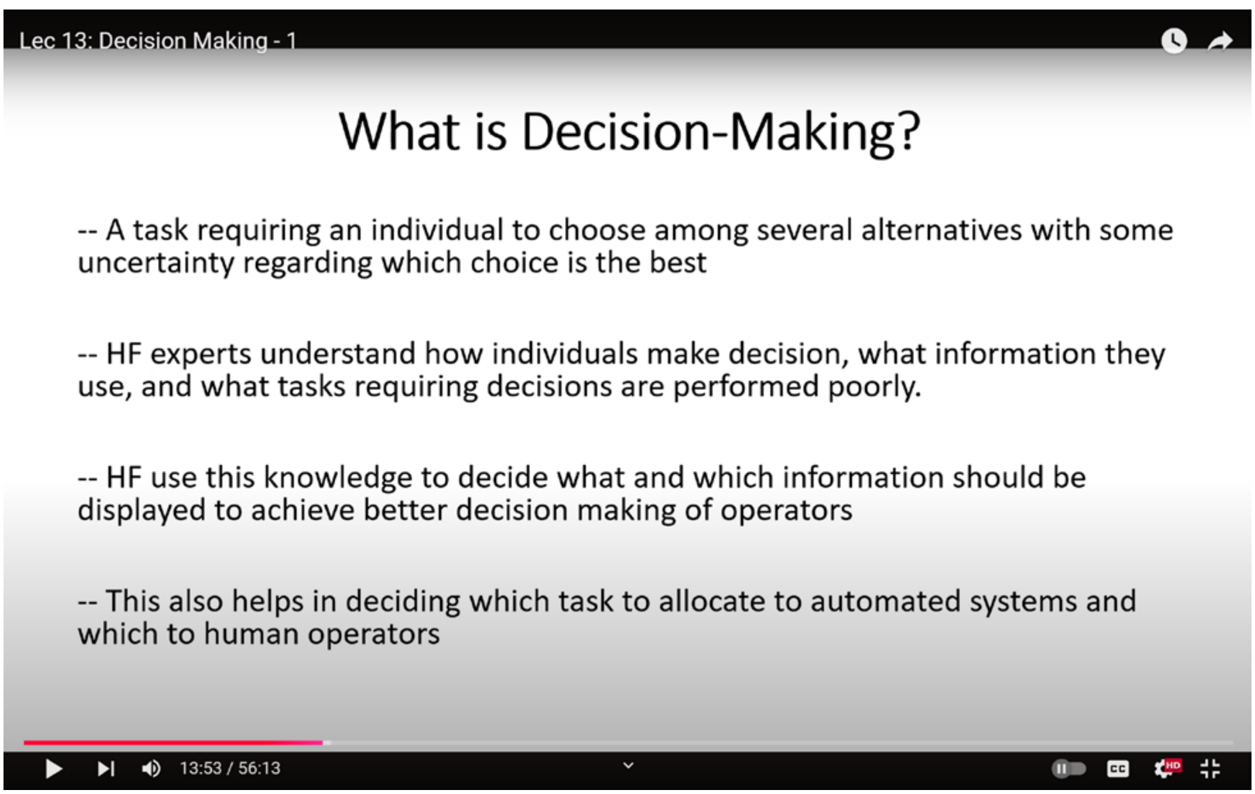

However, the available alternatives are not always certain; they do not possess a 100% probability of occurring or not occurring. There is always a degree of chance and uncertainty associated with alternative choices. The decision-maker's task is to consider these alternatives and the uncertainties related to them while making decisions. This process involves a certain level of risk. Consequently, operators make decisions based on their risk tolerance.

Human factor experts study how individuals make decisions, what information they utilize, and which tasks may lead to poor decision-making. The role of human factor specialists is to analyze the decision-making processes of individuals as they interact with systems. They must also comprehend what information operators considered when making a decision and what information they overlooked. Additionally, understanding which tasks were performed poorly is essential. If they can identify which decision-making tasks were inadequately executed and the reasons behind such poor performance, they can design better solutions and automated decision processes to assist operators in completing their tasks.

Human factor specialists leverage this knowledge to determine what information should be displayed to facilitate better decision-making among operators. Once they grasp how decisions are made, the information considered, and which decision-making tasks yielded positive outcomes, they will design interfaces and solutions that provide operators only with the essential information needed for decision-making. If certain processes require extensive computations, these will be assigned to automated systems, which will present a simplified version of the complex calculations to the operator, framed as yes-or-no decisions.

Understanding how people actually perform their jobs is crucial for human factor experts in designing systems that enable better decision-making. By analyzing what users are doing and where they encounter difficulties, human factor specialists can allocate some of the more complex decisions that do not require human input to automated systems, while preserving decisions that necessitate human involvement.

Consider the example of flying a plane: certain decisions demand significant cognitive capacity, while some routine decisions that are not critical to flying are managed by the autopilot system. However, decisions such as whether to land at an alternate airport or adjust the angle of approach are left to the pilots. Although landings and takeoffs are mostly automated due to their complexity, computers can handle these intricate calculations efficiently. The autopilot system provides pilots with a simplified version of the decision in a yes-no format.

The pilot must input his response, and the computer can execute the necessary tasks. This arrangement allows pilots to conserve their cognitive resources for the more challenging or essential aspects of decision-making.

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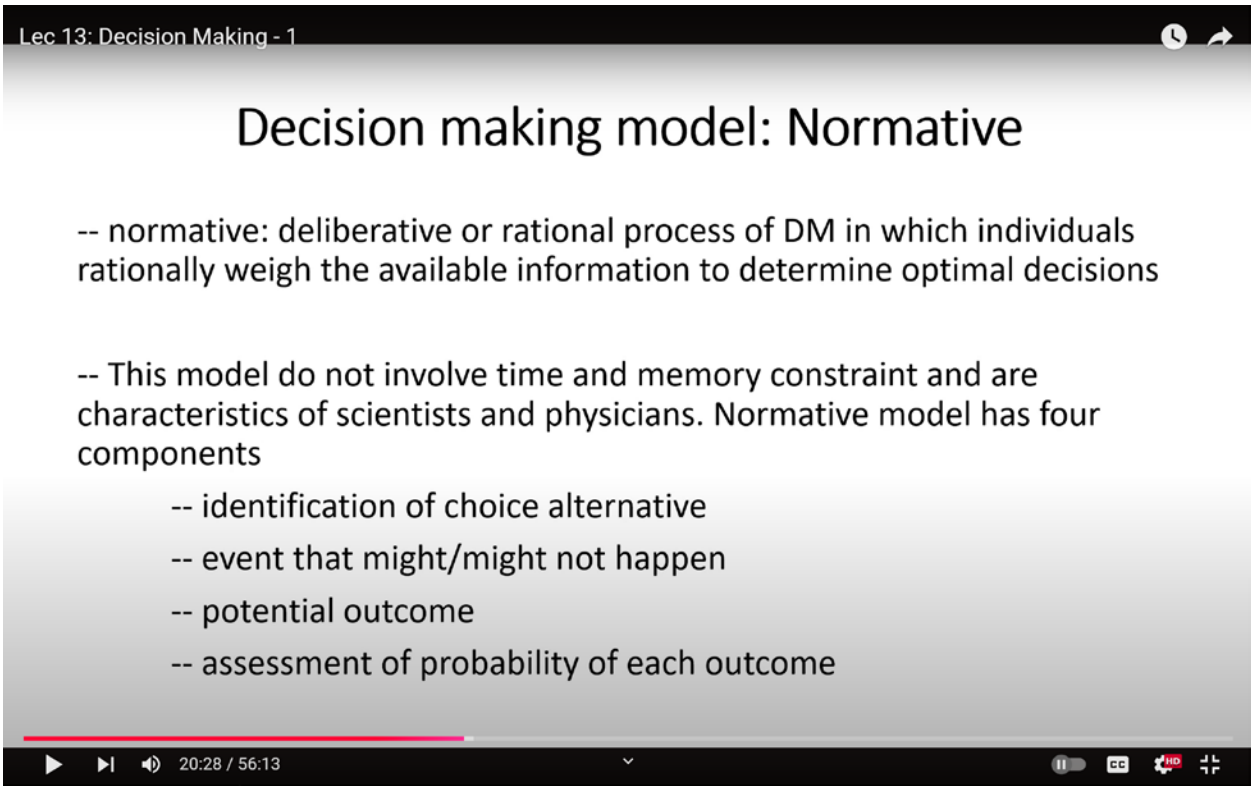

Now, we will discuss two models of decision-making: the normative model and the descriptive model. In addition to these two classic models, there exists a third model known as naturalistic decision-making, proposed by Klein and others. We will also examine this decision-making model.

Let us briefly outline the three models. The normative model of decision-making specifies the norms that govern decision-making, indicating what an ideal operator should do in various situations. When confronted with a problem, the normative decision model offers guidelines on how an ideal operator should proceed to make rational choices.

A rational choice is defined as a decision that maximizes profit while minimizing losses. In contrast, the descriptive model examines how operators actually make decisions. There exists an idealized approach to decision-making known as the normative model; however, operators often behave differently than this ideal scenario. This divergence is the focus of the descriptive model.

The naturalistic decision model investigates individual performance in real-life situations. It emphasizes how real-life decision-making varies from the theoretical frameworks established by the normative and descriptive models, forming the basis of the naturalistic decision model. Let us begin by exploring these models one by one, starting with the first model, the normative model.

The normative model is grounded in the utility model described in economics. It serves as a mathematical framework that calculates optimal decisions based on expected utility. I will clarify this concept in simpler terms as we progress through the lecture.

Now, let us define the normative model. It represents a deliberate or rational decision-making process in which individuals systematically weigh available information to determine optimal choices. The normative model posits that humans are rational beings and that the decision-making process itself is rational. In this context, humans are likened to machines, which assess all possible options and the information pertaining to each choice. They calculate the potential gains or losses associated with each course of action and decide on the most beneficial path to take when faced with a problem.

This model does not account for constraints related to time and memory, characteristics typically associated with scientists and physicians. The normative model assumes that humans possess unlimited memory and ample time to make decisions. However, when weighing all available information to select an option, substantial cognitive capacity is required. Individuals must contemplate every conceivable scenario and its possible outcomes. In reality, humans do not have infinite memory or time.

While idealized systems can evaluate all options and available information to derive solutions, the normative model of decision-making is primarily associated with scientists and physicians. Both of these professions require a high level of accuracy in their predictions, as the stakes often involve human lives. Although they may utilize heuristics, their reliance on shortcuts is typically limited, prompting them to adhere to the normative model to the best of their abilities.

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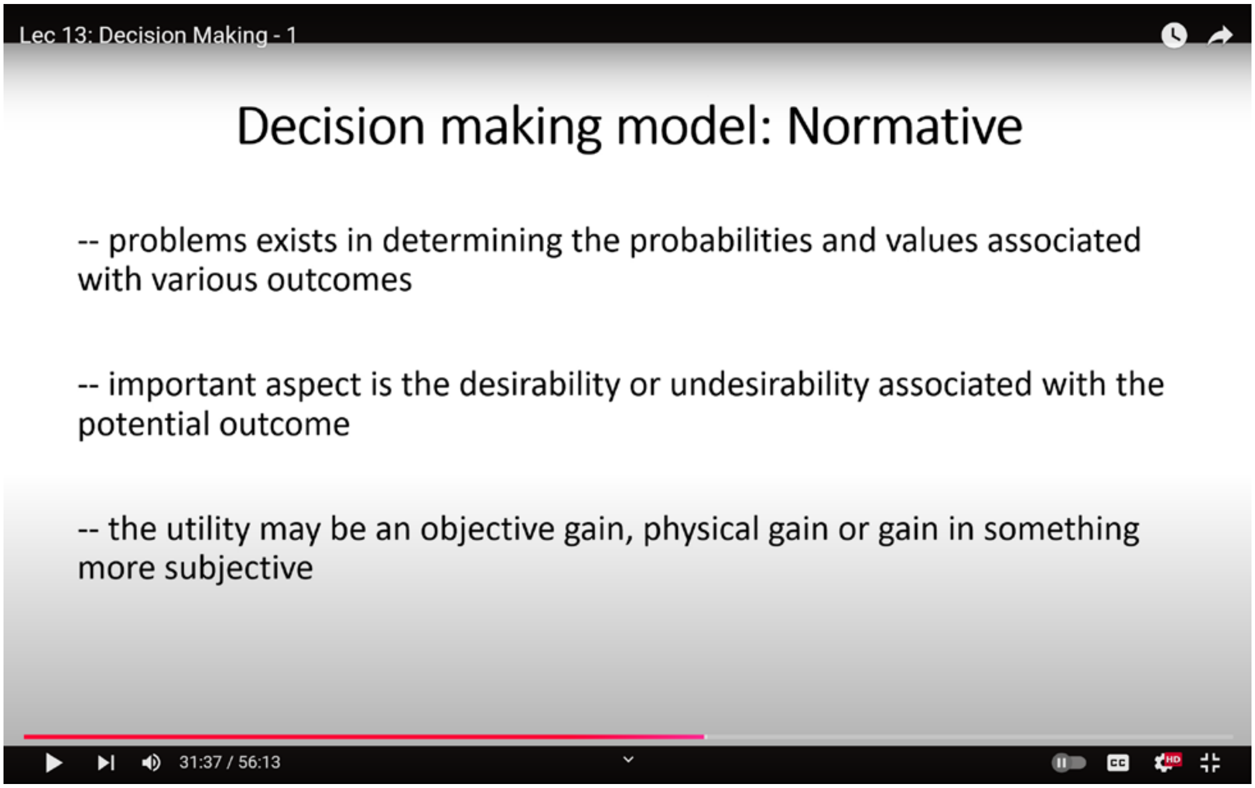

The normative model comprises four distinct components. The first component involves identifying alternative choices. There may be numerous solutions, some overt and others covert, for a given problem. The initial step in normative decision-making is to recognize which alternatives are available. Once these alternatives are identified, it is essential to consider all potential scenarios, both favorable and unfavorable, that may influence the decision to pursue a particular alternative.

Each alternative is associated with events that may support or oppose it. Normative decision-making requires consideration of all these events, whether they are beneficial or detrimental. The third step is to generate potential outcomes. After selecting an alternative and evaluating all possible events, one must determine the possible outcomes that could result from that choice. Finally, the last step is to assess the probability of each outcome.

Referring back to the previous example of the driver, if he is employing the normative model, the first step is to identify the alternative choices. In this scenario, the two alternatives are to drive during the night or to postpone the drive until morning. Various events may occur based on each choice. For instance, driving at night could lead to accidents or other problems, which may argue against night driving. Conversely, if he drives at night, he might encounter a clear road, allowing him to reach his destination more quickly and enabling him to take a break afterward.

Regarding potential outcomes, driving at night could result in accidents or other incidents, such as encountering a landslide or experiencing a vehicle breakdown, which could lead to accidents. Alternatively, driving at night might provide a clear road, allowing for earlier arrival at the destination.

The driver must then evaluate the probability associated with each outcome. Through experience, the driver can reasonably predict whether driving at night is advantageous. This is informed by data from other drivers regarding the frequency of accidents, the occurrence of problems, and how many drivers have successfully completed their journeys quickly at night. By considering all these alternatives, the driver will make a final decision.

One challenge within the normative model is accurately determining the probability and value linked to each outcome, as all of these outcomes are hypothetical.

The driver is still contemplating his options. If he chooses to drive during the night, he will reach his destination faster. However, this may come at the cost of not having time to rest. The value of this choice, which encompasses the satisfaction derived from delivering the goods more quickly and the additional time gained, is referred to as the value of the alternative. Additionally, one must consider the probability of reaching the destination faster; for instance, there is a risk of encountering a traffic jam, which must be factored into the decision.

Conversely, opting not to drive at night would save time, but it ensures safety. Thus, the utility in this case pertains to preserving one's life. The probability reflects the likelihood of each event occurring. By assessing these factors, the driver can determine whether to drive at night or not. However, this process is not straightforward. The calculations required to weigh potential benefits against the likelihood of various outcomes can be complex, as they involve hypothetical scenarios and mental simulations to create probabilities and values.

Memory also plays a role in this decision-making process. However, as I will elaborate further in this lecture, information drawn from memory may be biased and might not provide a complete perspective on whether to rely on this information. Consequently, challenges can arise in determining the probabilities and values associated with each option.

Another critical aspect to consider is the desirability or undesirability linked to potential outcomes. The driver faces two outcomes: the safety of being secure and the risk associated with reaching his destination quickly. If he prioritizes safety, he may sacrifice the opportunity to reach his goal more swiftly. Conversely, if he accepts a degree of risk, he could arrive at his destination faster. The desirability or undesirability of these options significantly influences the driver's decision to drive at night. If he has pressing obligations near his delivery location or an appointment, he may opt to drive. However, if there is no urgency, he may choose to wait until morning to make the journey. Thus, the factors of desirability and undesirability play a pivotal role in normative decision-making.

Utility can be categorized as either an objective gain, such as a physical benefit, or a more subjective gain. I previously mentioned the value of a decision, which is closely related to the concept of utility. Utility refers to the benefits derived from a decision. For instance, if the driver drives at night and arrives early, he may earn more money. This physical gain could also include additional rest or the pleasure of reuniting with family. Conversely, if he refrains from driving, the objective gain would be minimal, but the physical benefit would be adequate rest, enabling him to drive more effectively. Furthermore, there is the intrinsic value of safety.

Therefore, the utility of a decision, or the value of an alternative, hinges on the gains that individuals seek to achieve. The utility of an outcome is often expressed in monetary terms, correlating to the potential financial benefits. Testing expected utility theory in contexts where subjective values are involved is challenging. Assigning numerical values to the satisfaction derived from early arrival, for instance, is difficult.

To investigate expected utility, researchers often employ gambling tasks. One of the primary reasons for utilizing gambling tasks is that the utility of a decision can be quantified based on the potential gains or losses associated with that decision. For example, in a casino setting, if one plays a game and wins, the monetary reward serves as a measurable utility. The values can thus be analyzed and easily quantified. The probability of an outcome, whether a win or a loss, and the corresponding monetary value are considered before making a decision to gamble.

As previously discussed, studying normative values or models in real-world contexts is complicated because individuals attach subjective values to their decisions. Sometimes, people prioritize rest over financial gain or satisfaction over monetary rewards. This raises the question: how can we quantify satisfaction? While monetary benefits can be delineated as gains and losses, the challenge lies in defining satisfaction as a gain or loss. Additionally, individuals might resort to subjective parameters for measuring value, which can obscure the rationale behind their decisions.

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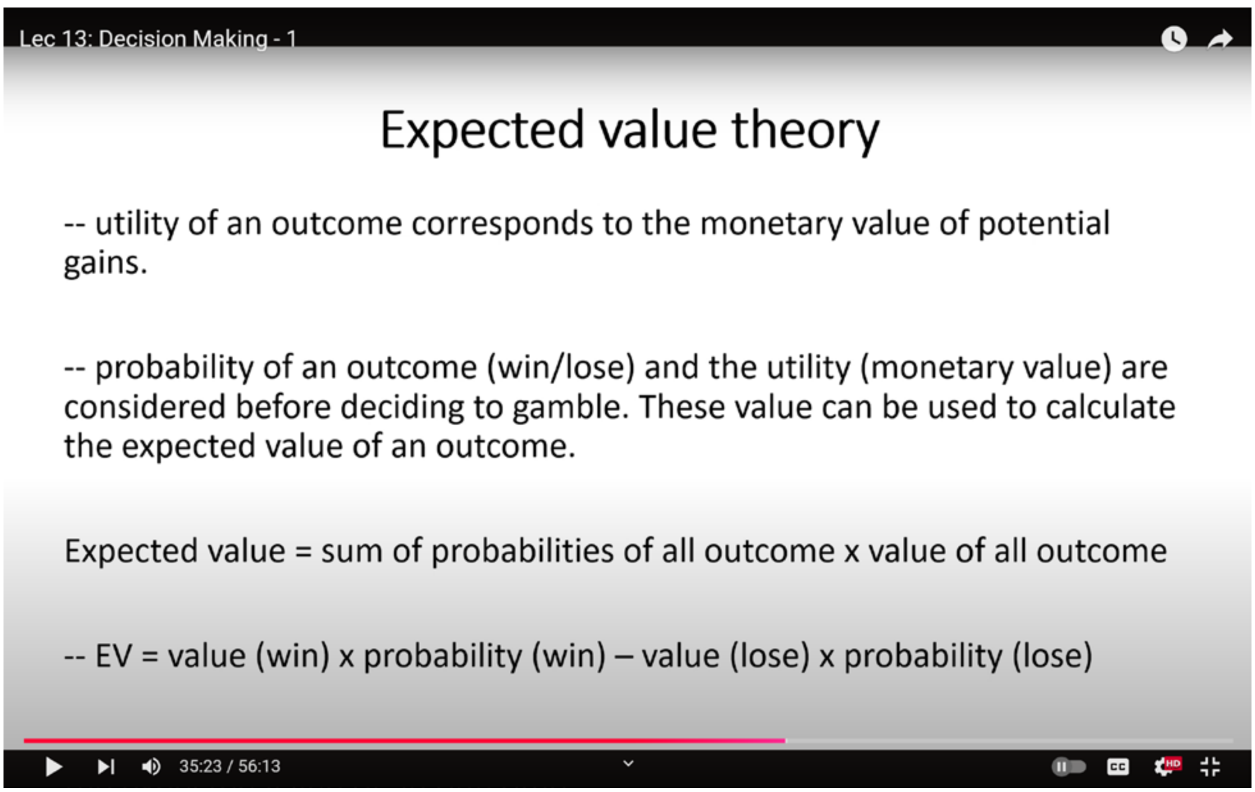

For this reason, gambling tasks become essential tools for understanding decision-making processes. To ascertain how decisions should be made or to evaluate the expected value of a particular option in a gambling scenario, one must first calculate the probabilities of outcomes in terms of winning and losing. Subsequently, one must assess the utility of each outcome, determining how desirable winning is and how undesirable losing is. By calculating the probability of an event occurring alongside its associated utility, one can gain insight into whether to proceed with a particular decision. These values can be computed to determine the expected value of an outcome.

The expected value of an outcome is defined as the sum of the probabilities of all possible outcomes multiplied by their corresponding values. In mathematical terms, the expected value can be expressed as the product of the value of a win and the probability of winning, minus the product of the value of losses and the probability of losing. To illustrate this concept, let's consider a simple example involving a dice game at a casino.

Imagine you are playing a game where rolling a six on a die earns you 100 rupees. However, there is a catch: the entry ticket for this game costs 10 rupees. The question arises: should you participate in this game? Let's perform a calculation.

The expected value of playing this game can be calculated as follows: if you win, you will earn 100 rupees, but considering the 10 rupee entry fee, the net expected value of a win is 90 rupees. The probability of rolling a six on a standard six-sided die is $\frac{1}{6}$, as there is only one outcome that results in a six.

On the other hand, if you do not roll a six, you will lose the 10 rupee entry fee. The probability of losing is $\frac{5}{6}$, as there are five outcomes (1, 2, 3, 4, or 5) that will not yield a six.

Thus, we can express the expected value as follows:

$$\text{Expected Value} = \left(90 \times \frac{1}{6}\right) - \left(10 \times \frac{5}{6}\right)$$

This calculation can be simplified to:

$$\text{Expected Value} = 15 - \frac{50}{6}$$

Assuming an approximate value for ease of calculation, let's say this results in approximately 2.5 rupees (noting that it could also be rounded to 5 rupees for practical purposes). Such calculations assist in determining whether to engage in the gamble. With the potential to win 90 rupees at a probability of $\frac{1}{6}$ versus the risk of losing 10 rupees at a probability of $\frac{5}{6}$, you can evaluate the expected value. If it is positive, you may decide to participate; if negative, you might choose not to play.

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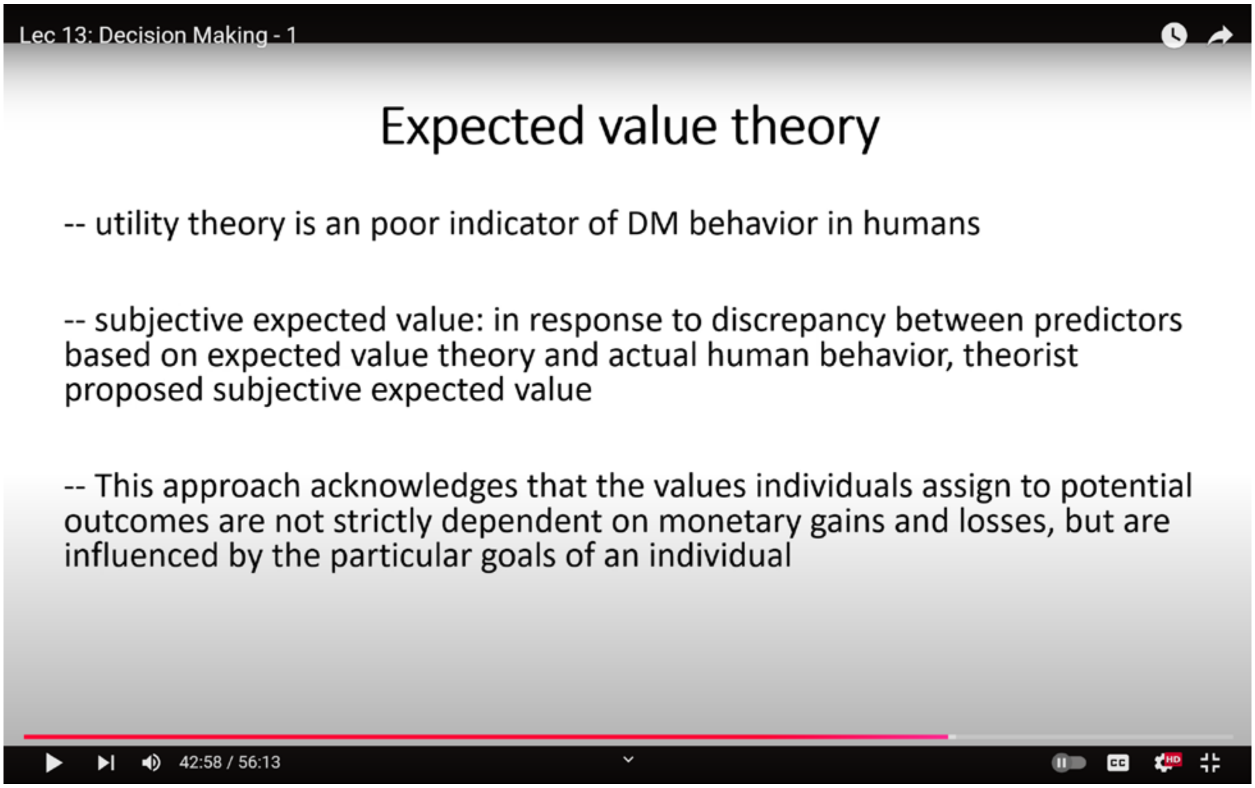

However, utility theory has been criticized as a poor predictor of human decision-making behavior. One primary reason is that utility theory relies on complex calculations, which humans often do not have the time to perform. In light of this discrepancy between the predicted outcomes based on expected values and actual human behavior, a newer form of expected utility theory has been introduced, known as subjective expected value.

Subjective expected value refers to the value that individuals assign to specific options, which can vary from person to person. While monetary values are universally observable, subjective expected values differ based on individual preferences. For example, one person might find comfort in a full night's sleep, while another might derive comfort from a lavish five-course dinner followed by sleep. Although both individuals might rate their comfort at a level of 5, their needs differ significantly. If we were to measure the comfort of both individuals on a scale, we would arrive at the same value, yet their requirements for comfort are distinct. This concept illustrates the essence of subjective expected value.

This approach recognizes that the value individuals assign to potential outcomes is not solely based on monetary gains or losses; rather, it is influenced by each person's specific goals. Thus, the notion of subjective expected value suggests that decision-making is not purely contingent on quantifiable gains and losses but is also shaped by subjective parameters and calculations.

The next approach to decision-making is termed descriptive decision-making, which focuses on how humans actually make decisions rather than how they ideally should. Humans do not typically engage in slow, elaborate deliberation processes when making decisions due to limitations in working memory and cognitive capacity, often influenced by situational factors. This phenomenon is referred to as bounded rationality, which highlights that individuals possess limited information about alternatives. Furthermore, certain situations may not permit the gathering of additional information or conducting thorough mental calculations.

Given these constraints, humans cannot be likened to computers in their ability to calculate the expected value of every possible outcome. Instead, they often resort to heuristics, or decision-making shortcuts. Rather than adhering to a single strategy, human decision-makers exhibit flexibility in choosing appropriate strategies based on their prior experiences. They identify similarities between the available alternatives and past decisions that have successfully led them to achieve their goals. This mapping process enables them to select the most suitable alternative based on their experiences.

Experienced decision-makers employ various kinds of heuristics, which can be highly effective in certain situations but may lead to bias and poor decisions in others. When utilizing shortcuts, the process primarily involves mapping past experiences to current decisions. A decision that proved successful in one scenario may not yield the same results in a different context. For example, while larger shops may accept online payments, smaller vendors and vegetable sellers may not have the means to do so due to the absence of a payment account. Thus, while carrying a phone to facilitate purchases works well in larger retail environments, attempting to apply the same method with vegetable vendors may not be effective. This illustrates that while some solutions may work, they can also create biases or lead to poor decision-making in different situations.

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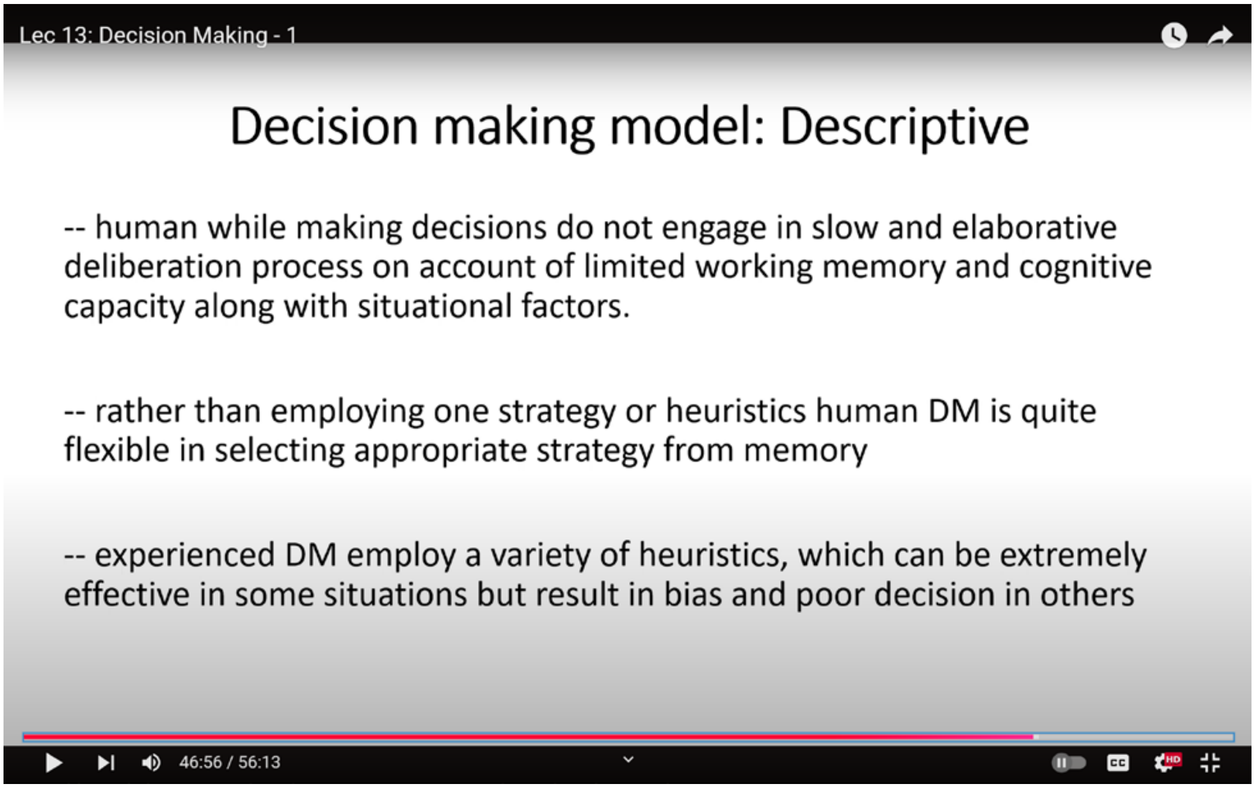

Heuristics are mental shortcuts or rules of thumb that enable individuals to make quick decisions or choices with minimal effort, often at the expense of accuracy. These heuristics serve as guidelines for predicting how certain solutions may function in future scenarios, but they can be flawed. One key advantage of heuristics is that they facilitate rapid decision-making with little cognitive load, trading off precision for ease of use. Therefore, some heuristic-based solutions may prove effective, while others may not.

Consider the example of doctors prescribing medication. When a prescribed medication does not yield the desired results, doctors often resort to a trial-and-error approach, adjusting the medication based on the symptoms presented by the patient. This process illustrates the hit-and-trial method. By analyzing observable symptoms, doctors aim to identify the most effective medication. If the initial treatment fails, they will modify their approach. This practice aligns with the descriptive model of decision-making, emphasizing speed over precision. Consequently, physicians who provide timely adjustments to treatment regimens are often regarded as the most competent, despite their reliance on heuristics derived from prior successful treatments in similar patient cases.

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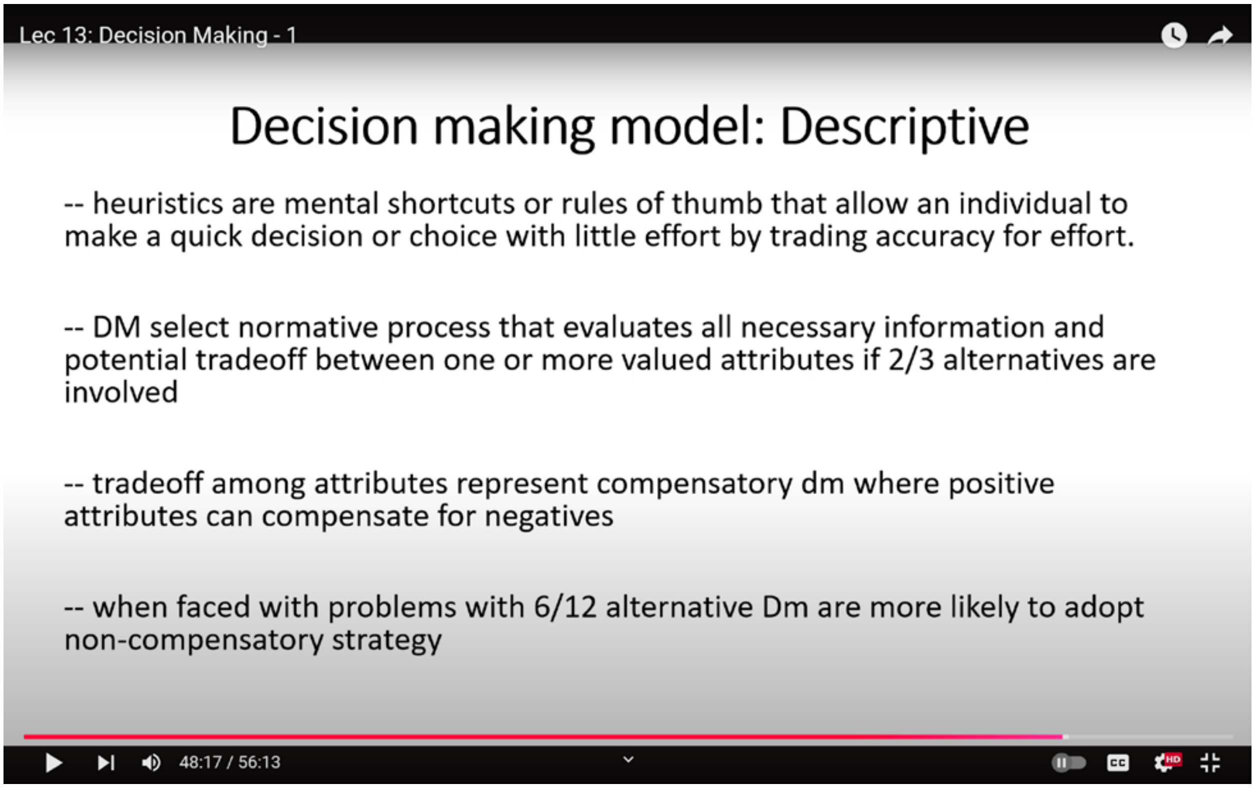

In the decision-making process, operators typically select normative approaches that evaluate all relevant information and potential trade-offs when faced with two or three alternatives. Research suggests that most decision-makers will adopt a normative approach when the options are limited, evaluating all possible outcomes and associated events for each alternative before making a decision. However, as the number of alternatives increases, ranging from six to twelve, decision-makers often resort to non-compensatory strategies.

Individuals typically employ a compensatory strategy when considering two or three options. This strategy allows them to trade off various attributes, where positive attributes can offset negative ones. For instance, if you are purchasing a phone and desire five or six features, but your preferred model lacks one or two of those features, you might consider another model that includes those features, even if it falls short in other areas. When limited to two or three alternatives, a compensatory mechanism allows you to prioritize the most important features, potentially overlooking less critical attributes.

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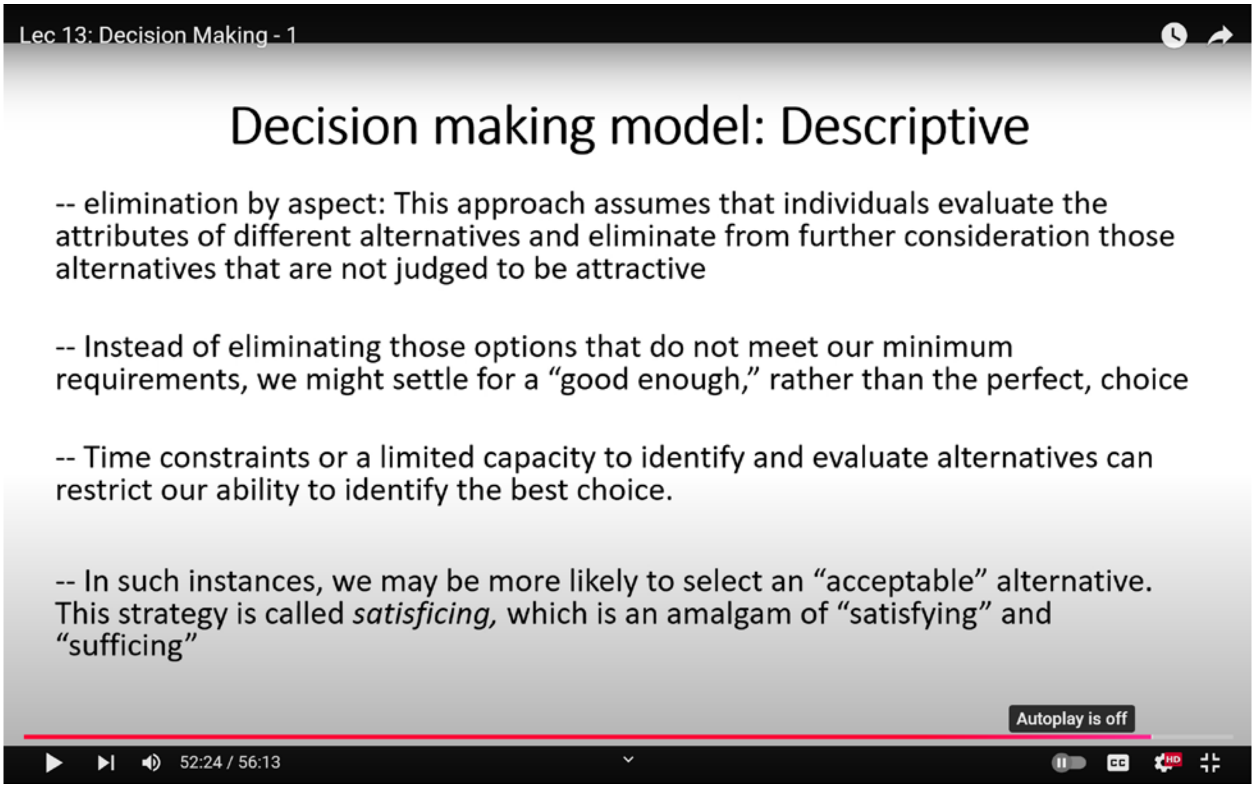

However, when faced with seven or eight alternatives, decision-makers are more likely to use non-compensatory decision-making strategies. One such strategy is known as elimination by aspect. This approach involves evaluating the attributes of different alternatives and eliminating those that do not meet certain criteria, thus narrowing the choices to more attractive options.

When presented with multiple alternatives, individuals tend to focus on those options that are attractive and offer greater value. Alternatives that do not meet their primary needs, such as the need to purchase a specific product or make a particular decision, are simply eliminated from consideration. This process is known as elimination by aspect. For example, if I primarily use a mobile phone for viewing videos, I will select a phone that has the capacity to display high-quality videos. Consequently, I will eliminate all other phones that do not possess this capability. This approach exemplifies elimination by aspect.

Rather than discarding options that fail to meet our minimum requirements, we might also choose to settle for a solution that is "good enough" rather than pursuing the perfect choice. Another strategy within this non-compensatory decision-making framework involves selecting an option that is adequate and possesses most of the desired attributes. Instead of insisting that the primary reason for purchasing a phone is its video capabilities, I could evaluate which phone provides the best overall value within my budget. In this case, I might conclude that a particular phone, while not ideal, offers more features than I require. This method of decision-making is referred to as satisficing.

Why do individuals resort to such techniques? One reason could be time constraints or a limited capacity to evaluate alternatives, which can hinder our ability to identify the optimal choice. Due to these constraints, along with limited cognitive capacity or knowledge, we may not have sufficient mental resources left for thorough evaluation. As a result, we often opt for the most beneficial option available. Under these circumstances, we are more inclined to select an acceptable alternative, a strategy known as satisficing, which is a blend of the words "satisfying" and "sufficing." It is "satisfying" because it meets most of our needs, and "sufficing" implies that it is adequate for managing the tasks we wish to accomplish with our cell phone.

In this class, we have examined the concept of decision-making and two distinct models of decision-making. In the next class, we will explore some of the heuristics individuals use in making decisions, as well as another form of decision-making known as naturalistic decision-making. Additionally, we will discuss some common errors that occur during the decision-making process. This concludes our session for today. Thank you and Namaskar.