What is decision-making?

Decision-making refers to the process by which individuals choose between multiple options based on their perceived values, preferences, constraints, and consequences. This process integrates sensory input, memories, emotions, and cognitive processes such as reasoning and judgment. Neuroscientists study decision-making through techniques such as functional imaging (fMRI), electroencephalography (EEG), single-cell recordings, and behavioural experiments in animal models. Understanding how neural systems support decision-making has important implications for fields ranging from psychology and economics to robotics and artificial intelligence.

Why is decision-making important?

Decision-making is crucial in our daily lives and disciplines, including business, finance, politics, healthcare, education, law enforcement, etc. Here are some reasons why decision-making is important:

- **Helps us make informed choices:** Good decision-making allows us to gather relevant data and evaluate it carefully before choosing among several alternatives. Informed decisions minimise risks, reduce uncertainty, and increase the chances of success.
- **Avoids negative outcomes:** Poor decision-making can result in costly mistakes, financial losses, damaged relationships, bad reputation, legal trouble, poor health, or even loss of life. Effective decision-making helps us avoid such situations.
- **Enhances productivity:** Efficient decision-making saves time, effort, and resources otherwise wasted on unproductive activities or suboptimal choices.
- **Improves problem-solving skills:** Making tough decisions frequently develops analytical thinking, critical analysis, creative problem-solving abilities, and adaptability. These traits are valuable assets both personally and professionally.
- **Facilitates better communication:** Clear decision-making often leads to clear and confident communication with others with differing opinions

or suggestions. Communication gaps can lead to misunderstandings, mistrust, or missed opportunities.
- **Nurtures personal growth:** Frequent exercises in sound decision-making strengthen self-awareness, self-discipline, self-esteem, responsibility, leadership qualities, wisdom, and resilience. Personal development is essential for leading fulfilling lives and achieving long-term happiness.
- **Encourages teamwork:** Collaborative decision-making involving diverse perspectives fosters mutual respect, trust, collective wisdom, shared ownership, higher job satisfaction, reduced turnover rates, and better work environments. Strong teams accomplish more together than they could individually.

Decision-Making Models

Many different models are used in decision-making, each providing distinct approaches, benefits, and limitations. Some popular ones include:

- **Rational Model:** Developed by economist Thomas Schelling, this model suggests that decision-makers possess complete information and assess probabilities rigidly using strict logical rules to pick the most advantageous choice. Disadvantages stem from overreliance on structured information and limited realism during rapidly changing environments or unexpected events.
- **Satisficing Model:** Introduced by Herbert Simon, satisficing means "satisfying" instead of maximising utility. This approach recognises incomplete information, bounded rationality, incrementality preference construction, and motivated action driven by aspirations instead of absolute numerical measures. Drawbacks arise due to the possible acceptance of undesirable solutions and restricted flexibility.
- **Administrative Science Approach:** Advocated by Philip Selznick, the model emphasises participatory expertise, blending subject matter knowledge with procedural acumen while seeking relative objectivity via open review mechanisms accommodating bias correction or social criticism. Possible deficiencies entail insufficiency in handling complex interdependencies where human intellect struggles conventionally to process gigantic configurations promptly enough.

- **Behavioural Economics Models:** This approach concerns micro-foundations of market processes acknowledging systematic deviations from standard assumptions. Examples include prospect theory analysis built upon Kahneman & Tversky's findings regarding flawed heuristics used intuitively under uncertain conditions or nonstandard convexities impeding comprehensive welfare evaluation. Nevertheless, since context-specific parameters remain unclear, fine-tuning common social policy applications relies on judicious experience-guided institutional tweaks supplementing insights derived from parsimonious formal laws or general axioms constraining classes of less restrictive equilibrium states without delving into concrete particularisations for fully closed research programs. Moreover, certain institutions cannot directly extrapolate straightforwardly.

Example of decision bias good vs bad decisions

A decision bias refers to a systematic tendency to make a certain type of decision, even when presented with new information that might suggest otherwise. Here are some examples of decision biases and how they can lead to good or bad decisions:

Confirmation bias occurs when we seek information confirming our pre-existing beliefs and ignore evidence contradicting them. Sometimes, this can lead to good decisions if our beliefs are accurate and the information we find supports them. However, it can also lead to bad decisions if our beliefs are inaccurate or incomplete and we miss important information that would have led us to a better decision.

Availability bias refers to our tendency to rely on easily accessible information when making decisions. For example, if we hear a lot about a certain type of crime on the news, we may overestimate the likelihood of that type of crime occurring in our community. This can lead to bad decisions if we make choices based on inaccurate or incomplete information.

Anchoring bias occurs when we rely too heavily on the first piece of information we receive when making a decision, even if that information is irrelevant or inaccurate. This can lead to bad decisions if the initial information

we receive is misleading or if we fail to consider other important factors that should influence our decision.

Overconfidence bias: This refers to our tendency to overestimate our own abilities and the accuracy of our judgments. This can lead to bad decisions if we take on tasks beyond our abilities or fail to seek out additional information or opinions that could improve our decision-making.

Framing bias occurs when we are influenced by how information is presented to us. For example, if a decision is presented as a gain or a loss, we may be more risk-averse when presented with the possibility of a loss. This can lead to good decisions if we can accurately weigh the risks and benefits of different options. Still, it can also lead to bad decisions if we are overly influenced by how information is framed.

A formal approach to decision-making

Several formal approaches to decision-making that are commonly used in decision neuroscience research include:

- **Expected utility theory:** This normative approach assumes that individuals make decisions by selecting the option that maximises expected utility, a function of the probability and magnitude of potential outcomes.
- **Prospect theory:** This descriptive theory suggests that people make decisions based on the subjective value they assign to potential outcomes rather than on the objective probabilities and magnitudes of those outcomes.
- **Reinforcement learning:** This computational approach models decision-making as a trial-and-error learning process in which individuals adjust their behaviour based on feedback from the environment.
- **Bayesian decision theory:** This normative approach uses Bayesian inference to integrate prior knowledge with new information to make optimal decisions.
- **Dual process theory:** This descriptive theory suggests that decision-making involves two distinct processes: a fast, intuitive system

that relies on heuristics and a slower, more deliberative system that uses more rational and analytical processes.

These formal approaches provide a framework for understanding the cognitive and neural mechanisms underlying decision-making.

Expected value theory

Expected value theory is a normative approach to decision-making that assumes that individuals make choices by evaluating the potential outcomes of each option and selecting the one with the highest expected value.

Expected value is defined as the probability-weighted sum of the potential outcomes of an option. For example, if a coin flip has a 50% chance of coming up heads and a 50% chance of coming up tails, and heads result in a gain of $10, and tails result in a loss of $5, the expected value of the coin flip would be:

Expected value = (0.5 * $10) + (0.5 * -$5) = $2.50

According to the expected value theory, a rational decision-maker would choose the option with the highest expected value. In the example above, the rational decision would be to choose the coin flip because it has a positive expected value.

Expected value theory is often used as a benchmark against which to compare actual decision-making behaviour. Researchers can examine whether individuals make choices that align with expected value theory and, if not, investigate the cognitive and neural mechanisms that underlie deviations from rational decision-making.

Utility

utility refers to the subjective value an individual assigns to the potential outcomes of a decision. The utility is often used in decision-making models to

capture that people may value different outcomes differently, even when those outcomes have the same objective value.

The utility is typically represented by a mathematical function that maps the objective value of an outcome to its subjective value or utility. For example, if an individual value a $100 gain twice as much as a $50 gain, their utility function might look like this:

U($50) = 1
U($100) = 2

In this case, the utility of a $50 gain is 1, while the utility of a $100 gain is 2. The utility function can be used to calculate the expected utility of a decision by weighing the utility of each possible outcome by its probability of occurring.

The utility can vary across individuals and can also be influenced by contextual factors such as the framing of the decision, the timing of the outcomes, and the social context in which the decision is made. Understanding how individuals assign utility to potential outcomes is important for understanding the cognitive and neural mechanisms underlying decision-making.

Marginal Value

Marginal value refers to the additional value or utility an individual assigns to each additional unit of a particular outcome. Marginal value is a key concept in economics and decision-making, as it helps to explain how individuals make decisions in situations where they have trade-offs between different outcomes.

For example, consider a decision between buying one or two apples. The marginal value of the second apple is the additional value that the individual assigns to the second apple beyond the value of the first apple. If the first apple is highly desired, the marginal value of the second apple may be lower than the marginal value of the first apple.

Marginal value can be used to predict how individuals will allocate their resources across different outcomes. When the marginal value of an outcome decreases with each additional unit, individuals will tend to allocate their resources to the outcome until the marginal value reaches zero. This is known as the law of diminishing marginal utility.

In the context of decision neuroscience, understanding how individuals assign marginal value to different outcomes is important for understanding the neural mechanisms underlying decision-making. Research has shown that the brain encodes the marginal value of different outcomes and that this encoding is related to activity in the brain's reward circuitry.