Orbis Idearum, Volume 12, Issue 1 (2024), Pages 11-51
ISSN: 2353-3900

THE HISTORY OF DUAL-PROCESS THINKING

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ABSTRACT

This paper reviews the history of the dual-mode information processing idea in philosophy, psychology, and cognitive science. It tracks how the concept that human thinking works through two separate but interconnected systems has developed from ancient times to now. The review looks at early philosophical ideas that suggested two processes in human thought. It points out Plato's separation of reason and appetite, and Aristotle's division of the soul into rational and irrational parts. Moving to modern times, the paper discusses how dual-process theories emerged in 20th-century psychology. It covers William James's ideas of associative and true reasoning, and Freud's theories of conscious and unconscious mental processes. The review then focuses on formal dual- process theories in cognitive and moral psychology from the 1970s onwards. During this time frame, researchers began to systematically study and test these theories. By following this historical path, the paper aims to show how the idea of dual-mode information processing has grown and become important in our understanding of human thinking across different fields and time periods.

KEYWORDS: Dual-process thinking, Automatism, Intuition, Reflective behavior, Decision making, Dual-mode information processing, System 1, System 2

1. INTRODUCTION

Human cognition is characterized by several key factors: automatism (unconscious responses to stimuli), intuition (immediate insights without conscious reasoning), consciousness (awareness and perception), reflective behavior (deliberate analysis before decision-making), and control (the ability to regulate internal states and external environments). These elements interact dynamically to influence how people perceive, decide, and act, with varying levels of conscious involvement. Some concepts about the human mind seem eternal. One such concept is dual-mode information processing—the idea that human cognition operates through two distinct yet interacting systems. The first system is rapid, automatic, and intuitive; the other - slower, deliberative, and analytical. The development of this idea spans from ancient philosophical considerations to most recent neuroscientific research. Contemporary researchers have identified brain regions associated with intuitive versus analytical thinking, providing biological support for the dual-mode model.

The automatic information processing mode may have biological roots common to other animals. The evolutionary basis for this type of processing is evident in its prevalence across various animal species, where swift automatic responses are crucial for survival. These processes are adaptive, having evolved to handle routine and familiar tasks efficiently without the need for conscious deliberation. In contrast, the deliberative mode appears to be unique to humans. This type of processing enables complex reasoning, problem-solving, and decision making that go beyond the capabilities of automatic responses. In its most developed form, it allows the maximization of the utility of decision-making. The development of this mode is linked to the cognitive functions of the human prefrontal cortex, which supports planning, reflective thought, and metacognitive abilities (Stanovich, 2005).

2. ANCIENT PHILOSOPHICAL FOUNDATIONS

The notion of multiple cognitive processes can be traced back to ancient Greek philosophy, particularly to the works of Plato and Aristotle. In *The Republic*, Plato proposed a tripartite model of the soul consisting of reason (*logistikon*), spirit (*thumoeides*), and appetite (*epithumetikon*). Reason was the highest part of the soul, responsible for rational thinking and decision-making. It was located in the head and corresponded to the ruling class in Plato's ideal state. Spirit, situated in the chest, was associated with emotions like courage and anger, and corresponded to the guardian class. Appetite, lo-

cated in the abdomen, was linked to bodily desires and corresponded to the working class (Cooper, 1997).

The three elements of the psyche are not independent, but rather constitute a system with its own hierarchy.

> We will liken the soul to the composite nature of a pair of winged horses and a charioteer. Now the horses and charioteers of the gods are all good and of good descent, but those of other races are mixed; and first the charioteer of the human soul drives a pair, and secondly one of the horses is noble and of noble breed, but the other quite the opposite in breed and character. Therefore in our case the driving is necessarily difficult and troublesome (Plato, Phaedrus, 246a-246b).

Plato argues that the charioteer (representing the rational soul, in other words *logistikon*) should control the entire system. The charioteer makes crucial decisions about when to give each horse its rein and when to restrain it. The system as a whole should be governed not by the desires of the horses, but by the rational decisions of the charioteer.

Aristotle developed these ideas in his work *De Anima* (*On the Soul*). He distinguished between the rational and irrational parts of the soul. The rational part (*sophia*) was unique to humans and responsible for logical reasoning and decision-making, while the irrational part (*phronesis*), was shared with animals and governed basic functions, sensations, and desires. Aristotle's dichotomy between rational and irrational aspects of the soul highlighted the tension between reasoned judgment and instinctual drives. He emphasized the idea that human cognition involves both logical, deliberative processes and more automatic, emotionally-driven responses (Shields, 2016).

In the centuries that followed, various philosophers and thinkers explored similar ideas about different modes of thinking. However, we had to wait until the 19th century for more formal theories to emerge.

3. WILLIAM JAMES'S TWO KINDS OF KNOWLEDGE

In his work *The Principles of Psychology* (1890), William James distinguished the differences between knowledge by acquaintance and knowledge by description.

Knowledge by acquaintance refers to direct, immediate awareness or experiences of the world. This type of knowledge is characterized by its intuitive and non-inferential nature. It is closely tied to sensory experiences, emotions, and gut feelings. For instance, the knowledge of the color red or the taste of chocolate is primarily knowledge by acquaintance. It is unnecessary

to engage in cognitive reasoning regarding these experiences; we merely undergo them. This form of knowledge can be seen as more automatic and less dependent on conscious reflection or deliberation.

In contrast, knowledge by description involves conceptual understanding and reasoning about things not directly experienced. It is mediated by language and abstract thought processes. For example, the knowledge of historical events or scientific theories is primarily knowledge by description. Although we have not directly experienced these phenomena, we can comprehend and analyze them through the use of language and conceptual frameworks. This type of knowledge requires more effortful cognitive processing and is closely tied to our capacity for abstract thought and reasoning. James emphasized that human cognition involves both immediate, experiential knowledge and more abstract, conceptual understanding.

James's concept of habits can be seen as an early recognition of automated behaviors. He argued that habits, once formed, operate with minimal conscious attention: "The more of the details of our daily life we can hand over to the effortless custody of automatism, the more our higher powers of mind will be set free for their own proper work" (James, 1890, p. 122). This insight suggests that the automation of certain cognitive processes and behaviors (through habit formation) frees up cognitive resources for more complex, deliberative thinking.

Several years later, Sigmund Freud explored the unconscious mind and its influence on behavior. Freud revealed a hidden realm of thoughts, memories, and desires that operate outside of conscious awareness.

4. SIGMUND FREUD'S PSYCHOANALYTIC THEORY

Freud, in *The Ego and the Id* (Freud, 1923/1961), proposed a tripartite structural model of the mind comprising the id, ego, and superego. It then became the most recognizable psychological theory ever.

The *id*, entirely unconscious, operates on the pleasure principle, seeking immediate gratification of instinctual drives. It represents the primitive aspects of the mind, closely associated with physiological needs and emotional impulses. The *id* can be conceptualized as an early formulation of subconscious processes that influence behavior without our awareness or control.

The *ego*, partially conscious and partially unconscious, functions according to the reality principle. It mediates between the *id*'s demands, the *superego*'s moral constraints, and external reality. The *ego* can be interpreted as a precursor to contemporary theories of controlled, analytical processing.

The *superego* embodies moral standards and ideals, developed through the parental and societal values. It serves as the mind's ethical component, often in opposition to the *id*'s primal urges.

Freud argued that a significant portion of human behavior is driven by unconscious motivations and conflicts (Ostow, 1959). The components he identified are not directly involved in cognitive activities as currently understood. Nevertheless, his ideas appeared to contain concepts that are relevant to contemporary discussions of cognitive processing.

5. EMPIRICAL RESEARCH ON THE DUALITY OF MIND

In the latter half of the twentieth century, a number of scientific experiments provided evidence for the existence of two distinct systems of information processing in the human mind. The experiments demonstrated that results varied depending on whether fast, automatic processing was induced by cognitive load or time pressure, or whether participants were allowed more time for deliberate processing.

In the classic Stroop (1935) task, participants were shown color names printed in incongruent ink colors (e.g., the word "red" printed in green ink) and were asked to name the ink color while ignoring the word. It turned out that participants took significantly longer to name the ink color when it conflicted with the word meaning compared to when they matched. This delay is attributed to the automatic nature of reading, which activates the semantic meaning of the word and interferes with the controlled process of color naming (MacLeod, 1991).

Frederick's Cognitive Reflection Test (CRT) consists of three deceptively simple questions that prompt immediate, intuitive responses, which are often incorrect. To arrive at the correct answer, participants must resist their initial impulses and engage in deliberate reasoning, requiring greater cognitive effort. An example from the Cognitive Reflection Test (CRT) involves the following problem: A bat and a ball together cost $1.10, with the bat costing $1.00 more than the ball. The intuitive response is that the ball costs $0.10. However, the correct answer is $0.05, as this makes the bat cost $1.05, summing to $1.10 (Frederick, 2005).

Shiv and Fedorikhin (1999) conducted a study examining the impact of cognitive load on decision-making, particularly in the context of food choices. Their study participants, placed under high memory load taxing their cognitive resources, were more likely to select unhealthy food options compared to participants deciding under low cognitive load. This finding suggests that when cognitive resources are depleted, individuals tend to rely

more heavily on emotion-driven processes rather than engaging in reflective, rational decision-making.

Finucane, Alhakami, Slovic, and Johnson (2000) examined the impact of time pressure on the relationship between perceived risks and benefits of various hazards. Their findings suggest that under time pressure, people rely more on affect-based judgments rather than analytical processing when assessing risks and benefits. The researchers presented participants with a list of hazards and asked them to rate the risks and benefits of each on separate scales. One group made these judgments under time pressure, while another group did so without time constraints. The results showed a stronger negative correlation between perceived risks and benefits in the time pressure condition compared to the control condition. In other words, when forced to respond quickly, participants exhibited a more pronounced tendency to judge hazards with high perceived risks as having low benefits, and vice versa. This pattern indicates that time pressure leads people to rely more heavily on an "affect heuristic" - an intuitive, emotion-based process of judgment. Under no time constraints, participants likely engaged in more analytical, deliberative processing, allowing for a more thorough assessment of risks and benefits, especially the tradeoff between riskiness and profitability, which is well known in financial markets.

Tyszka et al. (2017) examined how people form expectations about sequences of events. They compared reactions and predictions in various tasks involving binary event sequences. The findings showed that expecting trend continuation is the default, automatic response, evidenced by faster reaction times for repeated stimuli in a choice task and increased predictions of trend continuation under cognitive load. Children, who have less developed deliberative abilities than adults, show a similar pattern of predictions. Expecting trend reversal required more deliberative thinking, and therefore adults without cognitive load were more likely to predict trend reversal.

6. CONTROLLED AND AUTOMATIC PROCESSING

Shiffrin and Schneider (1977) proposed a formal distinction between controlled processing, characterized as slow, effortful, and limited by working memory capacity, and automatic processing, described as fast, effortless, and capable of occurring in parallel with other processes. Automatic processes operate quickly, with little conscious awareness or control, and can handle multiple tasks simultaneously. These processes are efficient but inflexible, difficult to modify once established. Controlled processes, on the other hand, requiring conscious attention and effort, are limited by working memory capacity, and are more flexible and adaptable than automatic processes.

Nisbett and Wilson (1977) explored the concepts of automatism and control mechanisms. They discovered that many judgments and behaviors occur without conscious awareness, indicating that individuals often lack insight into their own mental processes. As a result, decisions can be heavily influenced by automatic, nonconscious factors. For example, a person might automatically choose a familiar brand of coffee at the store without considering other options, simply because it is what they have always purchased. One group of processing is particularly noteworthy: "automatic and reflective." Automatic and non-reflexive processing involve actions and decisions made without conscious thought. It is characterized by a lack of awareness of mental processes, immediate instinctive reactions, and cognitive rigidity; for instance, driving a familiar route without thinking. Automatic and reflective processing on the other hand are informed by conscious awareness and reflection. Individuals can reflect and adjust adaptive responses allowing situational flexibility and cognitive control. An example of this includes choosing healthier food options despite impulsive urges.

Steven Sloman, in a 1996 article offered his own distinction between two separate reasoning systems. The associative system, whose concept relates to James's views, is a way of processing information based on similarity structures and relations of temporal contiguity. It involves representations of objects and phenomena, similarities between stimuli, encoded statistical regularities of the environment, frequencies, and correlations between various features of the world. Here, statistical regularities are captured more as associative connections rather than as a result of numerical calculations. For example, having wings correlates with the ability to fly simply on the basis that one is associated with the other. Instead of trying to reason based on the mechanical structure of phenomena, associative thinking relies on estimates based on the basic statistical structure. It draws conclusions from a particular statistical description of the environment, using similarity between elements of the problem and the interpretation of such general knowledge aspects like images and stereotypes. It employs intuition, imagination, creativity, fantasy, which relies on automaticity and lack of clear restrictions.

The second system, based on rules, largely depends on symbols and the way they are processed. Rules are various kinds of instructions, principles, regulations, laws, including laws of logic. Rules are abstractions that apply to all statements that have a certain well-defined, symbolic structure. Most importantly, they have both a logical structure and a set of variables. Variables can represent an unlimited number of objects, and therefore rules can be applied to an enormous number of situations. For example, the probability calculus rule $P(A \& B) \leq P(A)$ generates infinitely many true sentences, which we obtain by substituting names of specific events for variables A and

B. This system uses formal analysis, deduction, explanation, verification; actions are goal-oriented and conscious.

Keith Stanovich and Richard West (2000) first named the two types of information processing System 1 and System 2. They refined the dual-process model through research on individual differences in reasoning (Stanovich & West, 2008; Stanovich, 2009). Their studies showed that, while relying on intuitive processes, individuals with higher cognitive abilities are more likely to engage in analytical thinking that can override incorrect intuitive reactions. Stanovich and West (2008) suggested that System 1 processes are universal and mostly automatic, while System 2 processes show greater variation among individuals. They found that effective engagement of System 2 processes depends not only on cognitive abilities but also on thinking dispositions and knowledge of reasoning strategies.

Stanovich (2009) proposed a further refinement of dual process theories by dividing deliberate reasoning into two sub-systems: algorithmic and reflective.

For example, having wings correlates with the ability to fly simply on the basis that one is associated with the other system is closely tied to human intelligence and operates in "optimal performance situations," which are closed-ended scenarios with externally determined correct solutions, such as intelligence tests. In contrast, the reflective system functions in "typical performance situations," which are more open-ended and context-dependent. These scenarios are associated with real-life goals and rely heavily on critical thinking. The reflective system aligns more closely with the concept of rationality as understood in rational choice theory within the social sciences. Both the algorithmic and reflective systems are important, but they operate differently, with the algorithmic system being more linear in information processing.

An important class of cognitive fallacies involves the operation of the algorithmic mind without the necessary oversight of the reflective mind. A good example is the gambler's fallacy—an erroneous belief that a random process will self-correct. For instance, after a series of RED outcomes in roulette, one might erroneously assume that the probability of the next outcome being BLACK is higher. As Gilboa (2009, p. 42) points out, one must actually understand the statistical law of large numbers to fall victim to the gambler's fallacy. This is not merely a case of intuitive, automatic information processing but rather a (uncritical) misinterpretation of a mathematical principle.

The distinction between algorithmic and reflective thinking relates to Stanovich's (1993) concept of *dysrationalia*. *Dysrationalia* describes situations where intelligent and educated individuals act against their own best interests. A classic example of this is a university professor falling victim to

a Ponzi scheme and losing all their savings. This illustrates how even highly intelligent people can make irrational decisions if they lack critical thinking skills. Specifically, *dysrationalia* often results from the failure to apply important meta-rules or heuristics, such as "all that glitters is not gold." These rules help guard against being exploited in so-called hostile environments, where devious decision makers exploit the cognitive shortcomings of others.

7. Defining features of Type 1 and Type 2 processing

Jonathan Evans and Keith Stanovich (2013) presented a comprehensive defense against various criticisms that have emerged in the field, advocating for a default-interventionist model, where Type 1 processes generate intuitive default responses, and Type 2 processes can then intervene to override these if necessary. The researchers presented an evolutionary perspective, arguing that while rudimentary forms of Type 2 processing may exist in other animals, it is uniquely developed in humans, allowing for abstract and hypothetical thinking. Evans and Stanovich moved away from using the terms "System 1" and "System 2," preferring instead "Type 1" and "Type 2" processing. This shift in terminology usage reflected their emphasis on the types of processes taking place rather than the distinct cognitive systems.

Building on their defense of dual-process theories, Evans and Stanovich (2013) proposed a refined conceptualization focusing on the defining features of Type 1 and Type 2 processing. This approach aimed to address the criticisms of vague definitions and inconsistent attribute clusters associated with earlier dual-process models.

The key defining feature of Type 1 processing, according to Evans and Stanovich, is its autonomy. This type of processing operates independently from conscious control and is triggered automatically by stimuli in the environment. It functions without reliance on working memory, allowing for immediate responses to stimuli without consuming significant cognitive resources. The automaticity of Type 1 processing is often based on learned associations or innate responses, enabling quick judgments but potentially leading to biases due to its reliance on past experiences and intuitive reactions.

In contrast, Type 2 processing is defined by two key features: cognitive decoupling and mental simulation. Cognitive decoupling refers to the ability to separate thoughts from immediate sensory input and consider hypothetical scenarios, enabling abstract thinking and planning. Mental simulation involves the capacity to imagine different outcomes and scenarios, which requires the use of working memory resources.

Type 2 processing is heavily dependent on working memory and demands conscious effort and attention, making it slower and more resource-intensive than Type 1 processing. It is characterized by careful consideration, logical reasoning, and systematic analysis of information, allowing for flexible and adaptable problem-solving and decision-making. Because of its uniqueness to humans, it is much easier to define Type 2 processes than Type 1 processes. Thus, Type 1 processes may be defined simply as any cognitive processes that are neither Type 2 processes nor visceral processes. It is also worth noting that, according to the Stanovich and Evans typology, both consciousness and control, although heavily correlated with a given type of processing mode, are not their defining features. One can technically imagine decoupling and abstraction that are unconscious, and one can definitely imagine a very conscious and persistent adherence to emotionally laden Type 1 processing in some stubborn cognitive misers.

8. DUAL-MODE INFORMATION PROCESSING AND THE CONCEPT OF DUAL-SELF

Plato's tripartite model of the soul, with its metaphor of a charioteer and horses, Freud's theory of the id, ego, and superego, and modern models of autonomous and reflective systems should not be confused with the concept of multiple 'selves' inhabiting a single body in philosophy and decision sciences (Elster, 1987). Dual process theories generally assume a single self without dissociated or split personalities, but with different tools or interfaces for preferences, reasoning, and decision-making. In contrast, multiple-self models propose that human behavior may be best modeled as a strategic interaction of two or more internal agents, such as an impatient doer and a far-sighted planner (Thaler & Shefrin, 1981). Depending on the formulation, these internal agents may or may not be mere metaphors; in the latter case, one assumes that human behavior cannot be adequately explained by a single all-controlling self. Multiple-self models are not substitutes for dual processing models but rather complementary. The multiple-self approach offers valuable insights into phenomena like self-deception and self-signaling, which are often difficult to explain through traditional dual-process theories. In self-deception, individuals may hold conflicting beliefs where one part of the self actively deceives another. For example, a person might convince themselves that they are happy in a job they dislike, allowing their conscious mind to avoid the discomfort of facing the truth. This internal division enables the coexistence of contradictory beliefs. On the other hand, self-signaling involves actions that reflect personal characteristics or intentions, even if those actions do not directly influence outcomes. For instance, some-

one might donate to charity not only to help others but also to signal to themselves that they are a generous person (e.g., Prelec & Bodner, 2003).

9. DUAL-MODE INFORMATION PROCESSING AND THE CONCEPT OF INTUITION

Intuition can be defined as a cognitive process that facilitates rapid decision-making, often occurring without the involvement of conscious reasoning. It is characterized by an implicit understanding or "knowing" that emerges from a person's accumulated experiences and subconscious information processing. This process operates primarily through automatic cognitive mechanisms. Kahneman (2011) suggests that intuition can serve as a bridge between automatic perception and deliberate reasoning. This interplay allows for effective decision-making in complex or time-sensitive situations, where relying solely on controlled processes may be impractical or inefficient.

9.1 Cognitive-Experiential Self-Theory (CEST)

Seymour Epstein (2010) explored definitions of intuition, noting that it is often described by what it is not (e.g. not analytical reasoning). He proposed two definitions: a phenomenological one ("Intuition involves a sense of knowing without knowing how one knows") and a process-oriented one ("Intuition involves a sense of knowing based on unconscious information processing"). Epstein identified eight unresolved issues in intuition research, including its boundaries, validity, operating principles, core mechanism, dual- process necessity, the role of experience, affect, and the advantages of intuitive vs. analytical thinking.

To address these, Epstein introduced cognitive-experiential self-theory (CEST), positing two distinct systems: an experiential/intuitive system that is associative, automatic, and affect- laden, and a rational/analytical system that is verbal, conscious, and effortful. He argued that intuition is part of the experiential system, which is evolutionarily older and shared with other animals.

Epstein's Cognitive-Experiential Self-Theory (CEST) defines intuition as implicit knowledge and experiential processing, excluding superstitions and motor skills. CEST posits that intuition includes valid and invalid beliefs, uses associative learning, and involves affect. Epstein supported dual-system models over single-system theories, stressing experience and emotion in intuition. He argued for combining intuitive and analytical processing strengths. CEST frames intuition as an adaptive associative learning process shared with animals. Epstein advocated for the usage of both systems in regards to flexible cognition across different situations.

9.2 "Thinking, Fast and Slow"

Daniel Kahneman made a significant contribution to popularizing two distinct human information processing systems, known as System 1 and System 2, through his bestselling book *Thinking, Fast and Slow* (2011). Kahneman, along with Amos Tversky, empirically studied and described a wide range of heuristics, i. e. mental shortcuts used in judgment and decision making, becoming a founding fathers of contemporary behavioral economics (Buttiliere et al., 2024). A noteworthy approach was presented in a paper titled "Conditions for Intuitive Expertise: A Failure to Disagree." In this work, Daniel Kahneman and Gary Klein (2009) explored the intersection of two approaches to understand intuition and expertise. On the one hand, they analyzed the heuristics and biases approach and on the other hand naturalistic decision making. The origins of these approaches differ significantly. The heuristics and biases approach, influenced by Paul Meehl's work comparing clinical and statistical prediction, tends to be more skeptical of expert judgment, highlighting systematic errors and biases that can affect decision-making. Naturalistic decision making is rooted in studies of chess masters and later was applied to areas like firefighting, focusing on how experts make decisions in natural settings. It emphasizes pattern recognition and mental simulation in expert decision-making.

Despite their different backgrounds, Kahneman and Klein (2009) agreed that skilled intuition develops in high-validity environments where there are stable relationships between objectively identifiable cues and subsequent events. Adequate opportunities for learning are crucial for developing expertise. Both recognize that expertise is often domain-specific and can be "fractionated" – experts may demonstrate genuine skill in some areas but not in others. The conditions necessary for developing skilled intuition include valid environmental cues and adequate learning opportunities. Intuition can go wrong, particularly in low-validity environments or when heuristics are inappropriately applied. Subjective confidence does not appear to be a reliable indicator of the accuracy of intuitive judgments. True experts know when they do not know, but non-experts often lack this metacognitive ability. Becoming a true expert in a field may be a special case where the skills that normally necessitate reflective (Type 2) thinking become automatic (Type 1 style), as in the case of so-called tacit knowledge or tacit competence. True expertise is more likely to develop in environments with clear, consistent feedback and where patterns are stable and learnable. In contrast, environments with low validity or delayed, ambiguous feedback are less conducive to developing reliable intuitive skills. Two environments with the least chance of developing expertise are politics and financial markets, due to their inherent complexity.

9.3 Fuzzy-Trace Model

Reyna and Brainerd (2011) took a rather unconventional but noteworthy stance, proposing the Fuzzy-Trace Model, which challenges traditional dual-process theories. The authors suggest that people use two types of mental representations: verbatim (precise) and gist (fuzzy, meaning-based). Contrary to other dual-process theories, gist-based intuition is considered a more advanced form of cognition. The fuzzy-trace theory emphasizes that gist-based intuition is often adaptive and represents a sophisticated form of thinking, rather than a primitive or inferior process. This theory has been applied to explain cognitive patterns in neurodevelopment, autism, and Alzheimer's disease. For instance, individuals with autism tend to focus more on verbatim details and are less susceptible to framing effects.

Furthermore, the concept of dual-mode thinking began to appear in fields other than cognitive science, such as in persuasion theory.

10. ELABORATION LIKELIHOOD MODEL (ELM)

In 1986 Richard E. Petty and John T. Cacioppo presented the Elaboration Likelihood Model (ELM), which proposed two primary routes to persuasion. The central route and the peripheral route each represent distinct cognitive processes. The central route involves high elaboration, where individuals engage in thorough, analytical processing of message content. This route is characterized by careful scrutiny of arguments, critical evaluation of evidence, and extensive cognitive effort. It is typically activated when individuals are both motivated and able to think deeply about the message, such as when the topic is personally relevant or when cognitive resources are abundant. The central route aligns closely with controlled, systematic processing in other dual-process models.

In contrast, the peripheral route involves low elaboration and relies on simple cues or heuristics for quick, efficient information processing. This route comes into play when motivation or ability to process is low, perhaps due to time constraints, lack of personal relevance, or limited cognitive resources. Peripheral cues might include source credibility, message length, or emotional appeals.

Research has demonstrated that beliefs acquired through the central route are characterized by persistence, resistance to counter-arguments, and significant influence on an individual's behavior and decisions. Conversely, beliefs formed via the peripheral route tend to be more transient, less resistant to counter-arguments, and exert weaker influence on decision-making processes. Exhibiting low motivation or processing abilities increase periph-

eral cues' persuasive impact, while high motivation or abilities enhance central route processing.

The evolution of core dual-process theory will be examined through the lens of *belief bias* research, illuminating our understanding of human reasoning. This exploration traces how studies on *belief bias* have shaped our conceptualization of two distinct cognitive processes: intuitive and analytical. By investigating this phenomenon, researchers uncovered fundamental insights into the interplay between prior beliefs and logical reasoning, thereby refining and expanding dual-process theory.

11. LeDoux's dual pathway model of emotion

Joseph LeDoux's 1996 research on the brain's emotional processes resulted in the Dual Pathway Model of Emotion. This model suggests there are two separate neural routes for processing emotional information, with a specific focus on fear responses. LeDoux's work showed that the brain has a quick, direct path for emotional reactions, especially fear, as well as a slower, more detailed path that involves conscious awareness.

The *low road* is a rapid, subcortical pathway that transmits sensory information directly from the thalamus to the amygdala. This route allows for quick, automatic processing of potential threats, bypassing the slower cortical routes. The low road operates largely outside of conscious awareness and can trigger emotional responses before conscious recognition of the stimulus.

The *high road* involves a longer, cortical route. Sensory information travels from the thalamus to the sensory cortex for detailed processing before reaching the amygdala. This pathway allows for context-dependent emotional processing and is associated with conscious awareness of emotional stimuli. LeDoux's model demonstrated how specific neural circuits could give rise to different types of emotional processing.

12. Modern dual-process theories

Contemporary dual-process theory is a term encompassing several models.

These models differ in how they answer the following questions:

(1) What situational and contextual factors influence the mode type to be initiated?

(2) How do the modes cooperate with each other? Can they work together, or does one of them dominate the other in certain situations?

In other words, the discussion reviewed below agrees that the two types of processes differ in pace and demand on cognitive resources. The critical

debate is about how people know whether to use one or the other to solve a problem. In our opinion, this debate is often overlooked by people discussing dual-process theories when trying to situate their own studies within the dual-process framework.

Let us look at the following reasoning problem.

Premise 1: All flowers need water. *Premise 2*: All roses need water. *Therefore*: All roses are flowers.

Although at first glance it may seem logically correct, it is not. The reasoning is based on a flawed syllogistic mode:

Every P is M; Every S is M; therefore: Every S is P

To illustrate the error, consider the following reasoning:

Premise 1: All dogs are mammals. *Premise 2*: All cats are mammals. *Therefore*: All cats are dogs.

The reasoning is based on the same flawed syllogism as the previous one, but this time it leads to an evidently false conclusion.

Stanovich (2009) argues that correctly solving a syllogism requires the decoupling operation, which is a prime example of reflective thinking. Decoupling involves replacing real-world components with abstract concepts to "purify" the problem into a purely mathematical or logical form, rather than a factual, social, or moral one. This capability is uniquely human and is not found in any other animals, including primates.

Evans, Barston, and Pollard (1983) presented participants with problems like those about roses being flowers and asked them to evaluate whether the conclusion (the "therefore" statement) logically follows from the premises (the first two sentences). The authors discovered that the people's ability to assess logical validity is influenced by how believable the conclusion seems. In other words, people scrutinize the logical structure when they find the conclusion unbelievable, but readily accept believable conclusions without much inspection. This phenomenon is called a belief bias. It makes the foundation for what we know as the dual-process theory.

The believability of a conclusion is swiftly available to people, in other words a gut feeling. However, determining the logical validity of an argument requires mental effort - we need to construct a mental representation of the syllogism's structure, search for counterexamples, or apply our knowledge of logic. This difference indicates that people have two thinking systems. The dual-process theory of cognition describes two distinct mental systems: a fast, intuitive mechanism for everyday decisions, like recognizing roses as flowers (System 1), and a slower, more careful system for complex reasoning, such as evaluating logical rules like judging whether a given syllogism is valid (System 2). The mind must efficiently decide which system to use. Using both systems for every task would waste energy. The quick system exists to save time and effort on simple matters; it would be unneces-

sary if it always worked alongside the more thoughtful system. Based on these ideas, the first model of dual-process theory suggested a step-by-step approach: the intuitive system activates automatically when it encounters a relevant situation. If this system can't solve the problem, the more deliberate system takes over. This model helps explain why people tend to think more deeply when faced with surprising or hard-to-believe conclusions. Such instances represent cases where System 1 processing proved insufficient to accept the conclusion as valid (Evans et al., 1983).

Researchers soon realized this model was too simple. They noted that people also think deeply about their strong intuitions, not just counterintuitive ideas. A bigger problem emerged on how we decide when to use deeper thinking. The System 1 cannot do this, since it is the one creating the initial thoughts. The slower, analytical System 2 is not capable of this either, because something needs to trigger it first. This creates a puzzle about how we choose when to think more carefully.

Following Evans's et al. (1983) introduction of the sequential belief bias model, cognitive psychology gradually moved towards more complex, parallel models of dual-process theory. These new models aimed to explain higher-order thinking more comprehensively. In this updated view, both fast and slow thinking processes can operate simultaneously, rather than one after the other. A significant contribution to this shift came from Steven Sloman's (1996) paper, "The empirical case for two systems of reasoning." According to Sloman, the associative system operates on similarity and contiguity, processing information quickly and automatically, while the rule-based system follows logical rules and abstract relations, operating more slowly and deliberately.

Researchers began to explore how these two systems might operate simultaneously in syllogistic reasoning tasks. Klauer, Musch, and Naumer's (2000) study on belief bias in syllogistic reasoning also confirmed that logical analysis and belief-based responses might be processed in parallel. They suggested that the final response in a reasoning task could be a weighted combination of outputs from both processes.

In models of parallel reasoning, the resolution of system conflict is a key focus. Intuitive (System 1) and analytical (System 2) processes operate simultaneously when a person encounters a reasoning problem. The conflict arises when these systems produce divergent outputs. The resolution mechanism is often conceptualized as a race or competition between the two systems. The outputs of both systems are weighed against each other, with various factors influencing the resolution process. One crucial element in this process is the conflict detection mechanism.

A conflict detection mechanism monitors the outputs of both fast and slow thinking systems. When discrepancies arise, additional mental re-

sources are engaged to resolve the conflict. This process often results in longer response times and increased activity in brain areas linked to cognitive control (De Neys et al., 2008).

Experimental studies using time pressure and cognitive load challenged both parallel and sequential dual-process models, revealing complexities in human reasoning not fully explained by either approach (De Neys, 2006; Evans and Curtis-Holmes, 2005). Under time pressure, participants showed an increased belief bias, lending support to sequential models where belief-based responses dominated when analytical processing was limited. This finding aligns with the idea that quick, intuitive thinking takes precedence when time is constrained. However, the observation that some logical performance persisted even under severe time pressure is difficult to reconcile with strict sequential models. This suggests that analytical processing might not be completely shut off, even when resources are limited. The results suggested that neither parallel nor sequential models fully captured the intricacies of human reasoning, indicating the need to build hybrid models of cognitive processing.

De Neys (2006) employed a novel approach. Combining time pressure with the analysis of individual differences in cognitive capacity, he showed that even under time pressure, individuals with higher cognitive capacity exhibited less belief bias. For sequential models, it was problematic to explain analytical processing occurring under tight time constraints. Parallel models struggled to account for how cognitive resources were distributed between the two systems.

A key unresolved issue for parallel models was explaining how people determine when to engage with System 2, and how to resolve conflicts when both systems produce inconsistent conclusions.

Evans (2006) outlined the key ideas of the default-interventionist approach. He proposed that quick, intuitive thinking (heuristic processes) always happened first. Slower, analytical reasoning often follows, but its main job is usually to justify our initial gut reactions. We rarely use analytical thinking to critically examine our intuitions. This view suggests that our quick judgments typically drive our thinking, with analytical reasoning playing a secondary, often supportive role.

Keith Stanovich and Richard West further refined the default-interventionist model in their research on individual differences in reasoning (Stanovich, 2009; Stanovich and West, 2008). Their studies demonstrated that while people commonly rely on intuitive processes, individuals with higher cognitive ability are more likely to engage in analytical thinking that can override erroneous intuitive responses. Hence, some people are more able or willing to use their Type 2 processes than others.

The default-interventionist model offers greater flexibility compared to sequential models. It posits that analytical processing is not a mandatory stage in every reasoning task. Rather, the engagement of analytical thinking is contingent on factors such as cognitive capacity, motivation, and task complexity.

This model also differs when compared to parallel models in a key aspect. While parallel models propose simultaneous activation and concurrent operation of intuitive and analytical processes throughout reasoning, the default-interventionist model stipulates a distinct temporal sequence. It asserts that intuitive processes are initiated first, with analytical processes potentially intervening at a later stage if necessary.

The default-interventionist model, while influential, has faced criticism from some researchers who argue it may oversimplify the complex interplay between intuitive and analytical processes. More recent work, particularly by De Neys (2006), challenges the strict separation proposed by this model. De Neys's research suggests that some form of logical processing may occur implicitly in parallel with intuitive responses. To support this claim, De Neys conducted a series of studies focusing on conflict detection in reasoning. A key experiment in this line of research (De Neys, 2006) employed a base-rate neglect task. In this experiment, participants were presented with problems that included both base-rate information (statistical probability) and stereotypical descriptions. This design allowed researchers to examine how individuals process conflicting information from statistical probabilities and intuitive stereotypes, providing insight into the potential simultaneous operation of different reasoning processes.

In the first version, called the conflict version, base-rate information conflicted with stereotypical descriptions. For example, participants read about a study involving 1000 people, consisting of 5 engineers and 995 lawyers. Participants were told that Jack was randomly selected from this group. The description stated: "Jack is 36 years old, single, and somewhat introverted. He likes to spend his free time reading science fiction and writing computer programs." Participants were then asked: What is most likely? a) Jack is an engineer, or b) Jack is a lawyer. In this case, the base rate strongly suggests that Jack is a lawyer, but the description fits the stereotype of an engineer. In contrast, the no-conflict version presented base-rate information consistent with the stereotypical description. In this version, the study sample consisted of 995 engineers and 5 lawyers.

De Neys measured reaction time and incorporated an additional task to burden participants' working memory. The research yielded several important insights. Firstly, participants consistently took longer to respond to conflict problems compared to no- conflict problems, even when they provided stereotypically incorrect answers. Notably, this extended reaction time

for conflict problems persisted even when participants were under cognitive load. Furthermore, participants with greater working memory capacity were more likely to provide correct answers only for conflict problems. These findings suggest that individuals are sensitive to the conflict between base rates and stereotypes, even when they ultimately rely on stereotypical information in their judgments.

These results suggested that people intuitively detected the conflict between base rates and stereotypes, even if they ultimately gave a biased response. This detection occurred quickly and did not require intensive analytical processing, as evidenced by its persistence under cognitive load.

This study challenged purely default-interventionist models of reasoning and provided evidence for what De Neys called "logical intuitions" (De Neys, 2012, 2014). It paved the way for new models of human reasoning by proposing that some form of logical processing occurs automatically and simultaneously with heuristic processes. A key discovery was that participants experienced increased reaction times and decreased confidence when confronted with problems where intuitive and logical answers were in conflict, compared to problems without such conflicts. This indicated a covert sensitivity to logical-intuitive conflicts, even if overt responses were biased.

Białek's (2017) study provided intriguing insights into the interplay between intuitive and analytical processing in reasoning tasks. The experiment involved a two-stage process where participants were first introduced to the base-rate task, then asked to assess the likelihood of an individual (e.g., Jack) being a lawyer or engineer on a 0-100 scale. This assessment was based on the percentage of lawyers and engineers in a sample and a description fitting the engineer stereotype. Participants also evaluated how well the description matched the stereotype.

As in previous studies, stereotypical information predominantly influenced judgments of Jack being a lawyer or an engineer, but base rates still affected the final assessment. Unexpectedly, when evaluating how well the description fit the engineer stereotype, participants reported a better fit when the sample contained more engineers.

These results challenge the default-interventionist model by demonstrating that both intuitive (stereotypical) and analytical (base-rate) information processing occur simultaneously and influence each other. Participants integrated both logical and stereotypical information, even when the task required focusing on only one aspect. This integration of information traditionally attributed to separate systems does not align with previous dual-process theory models, which assume distinct, independent processing streams.

As in previous studies, stereotypical information predominantly influenced judgments of Jack being a lawyer or an engineer, but base rates still

affected the final assessment (Thompson et al., 2011), in which participants gave two consecutive responses to the same reasoning problem. First, they were asked to give an immediate answer under time pressure, which encouraged them to rely on intuitive, heuristic-based processes. This initial idea showed that a quickly given answer did not allow for deeper reflection and more profound cognitive processing. Then, participants were given more time to reconsider and re-evaluate the problem, which encouraged a more thoughtful and analytical approach. The second phase allowed participants to potentially change their initial answer based on more thorough reasoning. In this way, researchers wanted to check how often and under what conditions participants detected conflicts between their intuitive and analytical reactions. The aim of this paradigm was to understand the interaction and competition between the two types of cognitive processes. By comparing initial and subsequent responses, one can assess the accuracy and nature of intuitive and analytical reasoning.

This comparison provides insight into how and when analytical thinking can replace intuitive judgments. De Neys et al. (2008) proposed a hybrid model of the dual- process theory that challenges the assumptions of traditional approaches, particularly the default-interventionist model. This new perspective offers a novel framework for understanding the interaction between intuitive and deliberative thinking, significantly departing from conventional models. Using the two-response paradigm, researchers have shown that participants often give logically correct answers even at the intuitive stage (Bago & De Neys, 2017; Šrol & De Neys, 2021). Similar results have been observed in other domains, such as choosing mathematically favorable options in risky choice scenarios (Voudouri et al., 2024) and basing moral judgments on outcomes (Bago & De Neys, 2019). These findings challenge the clear dichotomy between intuitive System 1 and deliberative System 2 processes presented by earlier theories. Instead, De Neys (2022) advocates for a non-exclusive approach that integrates elements of both default interventionism and parallel processing. This model suggests a more dynamic interaction between intuitive and deliberative thinking, offering a more flexible understanding of human reasoning processes.

Contrary to conventional wisdom, De Neys et al. (2008) argues that responses typically attributed to deliberative processes can often be generated intuitively. This rejection of the exclusivity principle represents a fundamental shift in our understanding of intuitive thinking capabilities. A notable example supporting this view comes from recent research by Voudouri et al. (2024) using the two-response paradigm. In this study, the intuitive response given in the first stage resulted in a more mathematically calculated choice compared to the deliberative response provided in the second stage. This

finding directly contradicts the traditional view that equates intuitive thinking with less rational decision-making.

Traditional models struggled to explain how individuals decide to transition from System 1 to System 2 processing without falling into a circular logic. De Neys et al. (2008) offers an innovative solution to this problem. He suggests that the decision to engage in deliberative thinking is based on the relative strength of competing intuitions within System 1. This eliminates the need for System 2 to monitor its own activation, resolving a long-standing conceptual issue in dual-process theories. Contrary to the serial processing assumed in default-interventionist models, De Neys et al. (2008) proposes a more dynamic interaction between System 1 and System 2. His model introduces a continuous feedback loop where deliberation modulates the strength of intuitions, which in turn influences the likelihood of further deliberation. The assumption of continuous interaction provides a more flexible description of how people reason and make decisions in real-time. De Neys's framework is consistent with research on logical intuitions, offering fresh insights into how people reason. This model challenges the traditional assumption that logical reasoning always requires slow, effortful processing.

Instead, it suggests that logically correct responses can be generated quickly and intuitively. In this new framework, the role of deliberation is reconceptualized. System 2, traditionally viewed as essential for certain types of responses, is now seen primarily as a conflict resolution mechanism. It engages, as noted by Bago and De Neys (2020), when there is high uncertainty between competing intuitions. This shift allows for a better understanding of when and why people engage in effortful thinking.

The dual-process theory turned out to be a prominent framework in moral psychology that explains how humans make moral judgments.

13. HAIDT AND GREENE'S THEORIES OF MORALITY

Let us investigate the following classic moral dilemma:

A runaway trolley is heading towards five people. You can pull a switch to divert it to another track, where it will kill one person instead. Should you pull the switch?

A trolley is about to kill five people. You're on a footbridge above the tracks, next to a large stranger. The only way to save the five people is to push the stranger off the bridge onto the tracks, stopping the trolley but killing him. Should you push the man?

The first pattern we will name the 'switch scenario', whereas the second, 'footbridge' scenario.

These two scenarios are the cornerstone of research on how people define morality. A decision never to sacrifice a person is called deontological, and is driven by a set of fixed rules such as "cause no harm." Always sacrificing the one person to save more lives is called utilitarian morality, and is guided by the comparison of costs and benefits. Here, five is larger than one, thus the moral thing to do is to sacrifice the single person. However, people are rarely consistent across the two scenarios. Instead, a decision to act in the first, but not in the second scenario, is most commonly observed.

An important point here seems to be introducing the doctrine of double effect. The doctrine of double effect is a moral principle that allows certain actions to be permissible even if they cause harm as a side effect of achieving a good outcome. This principle holds that it is acceptable for harmful side effects to occur as long as they are unintended and the harm is not the means to achieve the positive result (Foot, 1967; Quinn, 1989; Thomson, 1985). Let us consider the 'switch scenario'. In this case, the death of the one individual is an unintended side effect of saving five lives.

The action of pulling the switch is morally permissible under the doctrine of double effect because the harm (the death of one person) is not the intended outcome; it is merely a side effect of a decision aimed at achieving a greater good. As noted by Waldmann and colleagues in their 2017 study, the clarity of the causal connection between the action taken and the resulting harm is crucial in assessing the moral permissibility of the action. In moral dilemmas involving the doctrine of double effect, the type of cognitive processing engaged can influence the decision made. Type 1 processing, which is intuitive and automatic, tends to be associated with the decision not to sacrifice an individual. Type 2 processing, which is more deliberative and analytical, is more likely to lead to the decision to sacrifice one person to save others.

In the footbridge scenario, where one must physically push a person off a footbridge to their death to save five others, this scenario typically elicits a strong Type 1 response. The visceral feeling of pushing someone to their death activates immediate emotional aversion, making the action feel intuitively wrong. This often results in the decision not to sacrifice the individual on the footbridge. In contrast, the switch scenario involves pulling a lever to divert a runaway trolley onto a track where it will kill one person instead of allowing it to continue on its current path, where it would kill five people. This scenario allows for more psychological distance, which can engage Type 2 processing. Although still emotionally challenging, this deliberative approach may lead some individuals to conclude that sacrificing one person to save five is the morally preferable choice. The distinction between these two dilemmas highlights how the causal link between the action taken and the resulting harm influences moral decision-making. In the footbridge sce-

nario, the direct action of pushing someone creates a strong emotional response, while in the switch dilemma, the psychological distance allows for more analytical reasoning, potentially leading to a different decision regarding sacrifice. Dual-process theories of moral judgments (Greene, 2007, 2009; Greene & Haidt, 2002; Haidt, 2001) are most likely a sub-category of the general dual-process theory developed in the study of reasoning and decision-making but contains unique features.

The core problem is the lack of normative standards to compare participants' responses. Without these standards, we are unable to determine errors or correct answers. Instead, we can only evaluate the extent of utilitarian bias under specific experimental conditions. This bias in moral dilemmas arises from a reduced aversive reaction to harming others, rather than a genuine concern for maximizing overall well-being (Białek & Terbeck, 2016; De Neys & Bialek, 2017).

Greene's 2001 fMRI study marked a significant advancement in our understanding of moral decision-making. The research revealed that personal moral dilemmas, such as the footbridge scenario, activate brain regions associated with emotion more than impersonal dilemmas like the switch scenario. This finding helps explain the differing responses to these scenarios and led Greene to propose a dual-process theory of moral judgment. According to this theory, moral decisions arise from an interplay between fast, emotional intuitions that promote deontological responses (which prioritize individual rights) and slower, more deliberative reasoning that supports utilitarian responses (which focus on the greater good) (Greene et al., 2001).

Research by Koenigs and colleagues in 2007 demonstrated that individuals with damage to the prefrontal cortex, the brain region responsible for processing emotions, tend to make more utilitarian moral judgments. This means they are more likely to endorse actions that maximize overall welfare, even if such actions involve sacrificing one person to save several others. However, damage to the prefrontal cortex often leads to significant difficulties in daily life, particularly in social situations. This finding suggests that relying solely on rational deliberation, without the influence of emotions, may undermine our basic moral instincts. Instead of enhancing moral reasoning, the absence of emotional input might remove a crucial component necessary for making balanced moral judgments. The interplay between emotion and reason is essential; decisions based solely on cold calculation may result in outcomes that feel deeply wrong on a human level.

Jonathan Haidt (2001) developed the Social Intuitionist Model (SIM) of moral judgment, which, while not explicitly framed as a dual-process theory, shares important similarities with Greene's work. Haidt argued that moral judgments are primarily driven by quick, intuitive responses, with reasoning often serving as a post-hoc justification for these judgments. His model em-

phasizes the social nature of moral decision-making, suggesting that individuals are more likely to change their moral views through social persuasion rather than through solitary reasoning. In Haidt's view, moral judgments arise from automatic, non-conscious intuitions, while conscious reasoning is typically focused on justifying these intuitions rather than generating them.

Haidt and colleagues conducted several influential studies that support the Social Intuitionist Model of moral judgment. In one study, they presented participants with scenarios designed to elicit moral disgust, such as consensual incest between adult siblings using contraception (Haidt et al., 2000). Participants often struggled to justify their moral condemnation of these acts, a phenomenon Haidt termed "moral dumbfounding." This highlighted the primacy of intuition in moral judgments, demonstrating that individuals frequently rely on immediate emotional reactions rather than rational reasoning to form their moral views. As a result, moral reasoning often serves as a post-hoc justification for these intuitive responses.

However, one should not conclude that moral dumbfounding demonstrates the weakness of moral intuitions, as these intuitions do not always align with rational reasoning. The language of morality may simply not be expressible in terms of reasonable argumentation. This was pointed out in an essay "The Wisdom of Repugnance," by Leon R. Kass (1997, p. 20):

> In crucial cases, however, repugnance is the emotional expression of deep wisdom, beyond reason's power fully to articulate it. (...) we are suspicious of those who think that they can rationalize away our horror, say, by trying to explain the enormity of incest with arguments only about the genetic risks of inbreeding.

Kass argues that gut reactions can hold moral wisdom that logic misses. Rational arguments may overlook crucial aspects like social cohesion. This echoes Chesterton's fence principle: dismissing a tradition as useless likely can mean we haven't fully understood its purpose.

An important take on cultural variability in moral judgments was proposed by Asma (2012) regarding the trolley dilemma, which involves sacrificing one family member to save several strangers. Asma observed that only one specific group – liberal Westerners – was willing to consider sacrificing a family member based on a quantitative utilitarian calculation. This indicates that the utilitarian response associated with deliberative reasoning may not be universal and requires a particular cultural context. This cultural variability highlights the importance of considering both intuitive and reasoned responses in understanding moral psychology. Relying solely on utilitarian calculations fails to capture the full complexity of moral decision-making.

Intuitive emotional responses, shaped by cultural and social factors, play a significant role in shaping moral judgments.

Both Greene and Haidt's works laid the foundation for understanding moral decision- making by emphasizing the significant influence of quick, intuitive reactions on our moral choices, while also acknowledging the role of careful reasoning. Their ideas led to decades of research and discussion, resulting in improvements and challenges to dual- process theories in morality. These foundations have faced criticism and undergone updates over time. Recent research indicates that the distinction between intuition and deliberation in moral judgments may not be as clear-cut as previously thought. Instead, a more integrated approach, referred to as a "hybrid view," may better explain how we make moral decisions. This perspective shows that our intuitions and deliberate reasoning work together more closely than we initially assumed when evaluating right from wrong. Interestingly, two studies have challenged early sequential dual-process models of moral judgment.

Białek and De Neys (2016, 2017) created moral dilemmas that involved no-conflict scenarios, where a moral transgression would not lead to better outcomes, making the harm unjustifiable. For example, they asked participants whether it is permissible to sacrifice one person to save five (a conflict moral problem, where the sacrifice is justified by its positive outcomes), or whether it is permissible to sacrifice five people to save one person (a no-conflict problem, where the sacrifice is not justified by its outcomes). In the first scenario, sacrificing one person to save five could be considered a utilitarian response, as it maximizes the number of lives saved. However, in the second scenario, sacrificing five people to save one person cannot be justified on utilitarian grounds and would be considered a harmful action with no positive outcome. Their findings revealed that participants who chose deontological responses (i.e., those who rejected causing harm) were less confident and took longer to reflect in conflict scenarios compared to no-conflict scenarios. This pattern persisted even under cognitive load. These results suggest that deontological judgments are not completely unaware of the utilitarian aspects of the dilemmas. A more plausible explanation is that deontological and utilitarian considerations are processed simultaneously and can conflict with each other. This challenges the idea that moral judgments follow a strict sequence, where intuitive deontological responses are followed by deliberative utilitarian reasoning. Rather, it suggests that both types of considerations are processed in parallel and can influence each other.

Bago and De Neys (2019) used a two-response method, which involves having participants provide an initial intuitive judgment followed by a more reflective judgment after a brief delay, allowing researchers to study the interplay between quick emotional responses and slower deliberative reason-

ing in moral decision-making. They found that utilitarian answers given after reflection were often the same as those provided quickly, suggesting that both rule-based and outcome-based moral thinking occur intuitively. This indicates that decision-makers have access to both types of moral considerations almost immediately, followed by reflection to resolve any conflicts between them. Additionally, studies by Białek and De Neys (2017), Greene et al. (2008), and Tinghög et al. (2016) showed that adding mental strain – such as cognitive load, time pressure, or distractions – tends to reduce utilitarian judgments. Mental strain can impair cognitive resources, making it more difficult for individuals to engage in reflective thinking and favoring quicker, intuitive responses instead. This implies that reflection typically favors outcome-based morality over rule-based thinking. However, this perspective also argues that deep thought is not necessary to recognize utilitarian considerations; these considerations are already present in our quick moral intuitions.

The hybrid model suggests that both deontological and utilitarian principles can be processed intuitively. When individuals face a moral dilemma, they quickly and automatically activate multiple competing moral intuitions (De Neys, 2012). The relative strength of these intuitions determines the initial response. If one intuition is clearly stronger, it will guide the judgment without further deliberation. However, if the competing intuitions are of similar strength, this conflict prompts deliberative reasoning (often referred to as System 2) to resolve the dilemma (De Neys and Pennycook, 2019).

In this model, deliberation does not create new moral principles; rather, it helps to evaluate and compare conflicting intuitions by clarifying and weighing the underlying reasons for each (De Neys, 2022). The hybrid model maintains a distinction between intuitive and deliberative processing but rejects the idea that certain moral principles, such as utilitarianism, are inherently linked to deliberation. Instead, it emphasizes that learning and experience shape moral intuitions, suggesting that with enough exposure and practice, even complex moral principles can become automatic and intuitive.

14. NEUROIMAGING EVIDENCE

Studies using functional magnetic resonance imaging (fMRI) and other neuroimaging methods have identified distinct neural correlates associated with intuitive versus analytical thinking.

Research has shown that intuitive, heuristic-based judgments are associated with increased activity in areas such as the ventromedial prefrontal cortex, the basal ganglia, and the amygdala. These regions are involved in emotional processing, reward-based learning, and rapid, automatic decision-making.

In contrast, analytical reasoning is associated with increased activity in areas such as the dorsolateral prefrontal cortex, the anterior cingulate cortex, and the parietal cortex. These regions are involved in working memory, cognitive control, and effortful computation (Lieberman, 2007).

Research on cognitive automation demonstrated that as tasks become more practiced and automated, there is a shift in neural activity from cortical to subcortical regions, consistent with the idea that automated processes require less conscious control (Poldrack et al., 2005).

The interplay between emotion and cognition was advanced by Antonio Damasio. He proposed the somatic marker hypothesis (Damasio, 1994) where emotional processes guided decision-making through rapid, unconscious signals from the body. This theory bridges the gap between purely cognitive accounts of decision-making and those emphasizing the role of emotion.

The somatic marker hypothesis proposes that emotional experiences become linked to specific situations or outcomes. This creates "somatic markers" - bodily sensations associated with emotions - that can rapidly influence future decisions. These markers function subconsciously, producing gut feelings or intuitions that can guide behavior before conscious thought takes place. This process allows for quick decision-making based on past emotional experiences, often without the need for explicit reasoning.

15. VISCERAL INFLUENCES ON BEHAVIOR

As it was already suggested in the past, even intuitive processing encompasses some kind of mental algebra. This distinguishes it from actions that are triggered by extreme physiological urges – so-called visceral factors (Loewenstein, 1997) – as in the case of strong addiction. Schelling (1999) provides an illustrative example: a patient after stomach surgery cannot drink water – it would be lethal – but nevertheless, motivated by extreme thirst, empties the glass of water someone accidentally left on the table, and dies. This is not intuitive information processing and decision making; it is a pure biological urge. Visceral influences explain behaviors that defy intuition and reason, extending beyond System 1 and System 2. These influences stem from internal states like hunger, thirst, sexual desire, moods, emotions, pain, and drug cravings. They have a direct, often negative, hedonic impact and affect the desirability of goods and actions. The theory has two key premises: (1) immediate visceral factors strongly influencing behavior, often overshadowing other goals, and (2) individuals underestimating or ignoring future, past, or others' visceral factors. This underestimation can cause significant gaps between behavior and perceived self-interest. Visceral factors'

influence on behavior varies with intensity. At low levels, people manage them properly. At intermediate levels, impulsiveness and self-control attempts start to emerge. At high levels, these factors can overwhelm both cognition and decision-making. This explains behaviors defying intuition and reason. For example, an addict may sincerely vow to quit but fail when near the addictive substance, as it triggers a visceral override. This demonstrates how visceral influences can overpower rational intentions, leading to actions that contradict stated goals or perceived self-interest (Loewenstein, 1997).

16. IMPLICATIONS OF DUAL-PROCESS MODELS

Does it truly matter whether or not we represent the human mind as a composition of different modules? Or would it be better to adopt a simpler, uni-modal approach? Let us consider one of the alternatives to the dual- processing model of cognition: the adaptive toolbox or smart heuristics model, which is deeply rooted in evolutionary psychology and the bounded rationality paradigm (Gigerenzer, Todd & ABC Research Group, 1999; Gigerenzer & Gaissmaier, 2012). The adaptive toolbox model presumes that all reasoning is rule- based, with its core concept being ecological rationality – the idea that reasoning rules should align with the structure of information in the environment. According to this approach, there is no inherent superiority of deliberative reasoning over fast heuristic responses. In fact, simple automatic rules like "take- the-best" or "follow-the-leader" can yield superior outcomes with minimal cognitive effort. Proponents of the smart heuristics model argue that the perceived superiority of deliberative reasoning typically occurs in "small worlds" – highly controlled, artificial environments (such as laboratory experiments) with closed-ended tasks and well-defined outcomes.

The adaptive toolbox model dismisses such cognitive tests as syllogisms as artificial and unrelated to real-world goals and utilities. These small-world settings can trick individuals in ways similar to optical illusions (Kruglanski & Gigerenzer, 2011), where our evolutionarily adaptive heuristics fail. In reality, people reason and make decisions in the "large world," characterized by significant uncertainty and an overwhelming amount of information. Real-world problems are often very complex, making it hard or impossible to gather and use all the relevant information. Many real-life challenges are like NP-complete problems in math and computer science – so complex that even powerful computers can't solve them perfectly. NP-problems are complex computational challenges in computer science, easy to verify but hard to solve. Their solution time grows exponentially with problem size. Important in real- world applications, they lack efficient universal solutions.

Heuristics are smart shortcuts because they help us make good enough decisions "quickly, cheaply, and accurately" (Kruglanski and Gigerenzer, 2011, p. 454) while ignoring much of the available information. This means we can decide with little mental effort. In other words, heuristics help us balance accuracy and effort in real life, saving us from a lot of work without losing much accuracy. The recognition heuristic is a well- known example of a smart shortcut. It says that if you have to choose between two options and you only recognize one of them, you should pick the one you recognize. Supporters of smart heuristics say this strategy works well in many different areas, like guessing who will win at Wimbledon, choosing stocks to invest in, or predicting election results. This view suggests that these mental shortcuts are valuable tools for dealing with complex, information-heavy situations where finding the perfect answer isn't practical or possible.

Proponents of the adaptive toolbox also suggest that reasoning could be improved by reformulating cognitive tasks to better align with our natural processing style. To improve probability reasoning, typically considered a "System 2" task in dual-process theories, using natural frequencies can be more effective than numerical probabilities. For instance, expressing a probability as "seven out of thirty" instead of a percentage or decimal can make the information easier to process and understand. This approach aligns statistical information with the way humans naturally process quantitative data, potentially reducing errors in probability judgments.

Meanwhile, the deliberative system of reasoning, which is unique to humans, is closely associated with our developed – and also unique – culture and civilization. Stanovich (2009, 2018) rejects the argument about the artificiality of small-world environments on two grounds. First, he argues that the autonomous system of reasoning evolved to promote the survival of the species rather than the well-being of the individual. Evolutionarily adaptive behavior is not the same as rational behavior (Stanovich, 2009, p. 55). Deliberative reasoning not only corrects the potential errors of autonomous or heuristic reasoning but also can override its evolutionary purpose. For example, the invention and application of contraception – a clearly deliberate exercise in reasoning and decision-making – demonstrates this teleological override.

Second, the idea that deliberative reasoning is only superior in artificial or laboratory environments overlooks the fact that many important decisions in modern life are indeed quite "artificial" and lack direct evolutionary equivalents. Stanovich (2018, p. 812) illustrates this with the following example: "Ironically, the argument that laboratory tasks and tests are not like 'real life' is becoming less and less true. 'Life,' in fact, is becoming more like the tests! Try arguing with your health insurer about a disallowed medical procedure, for example."

Thus, the dual-process theory highlights strategic interactions, an aspect that the smart heuristics paradigm overlooks. Stanovich (2009) categorizes environments into "benign" and "hostile." Benign environments are limited to a small circle of close kin, where interactions are generally straightforward and trustworthy. In contrast, hostile environments include agents who deliberately use reflective thinking to exploit cognitive misers – those who primarily rely on automatic processing. This category encompasses practices such as advertising, scams, deception, and propaganda.

As a side note, there is another argument supporting the uniqueness and importance of the deliberative system. Evolutionary-developed heuristics can sometimes be suboptimal, even in their natural environments. A notable example is the concept of melioration or distributed choice (Herrnstein & Prelec, 1991), which involves distributing effort among different reinforcement schemes. A real-life example is alternating between pizza and sandwiches for lunch. Although pizza may be more attractive, its appeal diminishes with consecutive consumption. People often intuitively divide their consumption to equalize the marginal utility of pizza and sandwiches. However, this approach does not necessarily maximize total utility. Similar suboptimal choices have also been observed in animals' foraging patterns within their natural environments.

Stanovich's distinction between benign and hostile environments, along with the idea of the reflective system overriding evolutionary adaptive responses, clearly supports the deliberative system of reasoning as one that allows humans to, in essence, rebel against evolutionary determinism (Stanovich, 2004). However, a more balanced perspective is also possible – one that emphasizes the inherent value of the autonomous system and its occasional superiority, even in today's highly structured and artificial environments.

While deliberate reasoning allows us to creatively override hard-wired natural impulses – such as in the case of contraception – this override may not always be beneficial on a social or individual level. Some preferences are so deeply ingrained in our brains – referred to as exogenous by decision scientists – that attempting to override them can verge on self-deception. For instance, a woman might convince herself that postponing pregnancy is straightforward and feasible, only to find years later that this plan fails spectacularly (North, 2024). Research on post-choice satisfaction indicates that seemingly deliberative choices, involving reasoned comparisons between alternatives, sometimes result in dissatisfaction because the agent suppresses deeper preferences (Hsee, 1999). An illustrative example of this is the attempt to rationalize away feelings of disgust (Rozin et al., 1986). In this study, some participants, when choosing between a standard chocolate bar and a larger one shaped like dog feces, rationalized that choosing the latter

made sense. However, their post-choice satisfaction was lower compared to those who intuitively rejected the oddly-shaped snack.

Rational choice theory assumes that individuals make decisions by weighing the costs and benefits of available alternatives to maximize their preferences. A key premise is that preferences must be complete (i.e. the individual can compare any two alternatives) and transitive (if A is preferred to B, and B to C, then A is preferred to C). However, research by Rusou, Zakay, and Usher (2013) suggests that intuitive judgments, such as evaluating the attractiveness of human faces, exhibit the highest consistency when made without extensive deliberation. This consistency is measured through choice transitivity, a core concept in rational choice theory. The findings indicate that intuitive evaluations, which rely more on automatic processes, may adhere more closely to the assumptions of rational choice theory compared to judgments made through analytical reasoning. This challenges the notion that rational deliberation always leads to better decisions.

Activities involving aesthetic judgments, such as appreciating poetry, music, and fine arts, challenge the notion that careful thinking invariably improves initial gut reactions. In these domains, first impressions or intuitive responses can often be as valid or even more authentic than conclusions reached through extensive analysis. Art's primary function is to evoke strong emotions, and some critics argue that creating masterpieces often requires the artist to "suspend" rational or deliberative judgments while maintaining artistic mastery – a skill termed negative capability. Additionally, appreciating art requires a "suspension of disbelief," essentially deactivating our deliberative, decoupling processing mode. As Schelling (1999, p. 278) noted, we need our irrational-emotional mind to be deeply moved by, for instance, a tragic death of a fictional character, while our rational reflective mind reduces it to mere strings of printed characters or digits in computer memory. Research on motivated reasoning, particularly in areas tied to social identity or political beliefs, reveals a counterintuitive trend. Higher cognitive abilities can paradoxically lead to stronger biases, as individuals become more adept at justifying their pre-existing beliefs. This occurs because they're better at finding arguments that support their pre-existing views or group affiliations. In essence, greater cognitive skill can be used to more effectively rationalize preferred conclusions, especially when personal or ideological stakes are high. This challenges the assumption that increased intelligence or reasoning ability always leads to more objective or accurate judgments in emotionally charged or identity-relevant topics.

Kahan et al. (2017) conducted a study that effectively illustrated how motivated reasoning can affect even simple data interpretation tasks when the subject matter was politically charged. The researchers presented participants with a straightforward task: estimate the correlation between two vari-

ables based on presented data. The key manipulation was the context of this data. In one condition, the data was framed as showing the relationship between gun availability and violent crime rates - a topic known to be politically divisive. The study found that participants' interpretations of the same numerical data varied significantly based on their political affiliations and beliefs about gun control. People tended to interpret the data in a way that aligned with their pre- existing views on gun control, rather than objectively analyzing the numbers. This demonstrates how even individuals with strong numerical and analytical skills can misinterpret straightforward statistical information when it relates to a topic that triggers their political or ideological biases. It highlights the power of motivated reasoning, where people unconsciously process information in a way that confirms their existing beliefs, especially on contentious issues. In such a situation, having higher cognitive skills actually contributed to more biased (less accurate) evaluation of available evidence. The effect was universal, observed both for right and left-wingers in their "sensitive" domains. Mercier and Sperber's (2011) argumentative theory explains this paradox by proposing that human cognition evolved primarily for social persuasion rather than objective problem-solving. They argue that our key cognitive skill is the ability to convince others, which is crucial for forming alliances and societies. This persuasive ability does not necessarily prioritize truth. Instead, our mind functions like a skilled lawyer, generating arguments to support a position regardless of its actual validity. This theory explains why higher cognitive abilities can sometimes lead to more biased reasoning, especially on issues tied to identity or deeply held beliefs. Essentially, our reasoning capabilities evolved to win arguments and maintain social bonds, rather than to discover objective truths.

Finally, it is not at all clear that humans can find their morality only through deliberate reasoning. James G. Frazer was in fact very skeptical (1909, p. 82): "(...) superstition has rendered a great service to humanity. It has supplied multitudes with a motive, a wrong motive it is true, for right action (...) of the two evils wrong action is in itself infinitely worse than false opinion." Frazer claims morality often stems from irrational beliefs, not just reason. He sees superstitions as beneficial when they promote good behavior, valuing right actions over correct beliefs. This challenges the idea that moral codes develop purely through rational thought.

The modern theory of gene-culture coevolution and group selection also stresses the importance of taboo in primitive societies and also organized religion of so-called moralizing gods in the development of modern civilization (Henrich, 2015). It is not at all clear that we can shed off this historical heritage and replace it with pure rational deliberation without the serious harm to the well-being of the human race.

Probably the most balanced view of the two worlds was offered by economist and social thinker Friedrich A. Hayek, within his framework of spontaneous social and economic order. Hayek (1988) distinguished two main spheres in which humans function: social micro-cosmos (family or small interconnected group) and social macro-cosmos or extended order (the realm of market economy and politics). Both spheres are necessary to human flourishing, however one should not apply the rules from one sphere to the other. Applying rules from micro-cosmos to extended order will destroy it via corruption and nepotism. But applying the rules from extender order to micro-cosmos will also damage the basic fabric of society, as was the case with the totalitarian grand project (Scott, 1998). Some of Hayek's insights in fact mimic the latter arguments of proponents of dual process theory – for example, Hayek (1988) argues that market economy in general and financial markets in particular are not intuitive at all, and should not be approached instinctively – it requires effort and learning to comprehend how free markets work.

Thus, the practical implication stemming from dual process theory of cognition and accompanying notion of dual world, is that researchers, policymakers, and entrepreneurs should carefully consider which cells of 2 x 2 matrix (autonomous – deliberate x micro – macro-cosmos) to deal with. There are some environments where comprehensive policy interventions seem perfectly valid, like in the area of financial consumer protection. This is because the average citizen is poorly equipped to deal with the complexity of the financial market. But on the other hand, the policy makers should accept that some superstitions, taboos, and tribalism are unavoidable even in contemporary society and the attempt to fully eradicate them may in fact badly backfire.

17. CONCLUDING REMARKS

Throughout history, thinkers have recognized the duality of the mind, a concept that has evolved from philosophical origins to a fundamental principle in cognitive psychology. The notion of dual-mode information processing has been explored independently by various philosophers and psychologists over centuries. This concept traces back to early philosophical thought, with Plato's tripartite model of the soul and Freud's psychoanalytic framework acknowledging the multifaceted and often conflicting nature of human cognition. These early ideas laid the groundwork for more sophisticated models of dual-process cognition. The cognitive revolution in the mid-20th century introduced rigorous information processing approaches, leading to the formalization of dual-process theories. These theories categorize cognitive pro-

cessing into two distinct systems: one that operates quickly and intuitively, and another that is slower and more analytical. While the System 1 and System 2 framework proposed by Kahneman (2011) is a notable example, it is part of a broader landscape of dual-process theories that explain various psychological phenomena.

Throughout the evolution of dual-process theory, the roles of emotions, automation, and subconscious influences have become increasingly recognized and integrated into our understanding of cognition. Emotions, which were once considered separate from or even opposed to rational thought, are now understood to be essential components of both intuitive and deliberative processing. This shift acknowledges that emotional responses can significantly influence decision-making and reasoning, enhancing our comprehension of human behavior. The concept of cognitive automation has also gained prominence, illustrating how complex skills can become effortless and efficient through practice. As individuals repeatedly engage in certain tasks, these activities can transition from requiring conscious effort to becoming automatic, allowing for more efficient cognitive functioning. Additionally, the recognition of subconscious influences on thought and behavior has enriched our understanding of the interplay between different cognitive processes. Subconscious factors can shape perceptions and decisions without conscious awareness, highlighting the complexity of human cognition and the interactions between various mental systems.

As research methodologies advance, we can expect the development of more sophisticated dual-process models that better capture the complexity of human thought and behavior. One promising avenue is the hybrid view proposed by De Neys (2020), which seeks to reconcile intuitive and deliberative processes. These advancements are likely to have significant implications not only for psychology and cognitive science but also for education, decision-making, and artificial intelligence (AI) design. The application of dual-process theories to AI development represents an exciting frontier in cognitive science and AI research. Yoshua Bengio has suggested integrating both System 1-like (fast, parallel, unconscious) and System 2-like (slow, sequential, conscious) processes within AI architectures to achieve more human-like reasoning and decision-making capabilities (Bengio, 2017). This approach aims to combine the efficiency and intuitive strengths of System 1-like processes with the flexibility and abstract reasoning capabilities of System 2-like processes. Furthermore, Kelly and Barron (2022) argue that some of the best-performing algorithms in chess and Go utilize a dual-system approach, involving an initial parallel search followed by deeper reflective exploration. This underscores how dual-process theories can account for both efficiency and accuracy, allowing for flexible internal trade-offs between these two aspects in cognitive tasks. Overall, the integration of dual-process

models into various fields holds the potential to enhance our understanding and application of human-like reasoning in both cognitive science and AI. The potential integration of dual-process theories into AI development suggests the possibility of creating AI systems that can not only process information rapidly and efficiently but also engage in more complex, deliberative reasoning when needed. In this way, AI systems have potential to mirror the cognitive flexibility observed in human decision-making. This line of research could lead to significant advancements in AI capabilities and provide new insights into human cognition.

The history of dual-mode information processing theories reflects the broader evolution of our understanding of the human mind. From philosophical speculation to rigorous scientific investigation, this field of study continues to provide valuable insights into the nature of human cognition, enhancing our comprehension of how we think, feel, and make decisions in an increasingly complex world.

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ACKNOWLEDGEMENT

This research was supported by funding provided by the Program SONATA BIS 9 of the National Science Centre, Poland, Grant No. 2019/34/E/ST4/00281.