Association for Psychological Science

Current Directions in Psychological Science
1–7

DOI: 10.1177/0963721419855658
www.psychologicalscience.org/CDPS
SAGE

Logic, Fast and Slow: Advances in Dual-Process Theorizing

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Abstract

Studies on human reasoning have long established that intuitions can bias inference and lead to violations of logical norms. Popular dual-process models, which characterize thinking as an interaction between intuitive (System 1) and deliberate (System 2) thought processes, have presented an appealing explanation for this observation. According to this account, logical reasoning is traditionally considered as a prototypical example of a task that requires effortful deliberate thinking. In recent years, however, a number of findings obtained with new experimental paradigms have brought into question the traditional dual-process characterization. A key observation is that people can process logical principles in classic reasoning tasks intuitively and without deliberation. We review the paradigms and sketch how this work is leading to the development of revised dual-process models.

Keywords

dual-process theory, reasoning, decision making, bias

Sometimes a solution to a problem pops into mind instantly and effortlessly, whereas at other times, arriving at a decision takes time and effort. This simple dichotomy between a more intuitive (*System 1*) and more deliberate (*System 2*) type of thinking lies at the heart of the dual-process theories that have been prominent in the reasoning and decision-making field since the 1970s. More recently, dual-process theory has gained a broader popularity, having been featured in best-selling books (e.g., Kahneman, 2011) and applied to a wide range of fields (Evans, 2008)—from moral philosophy (Greene, 2015) to prosocial cooperation (Rand, Greene, & Nowak, 2012).

The rise and development of dual-process theory in research on human thinking can be linked to an attempt to explain the phenomenon of bias in reasoning and decision-making research (Evans, 2016; Kahneman, 2011). Decades of research have shown that people readily violate the most elementary logical, mathematical, or probabilistic rules when a task cues an intuitive response that conflicts with these principles (see Fig. 1 for illustrations). Hence, reasoners often appear to be biased by their intuitions. The broad dual-process framework represents a simple and elegant explanation for the tendency of humans to be biased: Logical and probabilistic principles, unlike simple intuitive tasks such as making stereotypical judgments or executing stimulus–response pairings, require demanding deliberate processing (e.g., Evans, 2008; Stanovich & West, 2000). Because human reasoners have a strong tendency to minimize demanding computations, they will often refrain from engaging in or completing slow, deliberate processing when mere intuitive processing has already cued a response (Evans & Stanovich, 2013; Kahneman, 2011). Consequently, most reasoners will simply stick to the intuitive response that quickly came to mind and fail to consider the logical implications. Hence, people will typically be biased because they do not detect that their intuitive hunch conflicts with logical considerations. The few reasoners who manage to give the logical response will be those who have sufficient motivation and resources to complete the

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Syllogistic-Reasoning Problem

Standard "Conflict" Version	Control "No-Conflict" Version
Premises: All flowers need water. Roses need water.	Premises: All flowers need water. Roses are flowers.
Conclusion: Roses are flowers.	Conclusion: Roses need water.
1. The conclusion follows logically.	**1. The conclusion follows logically.**
2. The conclusion does not follow logically.	2. The conclusion does not follow logically.

Rationale: The conclusion in the standard version is not logically valid. However, because the conclusion is believable (i.e., it fits with our prior beliefs), many people will nevertheless accept it. In the control version, the conclusion is both believable and logically valid. Here, our prior beliefs and logic do not conflict.

Base-Rate-Neglect Problem

Standard "Conflict" Version	Control "No-Conflict" Version
A psychologist wrote thumbnail descriptions of a sample of 1,000 participants, consisting of 995 people whose favorite drink is wine and 5 people whose favorite drink is beer. The description below was chosen at random from the 1,000 available descriptions:	A psychologist wrote thumbnail descriptions of a sample of 1,000 participants, consisting of 995 people whose favorite drink is beer and 5 people whose favorite drink is wine. The description below was chosen at random from the 1,000 available descriptions:
Ryan is 27 and lives in Virginia. He drives to work in his truck and likes to wear shirts of his favorite NFL team. He loves hanging out with his buddies.	Ryan is 27 and lives in Virginia. He drives to work in his truck and likes to wear shirts of his favorite NFL team. He loves hanging out with his buddies.
Which one of the following two statements is most likely?	Which one of the following two statements is most likely?
1. Ryan's favorite drink is wine.	1. Ryan's favorite drink is wine.
2. Ryan's favorite drink is beer.	**2. Ryan's favorite drink is beer.**

Rationale: In the standard version, intuitive beliefs based on the stereotypical description ("a truck-driving, southern NFL fan typically drinks beer") conflict with the response that is favored by the base-rate probabilities (i.e., there are far more wine drinkers in the sample). In the control version, the base-rates are switched around so that both the base-rates and description cue the same response.

Bat-and-Ball Problem

Standard "Conflict" Version	Control "No-Conflict" Version
A bat and a ball together cost $1.10.	A bat and a ball together cost $1.10.
The bat costs $1 more than the ball.	The bat costs $1.
How much does the ball cost? ___ **(5 cents)**	How much does the ball cost? ___ **(10 cents)**

Rationale: Most people readily answer "10 cents" instead of the correct "5 cents" to the standard problem because they intuitively parse the $1.10 in $1 and 10 cents. In the control version, this intuitive parsing is also mathematically correct.

Fig. 1. Illustration of classic reasoning problems. Both standard and control versions are shown. The standard versions cue an intuitive response that conflicts with the logical response (i.e., the response consistent with standard logic or probability-theory principles, highlighted in bold). In the control versions, the cued intuitive response is consistent with the logical response. NFL = National Football League.

deliberate computations and override the initially generated intuitive response (Stanovich & West, 2000).

Intuitive Logic

The idea that logical reasoning requires deliberate processing fits nicely with the common belief that following logical or mathematical rules is hard (Kahneman, 2011). However, in the last decade, numerous findings have brought into question this key assumption and indicate that people have intuitive access to logical principles in classic reasoning tasks. That is, logic does not necessarily require System 2. Here, we review the experimental paradigms that led to this discovery.

Conflict-detection paradigm

The conflict-detection paradigm was developed to test whether reasoners who are biased—that is, they opt for an intuitively cued response instead of the logical response—detect that their answer violates logical considerations (De Neys & Glumicic, 2008). Put differently, the question is whether biased reasoners show some sensitivity to their errors. To assess this, the conflict-detection paradigm presents participants with standard "conflict" versions of classic reasoning problems and newly constructed "no-conflict" control versions (as illustrated in Fig. 1). In the classic conflict versions, an intuitive association cues a response that conflicts with the logical response. In the no-conflict versions, this conflict is removed, and both the intuitive association and logical considerations point to the same conclusion. Bias and conflict sensitivity are then reflected in differences in how people process both versions. If biased reasoners do not take logical principles into account, then conflict should be irrelevant and have no impact on reasoning.

Results indicate that biased reasoners often do show conflict sensitivity. For example, biased reasoners display increased response doubt—as reflected in lower confidence and longer decision latencies—when they give a biased answer on the conflict problems (De Neys, 2012). This conflict sensitivity is also observed under time pressure and cognitive load (De Neys, 2017a). Because deliberate processing is often assumed to be more time- and cognitive-resource demanding than intuitive processing, this finding implies that conflict detection occurs without the aid of System 2. Thus, the finding that biased reasoners show logical conflict sensitivity when deliberate processing is experimentally sidelined suggests that they are processing the logical principles intuitively.

Two-response paradigm

The two-response paradigm was designed to explore the time course of intuitive and deliberate processing (Thompson, Turner, & Pennycook, 2011). In this paradigm, participants are asked to give two consecutive responses. First, they are asked to give their initial hunch and to respond as fast as possible with the first intuitive answer that comes to mind. Afterward, they are allowed to take all the time they want to reflect on the problem and generate a final response. To make sure that the initial response is generated intuitively, it has to be generated under time pressure, under cognitive load, or both (Bago & De Neys, 2017; Newman, Gibb, & Thompson, 2017). This procedure helps to minimize possible deliberation. The critical finding is that many reasoners who gave a logical final response (i.e., after deliberation was allowed) already gave this response in the initial response stage, in which they had to reason intuitively (Bago & De Neys, 2017, 2019c). Hence, logical responders do not necessarily need to deliberate to override a faulty intuition; often, their intuitive response is already logical. This further indicates that logical principles can be processed intuitively in common reasoning tasks.

Instructional-set paradigm

In traditional reasoning studies, participants are expected to reason in accordance with logical principles. Typically, they are explicitly told to disregard their intuitive beliefs. In the instructional-set paradigm, these instructions are reversed (Handley, Newstead, & Trippas, 2011). Participants are not asked to indicate which response is logically or probabilistically correct; rather, they are asked to follow their intuition and indicate whether or not the conclusion is believable. The key observation is that people are slower to answer (and less confident) in those cases in which the intuitively cued, belief-based response conflicts with logicality (Pennycook, Trippas, Handley, & Thompson, 2014; Trippas, Thompson, & Handley, 2017). These effects are present even if deliberation is minimized by forcing participants to respond as quickly as possible (Thompson, Pennycook, Trippas, & Evans, 2018). Hence, although people are not instructed to reason logically, they spontaneously seem to do so, and this interferes with their ability to make belief-based judgments.

Logic-liking paradigm

In the logic-liking paradigm (Morsanyi & Handley, 2012), participants are presented with classic reasoning problems but are not asked to solve them. They are simply asked to make seemingly trivial judgments, such as how much they like the conclusion or even how bright they perceive it to be. The task and instructions explicitly avoid any reference to logic, reasoning, or validity. Participants are told they will see a number of statements and are asked to simply indicate how much they like them or how bright they look on the screen. Quite strikingly, results show that participants implicitly discriminate valid and invalid conclusions in this task. Although not instructed to reason, participants nevertheless indicate that they like valid conclusions more than invalid ones and judge them to be brighter (Trippas, Handley, Verde, & Morsanyi, 2017).

Why do people judge a valid conclusion as more likable or brighter when they are not even expected to reason? The explanation is built on a fluency-misattribution account (Reber, Winkielman, & Schwarz, 1998): Specifically, more fluently processed information is known to give rise to positive affect. If logical validity is processed intuitively, more fluently processed valid conclusions can be expected to give rise to positive feelings (Morsanyi & Handley, 2012). The idea is that

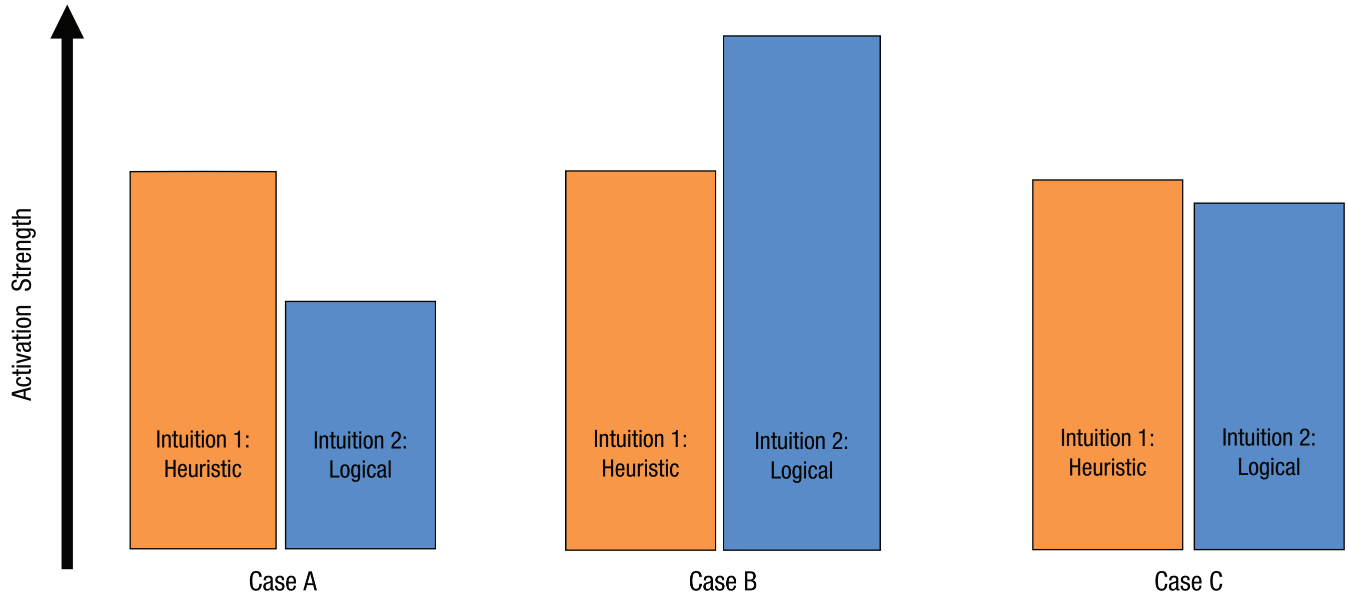

Fig. 2. Three prototypical cases illustrating a key feature of the dual-process model 2.0: that different types of intuitions will be generated that can differ in activation strength. The modal case (A) is the one in which the heuristic intuition dominates. In cases in which the logical intuition dominates (B), the logical response will be generated without further deliberation. The more similar the activation strengths (C), the more likely that the dominant intuition will be overridden via deliberation.

this affective-fluency signal is subsequently being interpreted as an increase in likability or brightness.

Irrespective of the specific fluency account, just like the instructional-set findings, the results of the liking paradigm indicate that people seem to spontaneously take logical validity into account. This further suggests that they can process elementary logical features intuitively without engaging in a deliberate reasoning process.

Toward a Dual-Process Model 2.0

The intuitive-logic findings are hard to account for in the traditional dual-process model. Various scholars have therefore claimed that it is time to move to a revised dual-process model (Ball, Thompson, & Stupple, 2017; Banks & Hope, 2014; De Neys, 2012; Handley et al., 2011; Pennycook, Fugelsang, & Koehler, 2015; Reyna, Rahimi-Golkhandan, Garavito, & Helm, 2017; Thompson et al., 2018). One central aspect of this emerging perspective is that our conception of intuitive (System 1) processing needs to be upgraded (De Neys, 2017b). Computations that were traditionally considered to require deliberate processing can also be cued intuitively. According to this view, multiple types of intuitive responses will be cued simultaneously (De Neys, 2012; Pennycook et al., 2015). For example, when we are faced with a classic reasoning problem, one of these responses will be the traditional "heuristic" intuitive response that is based on prior beliefs and other associations. But a critical second response will be what we can refer to as a "logical" intuitive response that is based on elementary knowledge of basic logical and probabilistic principles.

Crucially, different intuitions can vary in their strength or activation level (Bago & De Neys, 2017; Pennycook et al., 2015; Thompson et al., 2018). In cases in which multiple conflicting intuitive responses are cued, the strength difference will determine whether conflict is registered (the more similar the strength, the higher the likelihood of conflict detection) and whether deliberate processing will be called on (Pennycook et al., 2015). This deliberate processing can then be used to override the dominant intuitive response or to simply rationalize it and look for an explicit justification that supports it (Pennycook et al., 2015).

Figure 2 presents three illustrative cases. Obviously, the postulation of logical intuitions does not entail that people will always respond logically or that logical responding cannot be deliberate. Rather, the idea is that people have different types of intuitions—some of which are logical (accurate)—and that these intuitions can differ in strength. In some cases, the logical intuition will dominate the competing heuristic intuition (Fig. 2, Case B). Here, one can respond in accordance with logic without further deliberation. In other cases, the heuristic intuition will dominate (Fig. 2, Case A and Case C), and logical responding will therefore require deliberation. Crucially, the presence of a competing logical intuition allows people to detect conflict, which then can trigger the deliberative override of the heuristic intuition and result in a classic “slow” logical response. If the override fails, the reasoner will give the heuristic response. Any deliberate processing will be primarily used here to find an explicit justification for the dominant heuristic intuition (i.e., rationalization). Thus, even with successful conflict detection and resulting deliberation, people may still end up giving a biased answer.

Whether or not deliberate override will occur is tied to the likelihood of conflict detection. The more similar the strengths of the competing intuitions (Fig. 2, Case C), the more conflict will be experienced and the more likely that deliberation will occur. This, in turn, increases the likelihood that the dominant intuition will be overridden. Results from the two-response and conflict-detection paradigms indeed indicate that participants who show a more pronounced conflict-detection effect (e.g., as reflected in increased doubt about their initial response) are more likely to change their initial heuristic response after deliberation relative to those who are less responsive to conflict (Bago & De Neys, 2017; Thompson et al., 2011). Experimental manipulations that are aimed at increasing or decreasing the strength of logical intuitions (e.g., by making probabilities in base-rate-neglect problems, such as in Fig. 1, more or less extreme) further support this assumption (Bago & De Neys, 2019c; Pennycook et al., 2015).

A key implication of the logical-intuition findings and dual-process evolutions is that we need to rethink the traditional view on the nature of biased and logical responding. Biased responding does not necessarily result from a failure to recognize conflict. Although reasoners might not always manage to override their heuristic intuition, they are not necessarily oblivious to its questionable status. At the other end of the spectrum, sound reasoning does not necessarily require a deliberation process. Although deliberate override of an initial dominant heuristic intuition sometimes occurs, the most prolific reasoners do not always need it. This implies that good reasoners do not necessarily deliberate better; often they will simply have better intuitions (Bago & De Neys, 2019a; Thompson et al., 2018).

Outstanding Issues

Boundary conditions and individual differences

The emerging dual-process view “2.0” is a work in progress. Important challenges remain. For example, the framework does not entail that we have logical intuitions for every possible problem we face in life. Rather, the claims concern the type of elementary principles that are evoked in classic reasoning problems (De Neys, 2012). The idea is that most adult reasoners manage to automatize these principles because they have been extensively exposed to them (e.g., in the school curriculum). Moreover, how complex these principles can be is an active, open area of research (Trippas, Thompson, & Handley, 2017). Studies also point to individual differences: Although the modal biased reasoner might show conflict detection, a subgroup of individuals does not (Frey, Johnson, & De Neys, 2018; Pennycook et al., 2015). It is possible that this group has not managed to automatize the application of the necessary logical knowledge (Stanovich, 2018). Pinpointing the exact boundary conditions and individual differences remains an important challenge in the coming years.

Origin of logical intuition

The concept of logical intuition does not imply that it is inborn or instinctive. Although infants might show some early logical sensitivity (Cesana-Arlotti et al., 2018), it is assumed that people’s intuitive logical knowledge emerges from a learning process in which key principles have been practiced to automaticity (De Neys, 2012). The basic mechanism of a deliberate-to-intuitive automatization process (e.g., Shiffrin & Schneider, 1977) has long been recognized in traditional dual-process models. For example, it has long been assumed that experts in various fields are characterized by the automatization of previously deliberate procedures (Kahneman, 2011). Hence, the underlying automatization process that is assumed to give rise to logical intuitions is not new. The key insight is that it applies to a much wider range of phenomena—including mastery of basic logical principles by laypeople—than previously believed. Nevertheless, the logical automatization assumption remains to be tested directly.

What is the role of deliberation?

The case for fast, logical intuitions might seem to downplay the role of System 2 deliberation in dual-process theory. If we can generate logical responses intuitively, why do we even need to engage in effortful deliberation? The answer brings us back to the idea that different types of intuitions will be cued simultaneously. The generation of a logical intuition does not imply that it will dominate. Logical responding to the task will still require a deliberate override when the competing heuristic intuition is stronger. Furthermore, even when people have dominant logical intuitions, the fact that deliberation is not needed to override does not imply it cannot serve a different function. For example, Bago and De Neys (2019a) observed that after deliberation (in a two-response study), people had little trouble properly justifying their logical responses. Such correct justifications were much less likely for logical responses in the initial response stage. Hence, just as reasoners may use deliberation to look for a justification to support a heuristic intuition, they may need it to come up with a proper, explicit justification for their intuitive logical insight. In theory, such a process can play an important role in communication (e.g., Mercier & Sperber, 2017), but its precise nature remains to be clarified.

Generalization

We noted that the core ideas that were put forward by the original dual-process model have been applied in various fields. This led to dual-process models of, for example, prosocial cooperation (Rand et al., 2012) and moral reasoning (Greene, 2015) that became highly influential in their own right. The research reviewed here indicates that there are good reasons to question core assumptions of the traditional dual-process architecture that inspired these models. In theory, the various paradigms we introduced can be used to test dual-process assumptions beyond logical-reasoning tasks. Initial findings with the conflict-detection and two-response paradigms point to a remarkable similarity between logical and moral reasoning: The moral response that is traditionally believed to result from deliberate processing (i.e., calculating the greater good) is often cued intuitively (e.g., Bago & De Neys, 2019b; Białek & De Neys, 2017). Although this lends some credence to the generality of the findings, it will be critical to test the applicability of the new architecture in various contexts.

Conclusion

Research with new experimental paradigms indicates that logical processing can be done intuitively. We sketched how this is leading to a revision of popular dual-process-model assumptions. Although the traditional dual-process model has been highly instrumental, we believe it is time to move to a new conceptualization. We hope that the many students and scholars who are interested in the dual-process perspective will take note of the new developments and integrate them in their work.

Recommended Reading

De Neys, W. (Ed.). (2017b). (See References). A set of chapters by multiple authors that gives a detailed overview of the new experimental paradigms, evolutions, and current challenges in dual-process theorizing.

Evans, J. St. B. T., & Stanovich, K. E. (2013). (See References). A detailed overview of the traditional dual-process model, with common misconceptions and critiques.

Kahneman, D. (2011). (See References). Accessible overview of bias research and the traditional dual-process-model account.

Pennycook, G., Fugelsang, J. A., & Koehler, D. J. (2015). (See References). Prototypical example of a dual-process model 2.0.

Action Editor

Randall W. Engle served as action editor for this article.

Declaration of Conflicting Interests

The author(s) declared that there were no conflicts of interest with respect to the authorship or the publication of this article.

Funding

We acknowledge the support of a grant from the Agence Nationale de la Recherche (ANR-16-CE28-0010-01).

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