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Wim De Neys

BBS-D-22-00939_ De Neys_ Dewey

Categorizing Judgments as Likely to be Selected by Intuition or Deliberation

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Abstract: De Neys argues against the exclusivity assumption: that many judgments are exclusively selected by intuition or deliberation. But this is an excessively strong formulation of the exclusivity assumption. We should aim to develop weaker, more plausible formulations that identify which judgments are likely to be selected by intuition or deliberation. This is necessary for empirical comparisons of intuition and deliberation.

De Neys observes that dual-process theorists often assume that certain responses under certain conditions are only possible for either intuition or deliberation. For example, he points out that it's often assumed that the incorrect response to the bat-and-ball task is the result of intuition, and the correct response is the result of deliberation. If true, this would be convenient: we could compare intuition vs. deliberation just by comparing processing that results in incorrect vs. correct responses to the bat-and-ball task, respectively. But De Neys offers two arguments for why this exclusivity assumption is false: one theoretical and one empirical.

For his theoretical argument, De Neys argues that the exclusivity assumption contradicts the only plausible explanation for switching between intuition and deliberation. He explains that switching occurs when intuition detects conflict between responses and causes deliberation to intervene and resolve the conflict by selecting one of the responses. However, this contradicts the exclusivity assumption: if some responses are generated by intuition and other responses are generated by deliberation, intuition won't be able to detect conflict between intuitive and deliberative responses. So, he concludes, both responses must be generated by intuition and re-generated by deliberation.

But we must be careful to distinguish between response generation and response selection. The switching model only contradicts an exclusivity assumption about response generation—as we just noted. However, his switching model is consistent with an exclusivity assumption about response selection: even if intuition *generates* both responses and deliberation *re-generates* them, it's still possible that intuition exclusively *selects* one response and deliberation exclusively *selects* another response. So, an exclusivity assumption about response selection is theoretically coherent, but is it empirically plausible?

For his empirical argument, De Neys argues that the exclusivity assumption contradicts a growing body of evidence. He points to two-response paradigms as an example: subjects must give a first response very quickly and then are given plenty of time to reconsider and give a second response. The paradigm is designed to prevent deliberation in the first stage, isolating an intuitive response, and then to allow deliberation in the second stage, permitting a deliberative response. If intuitive responses to bias tasks are incorrect, as many assume, then the first responses should almost always be incorrect. But the evidence shows that many subjects who give the correct response on the second time gave the correct response on the first time too. This indicates that correct responses can be both intuitive and deliberative—contra the exclusivity assumption. I agree with De Neys that this evidence suggests that we're often wrong about which responses are selected by intuition vs. deliberation.

However, I think that it's critical to emphasize that we can't compare intuition and deliberation (see Section 4.2) unless we find better ways of categorizing responses as intuitive or deliberative. After all, we must classify responses as intuitive or deliberative in order to compare intuition and deliberation. For example, consider how Greene et al. (2001) looked for the neural correlates of moral intuition vs. deliberation. They had to start by categorizing moral judgments as intuitive and deliberative. This way, they could look for the neural correlates of intuitive and deliberative judgments. Then they could infer that the neural correlates of intuitive judgments were neural correlates for moral intuition itself and likewise for moral deliberation itself.

To be clear, I don't believe that Greene et al. (2001) correctly identified which moral judgments were intuitive and deliberative (see Kahane, 2012; Kahane et al., 2012). My point is only that they had to categorize moral judgments as intuitive and deliberative to identify the neural correlates of moral intuition and deliberation. Unless we're prepared to offer a better notion of exclusivity, though, it's unclear how else we could compare the neural basis for intuition or deliberation—or make any other comparison between them. So, I recommend that we should aim to develop weaker formulations of the exclusivity assumption: we should (a) only categorize responses as *more likely* to be selected by intuition or deliberation, (b) find more reliable ways of classifying responses as probably-intuitive and probably-deliberative, and (c) be careful to validate whether responses really are more likely to be selected by intuition or deliberation.

I believe that De Neys has made a valuable contribution here by calling attention to the exclusivity assumption and rejecting its strongest formulation. But the correct response, I think, is to calibrate our exclusivity assumptions more carefully. I've tried to do this in recent work, where I develop a weaker formulation of the exclusivity assumption that draws on switching models, like the one that De Neys offers here (Dewey, 2022). It claims that (a) conditions that impair metacognitive heuristics (e.g., that decrease the salience of the correct response) result in responses that are *most* likely to be intuitive and (b) conditions that improve metacognitive heuristics (e.g., that increase the salience of the correct response) result in responses that are *most* likely to be deliberative. Of course, I don't mean to be defending my account here: I'm just pointing to it as an example for how to formulate weaker exclusivity assumptions that avoid the issues that De Neys raises here.

Finally, this paper highlights a shift in the psychology of thinking and reasoning. Traditionally, single- and dual-process theorists mostly cared about how to compare intuition and deliberation. But these questions have fallen out of vogue after years of intractable debates between single- and dual-process theorists. Recently, the focus has shifted from comparing intuition and deliberation to the metacognitive mechanisms that switch between intuition and deliberation. But old questions about how to compare intuition and deliberation deserve answers too! De Neys does call for answers to these questions in Section 4.2, but I'd urge a more specific call: to get started, we need better formulations of the exclusivity assumption. So, I encourage the reader to read this paper as a welcome challenge from De Neys to sharpen our exclusivity assumptions so that we can get clearer on how to reliably compare intuition and deliberation.

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A View from Mindreading on Fast-and-Slow Thinking

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ABSTRACT: De Neys' incisive critique of empirical and theoretical research on the exclusivity feature underscores the depth of the challenge of explaining the interplay of fast and slow processes. We argue that a closer look at research on mindreading reveals abundant evidence for the exclusivity feature—as well as methodological and theoretical perspectives that could inform research on fast and slow thinking.

De Neys opposes the 'exclusivity feature', on which fast and slow processes are 'exclusively tied' to particular responses. De Neys explains that 'there is no solid empirical ground for the exclusivity assumption'—this is the 'fundamental problem' of the target article. However, with respect to empirical evidence, De Neys mentions mindreading only in passing. Will a closer look at mindreading give him reason to reconsider the exclusivity assumption?

Methodologically, the studies De Neys relies on mostly involve observing direct, explicit choices, as is typically the case in research on reasoning. In mindreading research, by contrast, the norm is to observe both indirect implicit and direct explicit behaviours generated by a single scenario. These include anticipatory looking and verbal responses (Clements & Perner, 1994), early mediolateral motor activity and purposive action (Zani et al., 2020), response times and choices (Edwards & Low, 2017), or curvature and initiation time of computer-mouse movements (Van der Wel et al., 2014). In Clements and Perner's seminal study, 3-year-olds correctly looked in anticipation of the belief-based action of an agent even though they gave incorrect explicit verbal predictions about where the agent will go to search for the object. The case for accepting that certain eye movements can index a fast mindreading process that is largely unchanging over development is strengthened by evidence that anticipatory looking in infants (Meristo et al., 2012) and younger and older adults (Grainger et al., 2018) show a similar pattern. Slow mindreading as indexed by verbal deliberations is scaffolded by culture, language and building of schemas and causal representations (Christiansen & Michael, 2016), and exhibits distinctive developmental trajectories.

None of this directly undermines De Neys' critique of the exclusivity feature. But a fruitful strand of developmental research relies on the method of signature limits (Carey, 2009). A signature limit of a process is a pattern of responses that the process generates which are incorrect or suboptimal (hence 'limit') and which no other process under consideration would generate (hence ‘signature’). Butterfill & Apperly (2013) argued on theoretical grounds that some fast processes for tracking others’ mental states are likely to generate incorrect predictions about beliefs involving mistakes about numerical identity. And in support of this, Low and Watts (2013) found that whilst 3-year-olds, 4-year-olds and adults show correct looking behaviour in an object-location false-belief task, the same participants showed incorrect looking behaviour in an object-identity false-belief task. The switch from processing a location false-belief task to a numerical-identity false-belief task did not influence the usual age-related improvements in participants’ explicit verbal judgements, as predicted. This is not just a hint that there is more than one process: seeing the same signature limit in adults as in infants (Edwards & Low, 2019; Fizke et al., 2017; Woo & Spelke, 2021), we infer that the fast process (and the conditions in which it occurs and the outputs it generates) does not completely overlap with the slow process (though not everyone would agree; Thompson, 2014). You cannot reject the exclusivity feature and use the method of signature limits. The view from mindreading therefore indicates that the exclusivity assumption is solidly grounded after all.

Given that the empirical basis for rejecting the exclusivity assumption is tenuous – at least in the context of mindreading research – it is important to evaluate the theoretical considerations offered by De Neys. He argues that, given the plausibility of automatization, any conclusion arrived at by a slow process could, in principle at least, also be arrived at by a fast process. However, this theoretical argument is less challenging than it first appears. Automatization tells us that any conclusion arrived at by a slow process could be arrived at by *some* fast process but not *which* fast processes could arrive at that conclusion.

Here we face a problem. A model of the interplay of fast and slow processes is needed, as De Neys argues. But De Neys’ own elegant model is unavailable because it ‘forces us to get rid of exclusivity’ (p. 24). Further, developmental evidence speaks against it. On De Neys’ model, the slow process should only be triggered if fast processes generate conflicting responses, leading to uncertainty. But consider children’s responses to a mindreading context set up by Ruffman et al. (2001). The children watched Ed acquire a false belief. They were then invited to place bets on which of two slides Ed would come down. Their bets revealed they felt no uncertainty (younger children went all in on the wrong slide). But Ruffman et al. also measured children’s anticipatory looking as Ed was about to emerge, and this measure indicated a correct prediction. We take the betting to index a slow process and the looking to index a fast process. In this case we seem to have neither conflict among fast processes nor uncertainty (although of course we cannot entirely rule this out).

Is there an alternative to De Ney's model? The key is to understand what other than conflict in fast processes might trigger (and halt) slow processes. One candidate is low cognitive fluency. In Ruffman et al.'s (2001) study, asking children to choose in which of two locations to place their bets interrupts their processing and so triggers deliberation; as they reason through the problem (Ed will go where his chocolate is), they regain cognitive fluency. Because this does not require that slow processes concerning a question are driven by fast processes generating responses to the same question, this proposal leaves room for discretion whereby individuals are free to make explicit judgements which conflict with implicit responses. Just as the developmental evidence indicates.

In sum, widening De Neys' view to consider mindreading highlights the potential of more diverse methods than commonly employed in research on reasoning, and points toward empirical and theoretical obstacles to the proposed advance. Taking a step back, though, we find ourselves on common ground with De Neys: his critique shows both that more evidence is needed and that the interplay of fast and slow processes is truly a deep problem.

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A Good Architecture for Fast and Slow Thinking, But Exclusivity is Exclusively in the Past

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Abstract: No doubt older work in the dual-process tradition overemphasized the importance and frequency of the override function, and the working model in this target article provides a useful corrective. The attempt to motivate the model using the so-called exclusivity assumption is unnecessary, because no recent dual-process model in the reasoning literature has rested strongly on this assumption.

This target article provides a valuable summary of the current state of play in dual-process theorizing and presents a working model that provides a basic architecture that incorporates most recent research. The working model has much to recommend it whether or not one endorses the historical narrative of developments in this area.

One of the prime motivations for the working model is said to be the correction of a mistaken assumption in the dual-process literature – the assumption of exclusivity. This assumption is that "traditional dual process models have typically conceived intuition and deliberation as generating unique responses such that one type of response is exclusively tied to deliberation and is assumed to be beyond the reach of the intuitive system" and it is said to be a "foundational dual process assumption." The target article omits citation of any particular dual-process theory that contained this assumption and that was published after the year 2000.

Some of us are old enough to have grown up with the dual-process theories of information processing that were so popular in the 1970s such as those of Posner and Snyder (1975) and Shiffrin and Schneider (1977), both of which made clear that information repeatedly transformed by control process operations could become automatized in (what is now called) System 1. Likewise, those of us enamored with the LaBerge and Samuels' (1974) automaticity theory of reading were captured by the idea of higher and higher levels of text structure becoming automatized with practice as a young child developed.

Certainly by the time that Stanovich and West (2000; see Stanovich, 1999) introduced the System 1/System 2 terminology into the psychology of reasoning, it was well-established that both information and strategies originally used by System 2 could also become instantiated in System 1. Stanovich (2004) made "the possibility of the higher-level goal states of the analytic system becoming installed in the more rigid and inflexible System 1 through practice" (p. 66) one of the themes of a book-length treatment of dual-process theory (see Figures 2.2 and 7.2 in that volume). Other dual-process theorists followed suit in the early part of this century (Evans, 2003).

Exclusivity as a background assumption of most theorists in reasoning had disappeared as far back as two decades ago. Has any major, influential theorist clearly defended the exclusivity assumption since 2000? There is no quote or citation to this effect in the target article. We must clarify here that our focus and expertise is solely on the reasoning literature.

To be clear, there is some inconsistency in the target article concerning the historical role of the exclusivity assumption. Late in the essay (p. 40), De Neys describes how "the basic idea that an originally deliberate response may be automatized through practice, is theoretically sound (e.g., Shiffrin & Schneider, 1977) and well-integrated in traditional dual process models (e.g., Evans &

Stanovich, 2013; Rand et al., 2012).” The citation of Shiffrin and Schneider and the phrase “well-integrated in traditional dual process models” is consistent with the history we have been describing in this commentary. In short, the field moved past the exclusivity assumption some time ago. Yet this is somewhat inconsistent with the later part of the essay when it is called a “foundational dual process assumption” that creates “paradoxes that plagued the traditional model.”

Earlier in the essay there is a puzzling attempt to finesse the conclusions we are drawing here. The target article allows that with repeated exposure any response that might initially require deliberation can become highly compiled and automatized, but claims that “whereas such a claim is uncontroversial for the alleged System 1 response in traditional dual process models…it is assumed here that it also applies to the alleged System 2 response.” This discussion is very confused by the ill-advised term “alleged System 2 response” (and likewise confused by the term “alleged deliberative response”). Response labels shouldn’t make reference to the mental state of an imaginary theorist. In a typical heuristics and biases task, two potential responses are usually pitted against one another—one normative and one non-normative. The normative response is the normative response—regardless of how it arose from a processing sequence point of view. The latter is what theories of internal processing are designed to explain.

That the automatization process included normative responses deriving from high-level mindware being repeatedly executed by System 2 processing has also been well established for a while now. Over a decade ago, when describing the domains to which Shiffrin and Schneider-type automatized learning applied, Stanovich (2009) stressed that System 1 contained high-level mindware: “decision-making principles that have been practiced to automaticity” (p. 57). These would include the probabilistic reasoning principles, such as the importance of sample size and the multiplicative probability rule, that those tutored in statistics come to think of as second nature. Indeed, some statistics instructors become unable to empathize with their students for whom the basic probability axioms are not transparent. The instructor can no longer remember when these axioms were not primary intuitions.

More so than dual-process theorists themselves, many *critics* of dual-process theory have been stuck in the past—focusing on strawman assumptions that were left by the wayside decades before (see Evans & Stanovich, 2013). The synthesis in the target article rightly focuses the field on the future. The architecture presented in the target article is motivated by both theory (De Neys & Pennycook, 2019; Evans, 2019; Stanovich, 2018) and recent empirical work (Bago & De Neys, 2017; Newman et al., 2017; Trippas et al., 2017). The author rightly points out that critical aspects of the architecture are orthogonal to the single- versus dual-process debate. It does not need to rely on a strawman motivation. It stands on its own as a valid synthesis of the state-of-play of reasoning work that uses the fast/slow distinction in whatever manner. No doubt older work in the dual-process tradition overemphasized the importance and frequency of the override function, and this target article provides a useful corrective.

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Unifying theories of reasoning and decision-making

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Abstract: De Neys offers a welcome departure from the dual-process accounts that have dominated theorizing about reasoning. However, we see little justification for retaining the distinction between intuition and deliberation. Instead, reasoning can be treated as a case of multiple-cue decision-making. Reasoning phenomena can then be explained by decision-making models that supply the processing details missing from De Neys' framework.

This provocative target article questions several key assumptions of popular dual-process models of reasoning and outlines a novel cognitive architecture for explaining the relationship between intuition and deliberation. A central argument is that a reasoner can have multiple, competing "intuitions" about the correct solution to a problem, with the activation strength of each intuition varying over time. We see this as a potentially valuable step in theory-building in the field of human reasoning, that brings the field closer to other productive areas of research in human judgment and decision-making.

We question, however, whether there is any need to retain the distinction between intuitive and deliberative processing. If we allow for multiple intuitions, some of which align with normative principles of probability or logic, there seems little need for an additional deliberative system. This is evident in the target article, where De Neys struggles to define a unique role for "deliberation". One suggestion is that deliberation involves the application of an algorithm or execution of a set of rules when solving a problem. But given that such rules can become automated with experience (Logan & Klapp, 1991), this seems like a weak definition. Another suggestion by De Neys removes deliberation from the decision-making process altogether – relegating it the role of rationalising or justifying decisions that have already been made.

As an alternative approach, we suggest that the notion of multiple "intuitions" should be re-framed in more general terms as attention to multiple cues that define alternative decision options. In this approach, reasoning in tasks like ratio bias, moral judgment or verbal syllogisms, can be captured by the same general cognitive architecture used to explain other decisions involving multiple cues or features. To illustrate the basic idea, consider planning to purchase a new car. This is likely to involve consideration of multiple cues (e.g., electric vs. petrol power source, price, manufacturer's reputation). As in the most interesting reasoning problems, these cues will often be in conflict (e.g., electric cars are more environmentally sustainable but are often more expensive). A theoretical model of decision-making in such cases needs to explain how the various cues are weighted when comparing options and how trade-offs between cues take place. In this framework, decision-making cues may vary in complexity, salience and familiarity. However, there is no need to assume discrete types of processing (e.g., intuition vs. deliberation, System 1 vs. System 2) for dealing with different cues.

A key implication is that models of multiple-cue decision making (e.g., Busemeyer & Townsend, 1993) can be applied to understand reasoning phenomena. We believe that this has many advantages. For one thing, the processing assumptions of these decision-making models have been laid out in far more detail, and been subject to more extensive empirical testing, than the architecture sketched by De Neys. For example, following the structure of popular "evidence accumulation" models of decision-making (Busemeyer & Townsend, 1993; Ratcliff, Smith, Brown & McKoon, 2016), reasoning could be thought of as a process of the dynamic accumulation of evidence relevant to each decision option (e.g., options based on absolute number vs. ratio in ratio bias problems; utilitarian vs. deontological responses in moral judgments; judging whether a verbal argument is valid or invalid). A decision is made when the evidence for a given option reaches a threshold. Unlike De Neys (2022), such models provide a principled account of how and why the "activation strength" associated with each cue changes over time (cf. Ratcliff et al., 2016). They also explain how the accumulation of evidence for each cue interacts with other components of the decision-making process such as how one sets a decision threshold and how one encodes the relevant cues.

Together these model components have the prospect of explaining many key reasoning phenomena. For example, the fact that arguments with believable conclusions are more likely to be judged as valid regardless of logical structure (Dube, Rotello & Heit, 2010), may be explained by assuming that believable arguments have a higher "start-point" for evidence accumulation than unbelievable arguments. Hence, they require less evidence to reach threshold for a "valid" response. Higher rates of endorsement of arguments based on their believability rather than validity under time pressure (Evans & Curtis-Holmes, 2005; Hayes, Stephens, Ngo & Dunn, 2018) can be explained by adjustment of the relevant decision thresholds. Evidence accumulation models are also well-equipped to explain the inconsistency we often see in individual reasoning patterns, such as shifts between utilitarian and deontological options across different moral judgments (e.g., Cushman, Young & Hauser, 2006) or shifts between a focus on the visual appearance of text as opposed to logical structure or argument plausibility in verbal reasoning (Hayes et al., 2022). Such shifts can be explained as context-driven changes in the rate of evidence accumulation for rival decision options.

To date, evidence accumulation models have most often been applied to simple perceptual decisions. However, there is good evidence that they "scale-up" to capturing the processes involved in complex decisions that more closely resemble those involved in reasoning tasks (e.g., Hawkins, Hayes & Heit, 2016; Krajbich, Bartling, Hare & Fehr, 2015; Palada et al., 2016).

In sum, the approach suggested by De Neys is a welcome departure from the dual-process accounts that have dominated recent theorizing about human reasoning. Retaining a hard distinction between intuitive and deliberative processes (regardless of whether this distinction is viewed as “qualitative” or “quantitative”), however, does little to advance our understanding. Instead, we suggest that reasoning in classic conflict tasks be treated as a special case of multiple-cue decision making. Doing so will allow us to apply powerful theoretical models that supply much of the processing detail missing from the architecture proposed by De Neys.

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Automatic Threat Processing shows Evidence of Exclusivity

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Abstract: De Neys argues against assigning exclusive capacities to automatic versus controlled processes. The Dual Implicit Process Model provides a theoretical rationale for the exclusivity of automatic threat-processing, and corresponding data provide empirical evidence of such exclusivity. De Neys' dismissal of exclusivity is premature and based on a limited sampling of psychological research.

De Neys argues that assigning exclusive capacities to automatic (i.e., intuitive, System 1) versus controlled (i.e., deliberate, System 2) processes is unsupportable in current dual-process frameworks and unsupported by evidence. Dismissing such exclusivity, however, is premature and based on a limited sampling of psychological research. In particular, the Dual Implicit Process Model (DIPM; March et al., 2018a, 2018b) details how automatic threat processing is fundamentally distinct from automatic valence-processing and deliberate processing. According to the DIPM, a neural architecture that facilitates survival evolved to preferentially process immediate survival threats relative to other negatively and positively valenced stimuli. Such preferential processing manifests as faster and stronger perceptual, physiological, and behavioral reactions to physically threatening stimuli. Due to the necessarily fast time course of those reactions, their functional utility could not be supported by deliberate (System 2) processing.

March et al. (2017) provided initial evidence of the exclusivity of automatic threat-processing based on reactions to four categories of stimulus images: threatening (e.g., snarling predators, gunmen), negative (e.g., feces, wounded animals), positive (e.g., puppies, babies), and neutral (e.g., doorknobs, cups). Three studies presented those stimuli in visual search, eye-tracking, and startle-eyeblink paradigms. Consistent with the exclusivity of automatic threat-processing, threatening stimuli (relative to the other stimuli), were detected faster, more frequent targets of initial eye-gaze, and elicited stronger startle-eyeblinks (with responses occurring between 200 and 1000 ms). March et al. (2022) provided even stronger evidence of exclusivity by suboptimally presenting those stimuli below conscious perception at 15 to 21 ms in three additional studies. Despite participants being unable to describe what was presented (based on two pilot studies), threatening stimuli (relative to the other stimuli) elicited stronger skin-conductance and startle-eyeblinks and more negative downstream evaluations. Automatic threat-processing (but neither automatic valence-processing nor deliberate processing) evoked functional responses to stimuli below conscious perception. It would be a strange argument indeed to suggest that participants deliberately reasoned skin-conductance and startle-eyeblink to vary uniquely with images of survival threats that they were unable to describe.

The DIPM provides a theoretical rationale for the exclusivity of automatic threat-processing and is empirically supported by evidence of such exclusivity. The DIPM, however, is just one example and there are others. In the arena of implicit social cognition, research indicates that automatic processes can commence immediately upon perception of a relevant object, render decisional and behavioral outputs within milliseconds, and return to baseline within a second or so, well before one might wager a guess about the price of a ball (Bargh & Ferguson, 2000; Fazio, 2007). In evaluative priming studies, a prime presented for 150 ms can facilitate categorization of a valence-congruent target, but its spreading activation effect dissipates within a second (Hermans et al., 2001). At least in this context, System 1 culminates well before any deliberative decision-making can occur, which might offer some insight into the "unequivocal threshold" problem posed by the De Neys (p. 17). In contrast, to even understand the problem posed to a participant in a ratio bias task or a CRT problem takes several seconds. By then, System 2 is likely to be already up and running. Thus, the decision processes involved in the sorts of tasks De Neys focuses on are likely to miss the very early effects of System 1. By broadening the scope of dual-process models and research paradigms considered, De Neys would have realized that exclusivity is theoretically and empirically supported.

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How Research on Persuasion can Inform Dual Process Models of Judgment

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Abstract: De Neys makes some useful points regarding dual process models, but his critique ignores highly relevant theories of judgment from the persuasion literature. These persuasion models predate and often circumvent many of the criticisms he makes of the dual process approaches he covers. Furthermore, the persuasion models anticipated some of the correctives to dual process models that he proposes.

Text:

De Neys aims to provide a broad critique of prevailing dual process and system (DP/S) models of judgment in "key fields," as well as introduce a more viable approach (see Petty & Briñol, 2008, on dual process versus system frameworks). However, his critique fails to consider theories from the persuasion literature such as the heuristic-systematic (HSM; Chaiken et al., 1989) and elaboration likelihood (ELM; Petty & Cacioppo, 1986) models that are clearly relevant and more highly cited than several of the covered DP/S approaches. Critically, the relevant persuasion models often agree with and predate the core points De Neys makes, and have already addressed some of the key challenges he poses. De Neys emphasizes how his new model is superior to prevailing DP/S models, but ironically his new model is better largely because it mimics features of the earlier persuasion models that were ignored. We illustrate our points largely using the ELM because we are intimately familiar with it, but also because there are numerous ELM studies that support our points (Briñol & Petty, 2012).

The first critique De Neys' offers of DP/S models is that they rely on *exclusivity* – the notion that fast (relatively low thought) and slow (relatively high thought) systems should yield different judgments. In contrast, the author proposes that high and low thought processes can: (1) "cue the same response" and (2) might not have "the same features." These two ideas are fundamental to the ELM which explains how and why high- and low-thought processes can result in the same outcome under some circumstances but different outcomes under others. For example, is it better for persuasion to give people 3 or 9 message arguments? The ELM holds that it depends on whether the arguments are cogent or specious and whether people are engaged in relatively high or low amounts of thinking. When thinking is high, people evaluate the merits of the arguments, but when thinking is low, they are more likely to rely on simply counting the arguments using the heuristic – the more the better. Thus, when the arguments are strong, 9 arguments produce more persuasion than 3 regardless of the amount of thinking because processing for merit and counting produce the same outcome. However, when the arguments are weak, the high and low thought processes lead to different outcomes. Under low thinking, 9 weak arguments are still more persuasive than 3 because of the quantity heuristic. But, under high thinking, 9 weak arguments are less persuasive than 3 because they produce more negative thoughts (Petty & Cacioppo, 1984).

Regarding the second point, the ELM explains that even though the persuasion outcome is the same under high and low thinking when the arguments are strong (i.e., 9 > 3), the "features" of enhanced persuasion under 9 arguments can differ because the processes that led to that superiority are different. Specifically, the evaluations induced by 9 arguments over 3 under high thinking are more likely to persist over time, resist change, and guide behavior than the very same evaluations induced via a lower thought heuristic process (Haugtvedt & Petty, 1992). Thus, although we agree with the author's insight, this notion has been evident in the ELM for a long time (for parallels in ELM-guided work on numerical anchoring, see Blankenship et al., 2008).

Another critique of DP/S models De Neys offers is that they do not explain how and when people might *switch* between low and high deliberation modes. De Neys also postulates that people always switch from low to high deliberation. In contrast, the ELM holds that people can start their processing at high elaboration. For instance, when a person initially views a particular judgment as important enough to think about carefully, there is no need to start with or generate a low deliberation response first that then has to be corrected (Petty & Cacioppo, 1990). That is, low deliberation is not assumed to be the default mode. Rather, many variables determine whether an initial judgment results from high or low deliberation or whether people shift from one mode to another (Carpenter, 2015).

To explain when people move from a low to a high deliberation mode, De Neys proposes that it stems from uncertainty about the correct output (i.e., when low and high deliberation modes produce different outcomes). When uncertainty reaches a particular threshold, people shift to high thinking and this deliberation ceases when uncertainty drops below that threshold. Although De Neys' *certainty threshold* notion is quite reasonable, we note that it parallels the earlier *sufficiency principle* from the HSM (Chaiken et al., 1989). Furthermore, according to the persuasion models, in addition to uncertainty (e.g., stemming from ambivalence; Petty et al., 2012), many other variables have been shown to motivate and/or enable enhanced deliberation (e.g., personal relevance of the judgment, responsibility for the judgmental outcome, etc.; Petty & Wegener, 1989).

Another critique is that DP/S models largely hold that the flawed (biased) outcomes occur when the output of low thinking is not corrected by high thinking. In contrast, De Neys proposes that deliberation "does not magically imply that the resulting response will be correct." Yet again, persuasion models had already proposed that the amount of thinking and the extent of bias in that thinking are orthogonal (Petty & Cacioppo, 1990; for an example about stereotyping, see Wegener et al., 2006). Thus, high thinking can sometimes lead to an even more flawed (biased) judgment than low thinking when, for example, a prime biases an initial (fast) judgment that then guides and contaminates the subsequent thinking (Petty, 2001).

In sum, although De Neys makes some reasonable points, a number of those points parallel principles previously proposed and documented in research examining relevant persuasion theories. By ignoring those frameworks, including their applications beyond the persuasion context (e.g., Petty & Briñol, 2014) and especially in judgment and decision-making domains where the criticized DP/S approaches have dominated (e.g., see Wegener et al., 2010), De Neys missed an opportunity to provide a more complete and integrative critique of DP/S models.

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Conflict paradigms cannot reveal competence

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ABSTRACT: De Neys is right to criticize the "exclusivity assumption" in dual process theories, but he misses the original sin underlying this assumption, which his working model continues to share. *Conflict paradigms*, in which experimenters measure how one cognitive process interferes (or does not interfere) with another, license few (if any) inferences about how the interfered-with process works on its own.

Imagine you want to study how people walk. If you're a dual process theorist, you would use a *conflict paradigm*. You start by shackling a big weight to your participants' ankles and testing if they can walk a lap around a track. If they fall down or give up, you conclude they must not be very good at walking. If they make it, you conclude that with enough effort and motivation, people's walking capacity can overcome their tendency to fall. Either way, you conclude that walking is effortful, requiring focused attention, motivation, and some combination of talent and training.

De Neys is rightly unhappy with this picture. To advance dual process theory, he proposes to figure out exactly how ankle weights affect walking. He reviews a wealth of evidence that complicates the picture: Some people (maybe Hafþór Björnsson) can still walk well even with the weight. If the weight is smaller, people walk better. If, instead of a weight, you attach a rope that pulls people towards the finish line (a *non-conflict paradigm*), they actually get there faster. This shows that walking and added weight do not have to produce different outcomes (De Neys: *the alleged System 2 response does not seem to be out of reach of the intuitive System 1*).

Wouldn't it be better to remove the ankle weight altogether? De Neys concedes that people do seem to be pretty good at walking without it (*nobody will disagree that educated adults can intuitively solve a problem such as "Is 9 more than 1?"*), but he thinks that dual process theories are not responsible for explaining this fact (*as any scientific theory, dual process models make their assertions within a specific application context. For the dual process model of logical reasoning, the application context concerns situations in which an intuitively cued problem solution conflicts with a logico-mathematical norm.*) As a description of dual process theories, this may be true. Still, it's fair to ask whether it should be.

Whether conflict paradigms are informative depends on what dual process theories are meant to be theories of. If they aim to explain interference itself – how and under what circumstances it appears, disappears, hinders or helps – then conflict paradigms are an excellent tool for eliciting the explanandum. But if dual process theories are theories of reasoning, then studying interference can tell us roughly as much about reasoning as shackling strongmen on a gym track can tell us about walking. If, as is typically the case, the interference is designed to impede reasoning, then conflict paradigms will create a performance limitation that necessarily underestimates reasoning competence. Nevertheless, despite their limited "application context", dual process theories make many claims about reasoning, tout court. For instance, De Neys describes how reasoning develops: *the working* *model postulates that intuitive responses primarily emerge through an automatization or learning process.* But his working model is based on evidence from different flavors of conflict and no-conflict paradigms, so the developmental claim is a non-sequitur. Evidence about how some other process does or does not interfere with reasoning cannot warrant any conclusion about how the interfered-with reasoning develops.

This is, in fact, a hard-won lesson from the history of developmental psychology. Jean Piaget (1950) famously studied children's ability to reason about number, volume, and other abstract concepts and he frequently used conflict paradigms. For example, to investigate how children thought about number, Piaget showed them two identical rows of coins across from each other. When he asked children if the rows had the same number, they correctly said "yes". But Piaget worried that children were relying on a proxy to number, the equal lengths of the rows. To test this, he created a conflicting cue. He spread one row out so it looked longer and asked the same question again. Children as old as 6 years of age consistently switched to saying "no", the rows did not have the same number. Piaget concluded that 6-year-olds could not reason about number per se without conflating it with other properties, like length or area. Just like later dual process theorists, Piaget presented his participants with a conflicting cue designed to tempt the wrong answer, showed that participants fell for it, and concluded that there was something wrong with their reasoning ability generally.

In the seven decades since, a vast body of work has shown that much younger children know much more about number than Piaget believed (see Carey, 2009; Carey & Barner, 2019). Summarizing this literature would take a book, but for present purposes it holds two critical lessons for dual process theories. First, evidence that younger children have rich numerical understanding did not come from more or better variants of conflict paradigms. It came from new tasks that were designed to eliminate both the confounds that Piaget worried about and the conflicting cues he added, to make reasoning as easy as possible given the requisite competence. Second, this new understanding emerged without anyone figuring out exactly why children fail on Piaget's conflict paradigm. It turns out there are many different ways to make that task easier (e.g. Mehler & Bever, 1967; McGarrigle & Donaldson, 1974; Rose & Blank, 1974; Samuel & Bryant, 1984), but still no comprehensive theory of exactly what makes it hard. Understanding the interference proved unnecessary for understanding the interfered-with competence.

The science of children's thinking progressed not by drilling down on conflict paradigms, but by leaving them behind. It is well past time to let the science of adults' thinking do the same. The deep, difficult question about reasoning is, and has always been, the one De Neys and other dual process theorists locate outside of the theory's scope. Discussing the conjunction fallacy, Kahneman (2011) notes in passing that it doesn't always arise. Everyone agrees that "Jane is a teacher" is more likely than "Jane is a teacher and walks to work". Kahneman even explains why: *In the absence of a competing intuition, logic prevails.* Right! Now, how does that work?

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BBS-D-22-00968_ De Neys_Osman

Using the study of reasoning to address the age of unreason

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Abstract: If we accept that societally, politically and even culturally enlightenment face some serious challenges, can we use this rethinking of theories of reasoning to address them? The aim here is to make a case for building on the work presented by De Neys as an opportunity to advance an applied reasoning research programme.

Since my critical review in 2004, and valuable critiques of others (Keren & Schul, 2009; Melnikoff & Bargh, 2018), the same question keeps getting asked, can we be sure that there are two qualitatively distinct reasoning processes? De Neys' recent answer to this is no, and because of this, De Neys shows how to handle the additional conceptual difficulty in explaining switching between the two processes.

De Neys' way out is to characterise the basics in an agnostic way that anyone other than a dual-process purist, be they a single system advocate, Bayesian, or other, might be happy. One key feature of his work is that the regulation of effort spent evaluating representations and inferences depends largely on internal (e.g. uncertainty, confidence) as well as external pressures (e.g. social interactions) to justify one's reasoning (De Neys, 2020). Dynamic-Value-Effort-based decision-making models have made similar proposals to explain moral behaviour (e.g., Osman & Wiegmann, 2017).

Where do we go from here?

What De Neys is proposing is as a new theoretical apparatus that diplomatically handles old internal factions. Can we use this as an opportunity to also rethink the study of reasoning on two other grounds: 1) what we do about normative standards? 2) How to promote the applied science of reasoning?

A feature unique to both reasoning and decision-making, is that they have at their disposal ways of benchmarking thought against normative standards, both a blessing and a curse. The research paradigms informed by how we ought to structure our thinking, and train us to do so better, is the success story. But, at the same time, we haven't gotten past the fact that we may be unfairly deferring to impossible benchmarks to assess the quality and success of an inferential process.
Maybe progress can be made if there is a more concerted interdisciplinary ambition like the one 100 years ago. In the 1890's the metaphysics club (for details see Kuklick, 2001) formed by Charles Sanders Peirce, William James, and John Dewey combined the interests of philosophy, mathematics, psychology, and linguistics. In their unified conception of language and thought viable inferences from impractical ones are sorted based on their communicative pragmatic value socially, politically and culturally, as well as internal coherence. Just as De Neys' alludes to, deliberation as we come to understand it in the current study of reasoning, is not merely epiphenomenal. Its function is to take us beyond a first pass inference to a defensible explanation that is persuasive to oneself and others; a position argued by others (Mercier, 2021). The reasoning field is already integrating insights from the psychology of persuasion, causal cognition, and linguistic pragmatism, but the next leap is to use this to agree on the normative approach to benchmark thought. We have the ingredients, but we need to agree on how to mix them.
Why is all this important?

As a field, we can capitalise on the popularised public face of reasoning, understood to be both fast and slow. But to do so, we might need to dedicate efforts to promoting the applied science of reasoning. Why? Because there is a sense that we are at a point in our history where enlightenment is taking a bruising. Equivalences are drawn between facts and feelings. The study of reasoning is crucial to addressing this, and other worrying patterns that emerging. The study of reasoning informs our understanding of how we develop sound arguments, how we identify sound arguments from bad, and how we reason from evidence. This is not only of scientific value, this is a given, the field is of value because the insights are essential in their applications to helping improve education, medicine, law, forensics, journalism, public policy, to name but a few.

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More than two intuitions

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Abstract: We consider an underdeveloped feature of De Neys's model. Decisions with multiple intuitions per option are neither trivial to explain nor rare. These decision scenarios are crucial for an assessment of the model's generalizability and adequacy. Besides monitoring absolute differences in intuition strength, the mind might add the strengths of intuitions per choice option, leading to competing and testable hypotheses.

The first stage of De Neys's model, the processing of intuitions, requires elaboration. We here respond to two of the author's key assumptions. The first assumption is that "the uncertainty parameter might focus on the absolute difference" (p. 44) between the strongest competing intuitions. The second assumption is that decision-making scenarios with more than two intuitions are "a-typical cases" (p. 45). As to the former assumption, we show, by example, that there are several different ways in which decision-makers might process more than two competing intuitions. As to the latter assumption, we argue that having multiple intuitions can be considered the norm rather than an anomaly.

For simplicity, we will only consider decisions with two choice options. Extending the author's (p. 31) example, suppose John has to choose between a cupcake and an apple for dessert. While John's first intuition (I1) favors the cupcake for its sweet taste, two other intuitions come to mind. The second intuition (I2) is the realization that an apple is tasty too, and the third intuition (I3) is that the apple is healthier than the cupcake. Like De Neys, we assume that these intuitions differ in strength. Although the cupcake is tastier (with a weight of .80) than the apple (.60), the apple's healthiness is also noteworthy (.50). We can now imagine two pathways for the intuitive response. In one pathway, the strongest intuition, I1 wins, and John decides to eat the cupcake. This is the outcome De Neys's model predicts from the monitoring of the absolute difference between the strongest competing intuitions. In the other pathway, the combined strengths of intuitions I2 and I3 override the strength of I1; John eats the apple because its acceptable tastiness and evident health benefit together trump the allure of the cupcake's sweetness (Anderson, 1981; Juslin et al., 2008).

Limited comparisons between the strengths of the strongest intuitions become less compelling as the number of intuitions favoring consumption of the apple grows, even if each additional intuition is weak. De Neys's process assumption neglects the possibility that separate but weak intuitions may amount to a strong incentive for choice. Here, the absolute difference between the two strongest intuitions has not changed as medium tastiness remains the primary intuition favoring the apple. By contrast, it is even conceivable that the absolute difference between cupcake and apple increases because the average intuition strength in favor of the apple decreases with each weak additional intuition in favor of it. Table 1 shows both possibilities of absolute difference and also the simple additive processing.

Table 1

Different processing styles of multiple intuitions in competing options

Intuitions	Cupcake	Apple
Intuition 1	.80	.60
Intuition 2	-	.50
Intuition 3	-	.10

Intuition 4	-	.10
Intuition 5	-	.10
Difference between strongest competing intuitions	.80	.60
Difference between means of competing groups of intuitions	.80	.28
Simple addition of intuitions	.80	1.40

This multiple-intuitions example is one of many non-trivial cases where individuals process multiple intuitions for competing options. At this early stage of model-building, purely theoretical exploration and thought experiments are a productive beginning. Yet, experiments and empirical research are needed to determine the conditions allowing the rise of multiple intuitions and to understand how people process them. A first step could be to test competing hypotheses about how decision-makers consolidate multiple intuitions (e.g., absolute difference vs. addition) by presenting them with combinations of intuitions that lead to different decisions depending on the assumed processing.

We recognize De Neys's call for research on cases with more than two competing intuitions, but we disagree with his emphasis. Research on cue utilization and information integration (e.g., Candolin, 2003; Cooksey, 1996; Gunes et al., 2008; Grüning et al., 2021; Plessner et al., 2009) shows that multiple intuitions are the norm in decision-making. Whereas novel situations may end in deliberation because intuitions are missing, familiar situations offer a rich range of different cues (e.g., color, availability, smell, and nutrition value) supporting the rise of multiple intuitions in the decision-maker's mind. Accordingly, we regard the question of how decision-makers process multiple competing intuitions to be pressing, especially for cases where individuals have learned new features of choice objects (e.g., that an apple also provides more energy than a cupcake and it requires less energy to be produced). Naturally, many familiar decision-making situations will be dominated by a few very strong intuitions per option. However, for these situations, too, our example above necessitates thinking about how more than two competing intuitions are consolidated. At the limit, we argue, the presence of many weak intuitions in favor of option B can overcome a single strong intuition favoring the alternative option A.

Conceptualizing decision-makers' multiple-intuitions processing as an act of adding instead of monitoring absolute difference changes the predictions about whether thoughtful reflection will occur. The view that individuals compare their strongest intuitions by assessing the absolute difference yields a clear prediction regarding the onset of deliberation: If the two strongest competing intuitions are close enough, the resulting feeling of indifference triggers the need for deliberate thinking. Adding a large number of weak intuitions to one option (i.e., the apple) should not change the outcome. Assuming additive processing, however, decision-makers with added weak intuitions in favor of the apple should come to a point of indifference about choosing the apple or the cupcake; exactly when the strong intuition about the cupcake's tastiness is matched by the composite of the apple's lower tastiness and the additional intuitions favoring it. Again, our main argument is not that addition is the more probable basic element behind intuition processing. This has to be tested. We suggest that thinking about how multiple intuitions are processed is central to predicting not only which intuitive decisions are made but also when deliberation occurs. How decision-makers process their multiple intuitions is the fundamental predictive mechanism of De Neys's model and understanding it is a key challenge for his theory.

In conclusion, we welcome De Neys presenting an intriguing and novel model of decision-making. Nevertheless, we think that one central aspect of the model, namely how decision-makers process multiple intuitions, requires more attention. Theoretical and empirical advancements in understanding this process are possible and would move De Neys's model closer to a general theory of decision-making.

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BBS-D-22-00970_ De Neys_ Zerilli

A tale of two histories: Dual-system architectures in modular perspective

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Abstract*:* I draw parallels and contrasts between dual-system and modular approaches to cognition, the latter standing to inherit the same problems De Neys identifies regarding the former. Despite these two literatures rarely coming into contact, I provide one example of how he might gain theoretical leverage on the details of his "non-exclusivity" claim by paying closer attention to the modularity debate.

The cleavage between thinking that's fast, intuitive, and stereotyped and thinking that's slow, effortful, and fluid is a defining feature of contemporary dual-system accounts. However, a parallel and largely independent tradition in cognitive science posits domain-specific cognitive systems or "modules" (Mountcastle 1957; 1978; Marr 1976; Chomsky 1980; Fodor 1983). In the canonical formulation, the existence of modules is thought to hinge on the difference between "central" and "peripheral" operations, where only the latter qualify as modular (Fodor 1983; cf. Sperber 1994; 2002; Carruthers 2006; Chomsky 2018). Peripheral systems encompass both sensory (input) and motor (output) systems, including those storing procedural knowledge and skill routines. They are characterised by a similar roster of diagnostic features as those commonly ascribed to the fast and intuitive "System 1" within dual-system accounts—in particular, a degree of informational encapsulation, automaticity, and introspective opacity. The main difference is that, with modules being domain-specific, one doesn't encounter an all-purpose "Peripheral Module," akin to System 1, that's set against the central system/"System 2." Instead, there are at least as many modules as there are input and output systems, and potentially separate modules for acquired skills (Karmiloff-Smith 1992). Furthermore, being peripheral, the operations of modules map imperfectly onto System 1 functions, with some possible overlap for skills. But even then, in dual-system accounts, the skills in question are more likely to be cognitive biases and rational heuristics—something more like intellectual habits—than perceptuo-motor and procedural skills. Perhaps ironically, the dual-system view has more in common with theories of "massive modularity," in that both view central operations as carved into stereotyped modes of functioning dependent on context (Barrett & Kurzban 2006). Both dual-system and modular theories are, in turn, distant cousins of the much older physiological division of the nervous system into the central ("voluntary") and peripheral ("autonomic"/"involuntary") nervous systems. According to the physiological classification, brain and spinal cord constitute the central nervous system, meaning that, counterintuitively, modular (peripheral) operations, being largely cortically controlled, fall under the the central nervous system, not the peripheral one.

Some philosophers have thought that if peripheral operations are "fast, cheap, and out of control" they will be less vulnerable to epistemically corrosive top-down/doxastic influences (Zeimbekis & Raftopoulos 2015; Machery 2015). Indeed, epistemic worries lay partly behind the traditional effort among modularists to show that perception isn't cognitively penetrable—that a visual module, for example, cannot access central information, such as an agent's beliefs and desires, and so operates without interference from what the agent believes or wants the world to be like (Fodor 1983; 1984). This form of informational encapsulation amounts to a more pronounced form of the System 1/System 2 distinction, albeit pitting perceptuo-motor tasks against System 2. De Neys' non-exclusivity model, for its part, predicts that System 2 responses are available to System 1, itself a highly suggestive claim that runs counter to the modularist's contention about the cognitive impenetrability of perception. For instance, De Neys speculates that "intuitive logical reasoning [c]ould serve to calculate a proxy of logical reasoning, but not actual logical reasoning." One compelling explanation for this feat is that the brain is able to execute quick, largely involuntary, and *reliable* routines by exploiting some of the same hardware—and information—that runs the slower (more deliberate) routines. If that's true, and generalises to perceptual systems, the epistemic worry would either dissolve (optimistically) or diminish (more likely), since perceptual systems would then still be fast, cheap, and out of control, and hence less vulnerable to interference from central information, despite having access to that information (i.e. being cognitively penetrable). But more importantly for De Neys (and whether or not the idea generalises to perceptual systems), it would offer De Neys a promising source of corroborating detail for his non-exclusivity framework: System 1 might generate System 2 responses efficiently and reliably because it has *access* to System 2 information! As it happens, a proposal along these lines finds support in some of the (anti)modularity literature, which suggests that perceptual systems do have access to central information.

For example, evidence of widespread neural "reuse" or "recycling" demonstrates that the neural communities subserving even our most evolutionally ancient transduction systems also subserve central systems; and it's also likely that transduction dynamics can sometimes be activated by the same domain-general nodes yielding central system dynamics (Anderson 2010; 2014; Dehaene 2005). Both findings are significant, because overlapping neural systems are likely to share information (Pessoa 2016). Further evidence that fast routines can indeed be gotten out of the elements of slower ones comes from research showing that visual processing integrates memories and prior expectations—which feature in slower, classically central, operations—implying that some perceptual processes have access to central information, despite being fast, automatic, and reflex-like (Chanes & Barrett 2016; Munton 2021). Take a simple example (based on true events):

> *Maple Syrup*: A bottle of "Hamptons Maple Syrup" on my kitchen benchtop struck me as "Hampton's Maple Syrup" for quite some time until one day I realised there was no apostrophe. In fact, for some of the time there *was* an apostophe, but it had been expertly occluded by my partner, an amateur lithographer, who gets a kick out of altering labels on household food items when he's bored.

Maple Syrup seems as good an example as any of the cognitive penetration of perceptual experience, and it's the cumulative force of multiple bouts of misremembering what I had previously seen, on top of heavily weighted priors, that plausibly accounts for it. The penetration is fast, automatic, and not readily susceptible to central revision. Crucially, it illustrates that fast and frugal dynamics can sometimes underwrite perceptual fidelity without the added requirement that perception be cognitively impenetrable—after all, there really *is* an apostrophe on bottles of Hampton's maple syrup!

Obviously De Neys can afford to be agnostic on the epistemic issues surrounding perception. But a fallout from this debate may offer just the lead he needs in gaining a tighter understanding of how his non-exclusivity proposal might work.

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Why is System 1/System 2 Switching Affectively Loaded?

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Abstract: Why are only some occasions of System 1 to System 2 switching affectively-loaded? This comment not only draws attention to this neglected phenomenon, but also shows how research in philosophy and the social and cognitive sciences sheds light on it, doing so in a ways that may help answer some of the open questions that De Neys' paper highlights.

We can begin with a question that goes unasked in De Deys' otherwise wide-ranging and insightful essay: Why is it that switching from System 1 to System 2 cognition is so often—though not always—an *affectively-loaded* experience? Here I take the affective dimension of switching to be familiar. It appears, for instance, as the feeling of unease that one experiences when an initially routine and mindless task suddenly becomes more difficult and cognitively demanding. But notice that a similar feeling is typically absent when, for instance, cognitive resources are ramped up more gradually. So why do we see this difference? This comment will not only draw attention to this neglected aspect of "system switching," but also show how research in philosophy and the social and cognitive sciences sheds light on it. The result will be greater clarity on some of the open questions that De Neys raises at the end of his paper.

Like De Neys, philosophers have recognized that dual-process theorists owe us an explanation of system switching. But these philosophers also add substance by highlighting a distinctive family of metacognitive emotions as underlying many of these System 1 to System 2 transitions. These emotions are *metacognitive* in the sense that they function to regulate one's first-order cognitive processing; they are *emotions* in the sense that they are automatically-engaged, motivationally-laden feelings. More specifically, on these philosophical accounts, metacognitive emotions are viewed as System 1 forms of cognition that use heuristics to map occasions of positive/negative value to distinctive feelings, and then use these feelings to generate an "affective alarm"—a warning that (re)directs attention and engages a distinctive suite of System 2 processing. (de Sousa 2008; Arango-Muñoz 2011; Kurth 2015, 2018a). So, returning to the earlier example, those feelings of unease are, on this metacognitive account, to be understood as automatically-engaged responses to problematic changes in one's circumstances: responses that function to warn of potential trouble and prompt higher cognitive processing to help one address the issue at hand.

Importantly, these theoretical proposals in philosophy are supported by empirical work from the social and cognitive sciences. For instance, we have research highlighting the role that *feelings of familiarity* play in the tip-of-the-tongue phenomenon (e.g., Schwartz & Metcalfe 2014). This work identifies these feelings as mechanisms that function to engage and sustain conscious mnemonic effort after heuristic-based monitoring systems have identified an instance of failed memory with partial recall (e.g., occasions where you cannot remember a person's name, but sense that it begins with a 'P'). Similar findings point to the role that *anxiety* plays in prompting deliberation in the face of difficult moral and political policy issues like affirmative action, immigration, and climate change (MacKuen et al. 2010, Valentino et al. 2008, Fernando et al. 2016). Here these feelings of worry are seen as working to flag decisions like these as being particularly difficult, thereby engaging reflection and information gathering efforts to help one work through the issue.

Crucially for our purposes, in both cases the empirical findings implicate the metacognitive role of emotion in these System 1 to System 2 transitions: we see affect acting as a System 1 *alarm*—one that both shifts our attention to the problem at hand and engages System 2 resources to help us address it. Moreover, notice as well that these two examples characterize their target phenomena as involving distinctive triggers, felt experiences, and forms of high cognitive engagement—features that suggest we have a family of distinct metacognitive emotions here, and not just a single, all purpose mechanism (Thompson 2009, Arango-Muñoz 2011, Kurth 2018b).

Here's why all this matters. First, the above examples provide us with concrete, empirically-grounded models of how central instances of System 1 to System 2 switching may operate, thus responding to De Neys' call for "further fleshed out, fine-tuned, and developed" accounts these processes (manuscript, p. 37). Second, by understanding these switching mechanisms *as emotions*, these models shed new light on some of the "deliberation issues" that De Nays flags in §4.3. For instance, given the familiar role that emotions play in *directing attention* and *sustaining effort*, we get the makings of explanations for questions about, respectively, the prioritization of deliberative effort across tasks and the amount of effort expended on a given occasion. Finally, if emotions have the alarm function suggested above, then we also get an answer to the question we started with: the reason why only some cases of System 1 to System 2 switching are affect-engaging is that only some of them are ones that our emotions have deemed to be alarm-worthy.

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"Switching" between fast and slow processes is just reward-based branching

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Abstract: Shortcuts to goals are rewarded by faster attainment and punished by more frequent failure, so selection of the various kinds— heuristics, cached sequences (habits or *macros*), gut instincts—depends on reward history just like other kinds of choice. The speeds of shortcuts lie on continua along with speeds of deliberation, and these continua have no obvious separation points.

This target article (TA) follows on De Neys' recent proposal "that trying to answer the core single vs dual process model debate is pointless for empirical scientists" so it is "time to move on" (De Neys, 2021, p. 16). What he proposes in the TA is "a more viable dual process architecture," which is "orthogonal [to] whether the difference between the two types of processing should be conceived as merely quantitative or qualitative." Nevertheless, he argues for two qualitatively different processes, perhaps characterized by the fourteen different properties he listed in the earlier article (fast, effortless, affective, automatic… vs. slow, effortful, affectless, controlled…De Neys, 2021, p. 4), which he calls here simply fast and slow. He demonstrates the flaws in dual process theories' usual assumptions: that the two processes must operate separately ("exclusivity"), and that there must be a "switch feature… by which a reasoner can decide to shift between more intuitive and deliberate processing;" but he pulls back from other authors' proposal that "we simply abandon the dual process enterprise." His refutation of the authors who have favored a single, quantitatively based decision process is just to point out that "some responses require more deliberation than others," which would not seem to require a dichotomy.

Dual process models have admittedly been popular over the years, beginning with Plato's wild versus well-behaved chariot horses. In addition to De Neys' fast versus slow examples, choice-making has been described as passionate versus reasonable, impulsive versus reflective, myopic versus far-sighted, hot versus cool, and model-free versus model-based, among others. De Neys also includes as fast the products of "automatization," by which repeated sequences of choices "will be elicited intuitively." In addition, brain imaging has found evidence for steep-discounting versus shallow-discounting brain centers (McClure et.al., 2004; van den Bos & McClure, 2013).

However, as DeNeys himself concludes, there is no operation that System 2 can perform that System 1 cannot, and "thinking always involves a continuous interaction between System 1 and System 2." Other authors have pointed out obvious problems with the dual approach: If there are distinct systems, there must be more than two of them, because the properties attributed to the two systems do not reliably occur together (Zbrodoff & Logan, 1986); in particular, automatic processes may or may not be affectively arousing (Ainslie, 2021). Furthermore, the listed properties such as effort, affect, and speed itself are themselves continua. If the two whole lists of properties really constitute discrete systems, there should be natural breaks in the continua from fast to slow, and the breaks should occur at equivalent levels in the *n* dimensions. As a negative example, the only obvious break in transparency would be too-fast-to-introspect versus not-too-fast-to-introspect, which would not define different kinds.

Most "type 1" processing in humans comprises sequences that have been automatized, macros (or habits) that call up other macros. In language, a squiggly line is interpreted as a letter, a sequence of letters is interpreted as a word, a series of words forms a concept (or cliché). All highly automatized; but if I was to find an anomaly—no, it should be "were to find an anomaly"—my ear would be quick to re-set it. This should not require a distinct system. Even if I stopped to ponder the use of the subjunctive, I would just be trying out sequences I had previously automatized. Likewise, as my calculation proceeds from 2+2 through, say 8+8, to 64+64 and so forth, at some points my mind will pause to find component automatizations; but is there a point where the pause divides two systems?

The strongest case for separate processes might be based on the activities of separate sites in the brain, but even here true separation is doubtful. The dorsolateral striatum (putamen) is differentially active when repeated connections have been cached to form macros, whereas the dorsomedial striatum (caudate) is more active during flexible behavior; but their functioning has been observed to be integrally combined (Dolan & Dayan, 2013; Keramati et.al., 2016). Similarly, the existence of separate steep and shallow reward discount centers in the brain is controversial (Kable & Glimcher 2007; Lempert et.al., 2019). If there do exist anatomically separate response-selection systems in the brain, the best candidates would be those for motivational salience and (supposedly separate) reward, governing the attraction of attention and behavioral approach/avoidance, respectively (Berridge & Robinson, 1998). But even here, salience and behavior selection are correlated with activity in mostly the same brain regions (Kim et.al, 2021); and when even threatening stimuli are voluntarily gated out, attention to them must have been weighed in the common marketplace of reward (see Ainslie, 2009).

The professed scope of the TA's model is universal, but except for its reference to cupcakes its examples are cognitive searches for correct solutions to puzzles, rather than choices among competing rewards. Accordingly, "the peak activation strength of an intuition reflects how automatized or instantiated the underlying knowledge structures are (i.e., how strongly it is tied to its eliciting stimulus)." This rather Pavlovian convention hampers the model's application to goal-directed activities. By contrast, it is feasible to model the selection of all learnable processes which can replace each other using the amount and timing of their contingent reward (Ainslie, 2017). The sources of reward—consumption goods, ethical goods, social cues, puzzle solutions, signal detections, emotions, the satisfaction of urges—as well as their speeds of onset, are miscellaneous. It should not matter that some of their subroutines involve particular parts of the brain (for instance the amygdala-- Aqino et.al., 2020—or hippocampus—Gauthier & Tank, 2018), as long as their weights are ultimately comparable to each other. Likewise, the weighing process may or may not involve a specific site, such as the orbitofrontal cortex (Bartra et.al., 2013; Levy & Glimcher, 2012), a set of interacting sites (Krönke et.al., 2020), or no identifiable dwelling place. In reward research, the adoption of millisecond-specific electroencephalography (for instance, Sambrook et.al., 2018) promises to give precise evidence about branching to fast, slow, and intermediate processes.

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BBS-D-22-00989_ De Neys_ Pennycook

Deliberation is (probably) triggered and sustained by multiple mechanisms

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Abstract: De Neys proposes that deliberation is triggered and sustained by uncertainty. I argue that there are cases where deliberation occurs with low uncertainty – such as when problems are excessively complicated and the reasoner decides against engaging in deliberation – and that there are likely multiple factors that lead to (or undermine) deliberation. Nonetheless, De Neys is correct to surface these issues.

De Neys argues – lucidly, in my view – that dual-process theories have been (largely) ill-focused. Indeed, it seems that the core aspect of any dual-process model is not simply how it describes the two types of processes (or "systems"), but rather how describes the *interaction* between the processes. To this end, De Neys proposes that *uncertainty* is the key explanatory factor that determines when "Type 2" deliberation is triggered (i.e., the "switch feature").

Although many popular dual-process models have ignored the issue, as noted by De Neys, there is nonetheless a growing body of work that has focused on understanding what triggers deliberation. If intuitive ("Type 1") processing is autonomous (i.e., it is triggered automatically from some stimulus or thought process), as myself and others have argued (e.g., Pennycook, 2017; Thompson, 2013), then deliberative processes must be triggered by some underlying cognitive factor or factors. That is, when explaining the progeny of the process, intuitive processes can be explained by simple stimulus-response pairings. However, one needs to posit additional factors that would then lead to subsequent deliberative processes.

In my past work, I have focused on the potential role of response conflict in triggering deliberation (Pennycook, 2022; Pennycook et al., 2015) – i.e., cases where the system detects a conflict between intuitive outputs lead to subsequent deliberation. The three-stage dual-process model separates the initial "intuition" stage (where processes are initiated autonomously) from the subsequent "metacognition" stage (where conflicts between outputs of Stage 1 are monitored). The presence or absence of conflict then determines the extent of deliberation in the final "reason" stage. This matches well with the sort of tasks that are common in the literature because they typically involve a salient (but incorrect) intuition that conflicts with some other relevant (and more normatively accurate) factor. However, as De Neys notes, a model that focuses solely on intuitive conflict does not help explain why deliberation occurs in the absence of intuitions.

To solve this problem, De Neys argues that general uncertainty casts a wider net and can explain both cases where conflict detection leads to deliberation but also cases where there are no apparent intuitions present. As conflict between intuitions leads to uncertainty, so to does a lack of clear answer. There is a lot to like about this proposal; however, I am hesitant to adopt uncertainty as the key explanatory factor.

One possibility is that "uncertainty" is merely correlated with the underlying causal feature (or features) that trigger deliberation. Indeed, there may be cases when uncertainty is high but deliberation is low. For example, when an individual is facing a problem that is prohibitively complicated they surely have a feeling of high uncertainty – nonetheless, the individual may decide to *not* engage in deliberation and to simply not bother attempting a solution (and, indeed, people do tend to prefer tasks that require less cognitive effort; Chong et al., 2016; Shenhav et al., 2017). Hence, in such a scenario uncertainty would not lead to deliberation.

De Neys has offered a strong framework for understanding how Type 1 outputs contribute to the engagement of subsequent deliberation. He even mentions a similar case where deliberation does not lead to an answer and the individual decides to stop deliberating. This is accommodating by noting that opportunity cost could be factored into the uncertainty parameter. However, one may question at that point whether deliberation is prompted by several separate mechanisms and that uncertainty is just a reasonable proxy for many of them.

This issue is related to recent work in the cognitive control literature that has investigated what might lead individuals to engage in effortful processing across situations. For example, the expected-value-of-control model posits that people weigh the costs and benefits of exerting mental effort (Shenhav et al., 2013, 2021). Of course, it may be that this calculation only occurs after deliberative processes have been initiated by some other process and therefore that costs/benefits play a role in how much deliberation occurs, not whether it is triggered in the first place. Nonetheless, if one takes the view that dual-processes can be considered as opposite poles of a single continuum (as opposed to two fundamentally separate processes; De Neys, 2020), then the expected value of control is a factor that may play a role in whether *substantive* deliberation occurs. This is noted by De Neys but the implications for the focus on uncertainty is not addressed.

Relatedly, a great deal of research has focused on apparent individual differences in the willingness to engage in deliberation (see Pennycook, 2022 for a review). If one were to focus solely on uncertainty as the factor that triggers deliberation, this would presume that individual differences in uncertainty-related processes (e.g., sensitivity to uncertainty) would be central. However, individual differences in deliberation tend to focus on whether people are willing to engage in cognitive effort (e.g., in the "Need for Cognition" scale; Petty et al., 2009) or in the willingness to question one's intuitions and prior beliefs (e.g., in the "Actively Open-minded Thinking" scale; Pennycook et al., 2020). Here too, the key factors that explain whether people engage in a meaningful level of deliberation may not be explained very well by appealing to uncertainty.

To conclude, I agree wholeheartedly with De Neys' argument that the underlying assumptions of many dual-process theories are poorly conceived – particularly as it related to the exclusivity feature. However, I am less convinced that deliberation can be explained by a single underlying causal mechanism. It seems likely to me that there are multiple separate mechanisms that are relevant for understanding why deliberation occurs. In any case, even if I am uncertain about using uncertainty as a key mechanism in dual-process models, I am nonetheless convinced that De Neys' proposal is certainly a step forward.

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BBS-D-22-00990_ De Neys_ Kołeczek & Sekerdej

Switching between System 1 and System 2: The nature of competing intuitions and the role of disfluency

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ABSTRACT: The commentary identifies two problems concerning the switch mechanism: the model explains too few instances of switching, and the switching mechanism itself seems fallible. The improvements we suggest are to clarify the nature of the competing intuitions as the initial intuition and its negation or alternative ways to solve the problem, and to incorporate cognitive disfluency into the switching mechanism.

While we agree that the proposed model is innovative and coherent, and that it undoubtedly contributes to the field, its further development may require addressing two problems regarding the switching mechanism. The first problem is that the model explains switching only in a particular type of situation: when two or more competing intuitions are available for System 1, or there are no intuitions at all. The model, however, does not explain the spontaneous activation of System 2 in situations when the "alleged System 1 response" is automatic, but the "alleged System 2 response" cannot be available for System 1 without System 2 activation because it *must* be first produced by the deliberation or calculation of System 2. For example, in the commonly-known CRT bat and ball task, the answer "$0.10" can be available to System 1 because $1.10 - $1.00 is a very easy equation that gets calculated automatically. However, to find the correct answer, more complex calculations are required: finding x if a) $x + y = \$1.10$ and b) $y = \$1.00 + x$. It is unlikely that this response can be automatically available to System 1.

De Neys' answer to this problem is the non-exclusivity assumption and the idea that System 1 can produce the correct answer itself. However, if System 1 can conduct such complex operations as the calculations presented above, then why do we even need System 2? De Neys further proposes that the correct intuition may be available to System 1, not thanks to its ability to conduct the calculations, but due to previous exposure to this riddle (or similar riddles) and learning the correct answer. However, by applying such reasoning, the model still does not explain switching when one encounters a completely new problem that requires calculating the correct answer first. It does not even explain switching in the case of a well-known problem presented with different numbers (even if the schema of a riddle is the same, but the numbers are changed, the response still needs to be calculated from scratch). Therefore, non-exclusivity does not fully resolve the problem of switching paradoxes.

Moreover, the proposed switching mechanism does not explain various manipulations that trigger System 2. For example, System 2 deliberation may be turned on by priming (Gervais & Norenzayan, 2012), presenting questions in a way that makes them difficult to read (Alter, Oppenheimer, Epley, & Eyre, 2007; Song & Schwarz, 2008), asking participants to frown during the study (Alter et al., 2007), explicitly asking participants to deliberate on the questions before answering, and other interventions (see Horstmann, Hausmann, & Ryf, 2009 for an overview). None of these effects can be explained by means of the proposed model.

The second problem is that the switching mechanism seems not to work in a considerable number of situations. First, a similar activation of competing intuitions should trigger System 2, but this does not always happen. For example, in logical riddles (e.g., syllogisms, base-rate problems) or moral dilemmas, we simultaneously present several alternative answers from which the participant may choose. Therefore, all alternatives should be equally strongly activated and trigger System 2. However, an explicit presentation of alternative responses does not make people more reflective or may even enhance more intuitive processing (Sirota & Juanchich, 2018).

Furthermore, the proposed feedback loop seems fallible. If System 2 deliberation leads to choosing an answer, then it should decrease the relative activation of the rejected intuition. For example, when one solves base-rate problems or assesses probability or randomness (e.g., what is more probable, six heads in a row or head-tail-tail-head-tail-head), deliberation lets them use the probability distributions to find the right answer. However, even though deliberation and formal knowledge allow giving the correct answer with high certainty, the "homunculus" keeps jumping and shouting the intuitive response (Gould, 1992, p. 469; see also Kahneman, 2011 and Thompson, 2009 for discussions on the subjective feeling that the intuitive answer is correct). This suggests that the relative activation of the initial, intuitive response is still very high.

The solution to these problems is either to clarify the nature of competing intuitions or to propose a more all-encompassing switching trigger. Regarding the first possibility, the competing intuitions should not be pictured as alternative responses (p vs q) but rather as either an intuitive response and its negation (p vs not-p) or as two alternative ways of solving the problem (e.g., the simple equation $1.10 - $1.00 vs applying formal algebra). With competing intuitions defined this way, the non-exclusivity assumption holds: System 1 is still able to generate the alternative intuition. It is impossible for System 1 to have access to certain responses (e.g., based on advanced calculations), but it may have intuitions that the initial response is incorrect (i.e., not-p intuition) or that there are different ways to approach the problem. To put it differently, it is impossible for System 1 to do complex calculations, however, people can still automatise the reaction of suspiciousness in response to logical riddles or the belief that it is better to rely on formal algebra than on a gut feeling.

Nevertheless, even after clarifying the nature of intuitions, the model still does not explain why manipulations such as priming, frowning, explicit instructions, or difficult-to-read font trigger System 2. Therefore, we suggest the incorporation of a more universal switching mechanism into the model. It is not a new idea to identify processing disfluency as the ultimate intuitive trigger of System 2 (e.g., Alter et al., 2007; Thompson, 2009). The general idea behind disfluency is that System 2 is activated if processing within System 1 does not go smoothly. Including a disfluency-triggered switch does not rule out the possibility of the switching being caused by uncertainty, as disfluency should lead to uncertainty (Gill, Swann Jr, & Silvera, 1998). However, this modification will allow the model to explain a wider range of phenomena: Disfluency may be caused by difficult-to-read font, the instruction to think twice before answering, a lack of faith in the intuitive answer, etc.

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BBS-D-22-00991_ De Neys_ De Houwer et al.

What is intuiting and deliberating? A functional-cognitive perspective.

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ABSTRACT: We applaud De Neys for drawing attention to the interaction between intuiting and deliberating without committing to single or dual process models. It remains unclear, however, how he conceptualizes the distinction between intuiting and deliberating. We propose several levels at which the distinction can be made and discuss the merits of defining intuiting and deliberating as different types of behavior.

The idea of two distinct types of thinking has been highly influential within psychology and beyond. De Neys (this issue) refers to these types of thinking as intuiting and deliberating and identifies core aspects of the interaction between both. In doing so, he provides a valuable contribution to the literature.

It remains unclear, however, how the distinction between intuiting and deliberating itself should be conceptualized. There are at least three levels of analysis at which the distinction can be made: (1) at the descriptive level in terms of subjective experience (i.e., the experience of intuiting and deliberating); (2) at the functional level in terms of the environmental conditions under which thinking occurs (e.g., whether it requires time or the absence of other tasks); (3) at the mental level in terms of mental mechanisms and the mental representations on which they operate (e.g., associative or propositional representations).

Like others before him (e.g., Kahneman, 2011), De Neys draws the distinction in terms of speed and effort: whereas intuiting is used to refer to fast and effortless thinking, deliberating refers to slow and effortful thinking. It is not entirely clear whether speed and effort are conceptualized at the descriptive level (i.e., a subjective experience) or at the functional level (e.g., actual time required; interference by other tasks) but De Neys does not seem to situate the distinction at the mental level. For instance, he argues that "both single and dual process theories focus on the interaction between intuition and deliberation" and that his "criticism and recommendations equally apply to single and dual process models" (p. 7). Assuming that the distinction between single and dual process models is situated at the mental level, these arguments suggest that the distinction between intuiting and deliberating needs to be made at another level than the mental one.

We definitely agree that there are many benefits to separating to-be-explained phenomena (such as intuiting and deliberating) from explanatory mental mechanisms (e.g., spreading of activation; propositional reasoning; see Hempel, 1970; Hughes et al., 2016). However, in his target paper, De Neys does so in a manner that is not entirely coherent. Most importantly, he allows for the concept of low effort deliberation. If deliberation is by definition effortful (either descriptively or functionally), then how can it be effortless? In our opinion, the idea of low effort deliberation makes sense only if deliberation is situated at the mental level, for instance, when postulating a single process theory in which all deliberating involves the manipulation of propositional representations (i.e., propositional reasoning). Hence, by allowing for the idea of low effort deliberation, De Neys seems to implicitly conceptualize deliberation at the mental level. We encourage him to be more explicit about how exactly he draws the distinction between intuiting and deliberating, most importantly, with regard to the level of analysis at which this distinction is situated.

In the remainder of this commentary, we discuss two ideas for clarifying the nature of intuiting and deliberating that, in our opinion, have not yet been given sufficient consideration in the literature. First, when delineating intuiting and deliberating, we see merit in taking seriously the descriptive level. In recent years, important progress has been made in studying a variety of subjective experiences such as the experience of confidence (e.g., Desender et al., 2018), sense of agency (Marcel, 2003), conflict (e.g., Desender et al., 2014), making an effort (e.g., Naccache et al., 2005), and the urge to err (e.g. Questienne et al., 2018). We believe it would be interesting and feasible to study also the experience of intuiting and deliberating. This approach would draw attention away from the ontological and most likely unproductive debates about what is the "true" nature of intuiting and deliberating. It would also allow researchers to document the conditions under which people report intuiting and deliberating, as well as the possible differences in decisions produced under these conditions (i.e., to conduct functional research on intuiting and deliberating as descriptive phenomena). Finally, knowledge about these conditions and differences would help constrains theories about the mental mechanisms that produce the subjective experience of intuiting and deliberating.

Second, clarifying the nature of intuiting and deliberating not only requires specifying how they differ but also what they have in common. Both are typically thought of as instances of thinking but what is thinking? Here we see merit in conceptualizing thinking as a type of behavior (De Houwer, 2022; De Houwer et al., 2018). Functional psychologists have successfully explored the benefits of this approach with regards to a variety of cognitive activities such as perceiving (e.g., Skinner, 1963), memorizing (e.g., Guinther & Dougher, 2014), and learning (De Houwer & Hughes, 2020, in press). Conceiving of intuiting and deliberating as behavioral phenomena allows one to distinguish them at the descriptive level (i.e., as different subjective experiences; see De Houwer, 2022) or at the functional level (e.g., as relational responding in a slow or fast manner; see De Houwer et al., 2018; Hughes et al., 2012) without making a priori assumptions at the mental level (i.e., about the mental mechanisms that allow for thinking as behavior). From this behavioral perspective, the primary aim of research is to understand the environmental conditions that moderate these phenomena. For this research, inspiration can be found in the extensive literature on known moderators of behavior in general (e.g., Catania, 2013; Fisher et al., 2011). For instance, it is likely that switching between the behavior of intuiting and the behavior of deliberating is heavily dependent on antecedents (i.e., discriminative stimuli) and consequences (i.e., reinforcers and punishers). In line with the functional-cognitive framework for research on psychology (De Houwer, 2011; Hughes et al., 2016), knowledge about the moderators of intuiting and deliberating not only has merit as such (i.e., it allows for prediction and control) but also facilitates the development of theories about the mental mechanisms that mediate these phenomena. In this way, combining descriptive and functional definitions with a behavioral perspective can provide a new impetus for both functional and cognitive research on intuiting and deliberating.

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BBS-D-22-00992_ De Neys_ Lee & Morewedge

Correction, uncertainty, and anchoring effects

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ABSTRACT: We compare the predictions of two important proposals made by De Neys to findings in the anchoring effect literature. Evidence for an anchoring-and-adjustment heuristic supports his proposal that System 1 and System 2 are non-exclusive. The relationship between psychophysical noise and anchoring effects, however, challenges his proposal that epistemic uncertainty determines the involvement of System 2 corrective processes in judgment.

As a case study, we compare two of De Neys' important proposals to findings from the literature on anchoring effects. Evidence for an anchoring-and-adjustment heuristic supports De Neys' proposal that System 1 and System 2 are non-exclusive (Epley & Gilovich, 2001; Simmons, LeBoeuf, & Nelson, 2010; Tversky & Kahneman, 1974). The increase in anchoring effects with quantifiable measures of uncertainty (Lee & Morewedge, 2022), however, challenges his proposal that uncertainty monitoring drives the involvement of System 2 correction processes in judgment.

As background, an anchoring effect occurs when considering an initial value (i.e., an anchor) biases subsequent estimates of a stimulus (i.e., the target). Inaccurate estimates of the target are more likely to fall between the anchor and the correct answer than beyond the correct answer (Tversky & Kahneman, 1974). When people are asked to estimate the duration of Mars' orbit, for instance, the number that typically first comes to mind is the duration of Earth's orbit (i.e., 365 days). This anchor influences estimates of Mars' orbit. People are more likely to underestimate the duration of Mars' orbit than to overestimate its duration (Epley & Gilovich, 2001).

An influential anchoring-and-adjustment heuristic theory of anchoring effects suggests that people make estimates by correcting from intuitive (but wrong) anchors until they reach the first plausible value of the target of their estimate. As the first value in the range of plausible values is usually incorrect, adjustment from anchors tend to be insufficient (Epley & Gilovich, 2001; Simmons et al., 2010; Tversky & Kahneman, 1974). Two forms of evidence from tests of the anchoring-and-adjustment heuristic support De Neys' proposal that System 1 and 2 are non-exclusive. First, few participants in anchoring studies give anchors as their final responses (e.g., < 2.8% in Study 1B, Simmons et al. 2010). Even participants constrained by cognitive load or intoxication, for instance, would be unlikely to guess the duration of Mars' orbit to be the same as Earth's orbit. They would guess the duration of Mars' orbit to be closer to 365 days than thinkers who are unconstrained (Epley & Gilovich, 2001; 2006). Second, motor movements associated with the rejection and acceptance of answers influence the degree to which people correct from anchors (e.g., head nodding and shaking; Epley & Gilovich 2001). These results show System 2 correction occurs even under constraint and System 1 can influence when System 2 correction ends.

Anchoring paradigms are also useful for examining De Neys' uncertainty monitoring proposal as anchoring is a bias where the degree of uncertainty within the judge can be quantified. Uncertainty can be expressed as the width of the plausible range of values of the target of judgment (Jacowitz & Kahneman, 1995); the distance between the lowest and highest plausible value. This range varies with factors like the expertise of the judge (Smith et al. 2013; Wilson et al. 1996) and with correlates of uncertainty like psychophysical noise. Due to the increasing psychophysical noise associated with numbers as they increase in magnitude (Feigenson et al., 2004), the plausible range (uncertainty) of values for estimates of larger numbers is wider than for smaller numbers (Lee & Morewedge, 2022; Quattrone et al. 1984). People estimate the calories in a small serving of McDonald's French Fries be anywhere between 141.48 and 223.46, whereas they estimate the calories in a large serving to be anywhere between 266.98 and 423.36. In other words, they perceive the plausible range of calories in a large serving of French fries to be wider than the plausible range of calories in a small serving of French fries (widths of 156.38 and 81.98 calories, respectively). The same pattern holds for novel unfamiliar stimuli like smaller and larger dot-arrays.

Challenging De Neys' (2022) proposal that uncertainty monitoring determines the activation and engagement of System 2 adjustment processes, epistemic uncertainty does not increase the probability or extremity of System 2 correction from anchors (i.e., System 1 intuitions). De Neys' (2022) proposed mechanism for the intervention of System 2, uncertainty monitoring, implies that correction from anchors should be more likely and more extreme when uncertainty about the value of the target is greater: when the plausible range of values for a target stimulus is wider. However, research participants do not exhibit more correction from anchors when plausible ranges of a target are wider. Correction from anchors is as likely and proportionally similar for targets with wider and narrower plausible ranges. When estimating the number of dots in 35-dot and 273-dot arrays, for instance, people first exposed to a low anchor (a 10-dot array) tend to give answers similar in relative distance from the lowest plausible values of the target. When one examines the raw size of anchoring effects (i.e., absolute values), people exhibit larger anchoring effects when the plausible range of stimulus values are wider than narrower (i.e., when uncertainty is greater). This pattern holds whether people are estimating the number of dots in larger or smaller dot-arrays, the prices of larger and smaller servings of donuts, the weight of larger or smaller dog breeds, the prices of higher or lower rated hotels, or the number of calories in larger and smaller servings of McDonald's French fries (Lee & Morewedge, 2022). These findings suggest epistemic uncertainty bounds the extent to which anchors influence judgment. It does not determine the extent of System 2 adjustment from anchors.

More generally, our comparison illustrates the value of anchoring paradigms for tackling the exciting questions De Neys raises about the relationship between intuitive and corrective mental processes.

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BBS-D-22-00994_ De Neys_ Sherman & Klein

The Dual-System Approach is a Useful Heuristic but Does Not Accurately Describe Behavior

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Abstract: We argue that the dual-system approach and, particularly, the *default-interventionist* framework favored by De Neys unnecessarily constrains process models, limiting their range of application. In turn, the accommodations De Neys makes for these constraints raise questions of parsimony and falsifiability. We conclude that the extent to which processes possess features of System 1 versus System 2 must be tested empirically.

De Neys has described an elegant dual process model to overcome conceptual shortcomings among other models. At the same time, the model is constrained to fit a systems approach and a *default-interventionist* framework, which significantly limits its range of application. We question the necessity and value of these constraints and key components of the model designed to accommodate those constraints.

De Neys restricts his model to accounting for behavior that can be described in a default-interventionist framework, in which System 2 processes are engaged only when System 1 fails to offer an adequate response. However, not all dual-process models share the default-interventionist structure (e.g., Gilbert, 1999; Sherman et al., 2010). In fact, many models assume that System 2 is the default. For example, Jacoby's work on recognition memory specifies that familiarity (System 1) only drives responses when recollection (System 2) fails (Jacoby, 1991). In Payne's work on implicit stereotyping, people rely on automatically activated stereotypic associations (System 1) only when judges are unable to determine whether they are looking at a gun or a tool (System 2; Payne, 2001). Ferreira et al. (2006) extended the same logic to standard judgment and decision-making errors (e.g., base-rate; conjunction; ratio-bias effect; and law of large number problems). Importantly, direct modeling comparisons in these domains show that

System 2 default models better account for these judgments than a default-interventionist model. As well, none of the tasks in these examples inherently demands the prioritization of System 2 (a condition De Neys identifies as irrelevant to his discussion of dual systems).

It is the default interventionism requirement that necessitates a switching mechanism, which we find problematic in a number of ways. Most basically, we are skeptical that a serial model is more efficient than a parallel model. Certainly, it is an unusual claim among general theories of information processing. In any case, De Neys solves this problem by positing that there may be System 1 versions of System 2 processes that do operate in parallel to System 1. However, this accommodation further requires that conflicting responses and their detection must also reside in System 1. These claims are undermined by considerable behavioral and neuroscience evidence that conflict monitoring requires attention and effort, presumably indicating a System 2 process. As well, conflict monitoring is associated with activation in the dorsal anterior cingulate cortex (dACC), a brain region involved in higher-level function. The dACC is associated with attention to a problem and effort to address it with intentional action (e.g., Carter & van Veen, 2007).

Of course, De Neys can evade these problems by simply positing that any conflict detection that appears to involve System 2, in fact, involves a System 1 routinization of System 2 (and, presumably, is generated in a site different than dACC). But doing so raises concerns about parsimony and unfalsifiability. If there is always the possibility of unmeasured System 1 operations, then it is not clear how the model could possibly be falsified.

Adherence to the requirements of a dual process or system approach also unnecessarily constrains the model and its assumptions. We certainly concur with De Neys that Systems 1 and 2 cannot be expected to yield unique responses. However, process exclusivity--the notion that, at any given time, processes must belong solely to System 1 or 2--also is problematic. For example, driving may become quite efficient (System 1 feature) but continue to require intention (System 2 feature). The ability to inhibit racial bias is compromised by old age and alcohol (suggesting System 2), yet frequently operates effectively on implicit measures of bias (suggesting System 1; Calanchini & Sherman, 2013). Thus, the same process may possess features of either system and those features (e.g., intention; awareness; controllability; efficiency) rarely all coincide (Gawronski et al., 2014).

More broadly, these issues highlight the problematic dual process tendency to conflate *operating principles* and *operating conditions*. Whereas operating principles refer to the qualitative nature of a process (i.e., what the process does—detect; suppress), operating conditions refer to the conditions under which the process operates (e.g., with or without intention or cognitive resources). In dual process models, it is common to assume that certain processes (e.g., response inhibition) must possess certain features (e.g., resource-dependence). Such assumptions are often necessary to maintain the claim of two distinct process types or systems. However, whether a process possesses features ascribed to System 1 and/or 2 is an empirical question that should be tested directly (Sherman et al, 2014).

In our own research, we have adopted this approach via the use of multinomial modeling techniques (Sherman et al., 2010). We found De Neys' model especially interesting in that, in many ways, it aligns with a model we have applied extensively (Sherman et al., 2008). Briefly, the Quad model proposes that, when an automatized response (implicit bias) conflicts with an intended response (respond favorably), a third process acts as arbiter to decide the winner. Obviously, this bears similarity to De Neys' portrayal of conflict detection and resolution, which we found highly valuable. However, we make no assumptions about the System 1 versus 2 features of these processes. Rather, we measure the processes independently and directly examine how they respond to interventions. For example, we know that both the intended response and conflict arbiter processes are relatively inefficient because they are undermined by short response deadlines. We believe this is the way forward for describing and testing process models.

If dual processes or systems cannot be distinguished by exclusive outcomes, processes, or features of processes, one must ask what is the point, particularly if they necessitate the sorts of work arounds De Neys must build to make it all work. It is more productive to simply identify the processes involved in some operation and the conditions under which they operate with no constraint of fitting into distinct process types or systems. The dual-process approach is effective as a heuristic for thinking about human behavior, but rarely describes that behavior accurately.

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BBS-D-22-01013_ De Neys_ Ackerman & Morsanyi

We know what stops you from thinking forever: A metacognitive perspective

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Abstract: This commentary addresses omissions in De Neys' model of fast-and-slow thinking from a metacognitive perspective. We review well-established meta-reasoning monitoring (e.g., confidence) and control processes (e.g., rethinking) that explain mental effort-regulation. Moreover, we point to individual, developmental and task design considerations that affect this regulation. These core issues are completely ignored or mentioned in passing in the target article.

This commentary addresses several major omissions in De Neys's "working model". We predominantly focus on gaps in the conceptualisation of the "switch feature" and stopping deliberative processes (S2).

Metacognitive research deals with the monitoring and control of thinking processes (Nelson & Narens, 1990). More than thirty years of research have dealt with the processes that inform subjective assessments of success (e.g., confidence) and the subsequent decisions (e.g., to rethink, see Fiedler et al., 2019). Of particular relevance is the *meta-reasoning* framework (Ackerman & Thompson, 2017), which is mentioned briefly in section 4.4. By using well-established metacognitive concepts, this framework opens the "black box" of mental effort regulation. It details monitoring and control processes that take place in the early intuitive reasoning stages (S1) separately from the deliberative stages (S2), including processes discussed in the target article and more.

First, the processes covered by the "switch feature" are discussed in length in the literature initiated by Thompson et al. (2011) using the two-response paradigm with *Feeling of Rightness* judgment (FOR, mentioned in section 4.4; Ackerman & Thompson, 2017). FOR is the metacognitive judgment that accompanies the initial response that comes to mind. It has been considered to *trigger the switch between S1 and S2* and found to predict S2 engagement (e.g., Thompson et al., 2013).

A further issue is that the proposed model is incomplete in that the alleged “switch mechanism” is considered to depend entirely on the relative activation levels of competing intuitions and the mysterious “deliberation threshold”. In fact, a variety of *situational and personal factors* have been found to affect metacognitive control decisions, such as reasoning time and response choice. Specifically, task design, such as instructions to reason logically (e.g., Ferreira et al., 2006; Morsanyi et al., 2009), cognitive load (De Neys, 2006; Morsanyi et al., 2014), and time pressure (Sidi et al., 2017), as well as individual characteristics, such as thinking dispositions (Cacioppo et al., 1996), cognitive ability (e.g., Stanovich & West, 2000), task-relevant knowledge (e.g., Chiesi et al., 2011; Stanovich & West, 2008), and anxiety levels (e.g., Beilock & DeCaro, 2007; Primi et al., 2018) affect reasoning time and response choice. Thus, any model explaining the "switch feature" should incorporate and account for the contextual and individual factors that influence the reasoning process.

Second, the target article discusses stopping deliberative processes (S2) and reverting to S1. An overlooked issue, though, is *when to stop S2 and provide a response*. Within the metacognitive literature, several models address stopping effortful thinking: the discrepancy reduction models (Nelson & Narens, 1990), the region of proximal learning (Metcalfe & Kornell, 2005), and the Diminishing Criterion Model (DCM, Ackerman, 2014; see Ackerman et al., 2020, for a review). According to the most recent model, the DCM, stopping thinking efforts is guided by a combination of two stopping criteria: (a) Confidence in each considered answer is compared to a desired confidence level. Importantly, this stopping criterion dynamically drops as people deliberate longer, reflecting compromising on expected success. (b) A time limit for thinking about each task item, beyond which people are reluctant to think any further (see also Hawkins & Heathcote, 2021).

Third, based on the suggested model, “System 2 deliberation will extend for as long as the uncertainty remains above the threshold” (section 3.4). Thus, under substantial uncertainty people are *doomed to think forever*. Nevertheless, a totally overlooked aspect is when *people opt out* (e.g., “I don’t know”) or turn to external help (see Ackerman, 2014, Undorf et al., 2021). In particular, considering children and novices brings to the fore that people looking at unfamiliar problems may not have any available heuristics to activate. Developmentally, there is a blurry line between deliberative and intuitive processes (Osman & Stavy, 2006) in that responses that can be given quasi automatically by adults may require cognitive effort for children (Morsanyi & Handley, 2008) and may become established by learning (Fischbein, 1987; Gauvrit & Morsanyi, 2014). De Neys briefly considers lack of S1 response (section 2.1.5). Another possibility is that people may activate a series of distantly related heuristics, but none of these would be sufficiently strong to offer an answer. In contrast, according to the DCM, when people get to a pre-set time limit, they may prefer opting out over providing a low confidence response. This topic was discussed in metacognitive research already in the 90’s (Koriat & Goldsmith, 1996) and was further developed since then (see Undorf et al., 2021). Thus, there are processes that prevent people from thinking forever.

Forth, De Neys asks in the introduction "how do we know that we can rely on an intuitively cued problem solution" and mentions that “the internal switch decision is itself intuitive in nature”. In metacognitive terms, these intuitions are based on heuristic cues that underly all metacognitive judgments (Koriat, 1997). Metacognitive judgments *combine* an extensive amount of features (Undorf & Bröder, 2021), including individual self-perceptions and beliefs (“beyond my expertise”), task characteristics (time pressure), and item characteristics (conclusion believability) that may influence, and sometimes mislead, metacognitive judgments (see Ackerman, 2019). Given the wide-spread biases in judgments like FOR and confidence (Thompson et al., 2013), considering potential misleading factors must be incorporated in any model of switch and stopping mechanisms.

Finally, from a developmental perspective, adults have a larger repertoire of heuristics and better ability to integrate them into their cognitive and metacognitive processes than children (Koriat et al., 2014). However, in the proposed model, the more heuristics are considered, the longer the thinking process that deals with potential conflicts among them. This contrasts with the traditional role assigned to reasoning heuristics - that they offer immediately available (and highly compelling) responses *immediately* (e.g., Evans, 2006), which is why they are considered to be adaptive and essential parts of the cognitive architecture.

In sum, the proposed model ignores well-established bodies of literature that address the central issues it was meant to cover. Particularly, metacognitive research offers switch and stopping rules, heuristic processes, individual characteristics, and developmental trajectories required for describing the complex processes underlying reasoning.

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Hoist by its own petard: The ironic and fatal flaws of dual-process theory

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Abstract. By stipulating the existence of a System 1 and a System 2, dual-process theories raise questions about how these systems function. De Neys identifies several such questions for which no plausible answers have ever been offered. What makes the nature of Systems 1 and 2 so difficult to ascertain? The answer is simple: the systems do not exist.

Dual-process theories of human reasoning have yet to provide plausible answers to basic questions about the nature of System 1 and System 2 processing. Can System 1 reason logically? How do people switch from System 1 to System 2? As De Neys convincingly argues, existing answers to these questions fail under logical and empirical scrutiny.

There is an irony to this. The questions that confound dual-process theories are the very questions that these theories introduce in the first place. By positing that System 1 and 2 exist in some meaningful sense, dual-process theories saddle themselves with the challenge of explaining how these systems (or types of processes) operate and interact. Having long failed to meet this challenge with even a single coherent hypothesis of something as basic as how System 2 is activated, it is worth asking if dual-process theories are wrong at the most fundamental level: Maybe System 1 and System 2 simply do not exist. Maybe what De Neys presents as important puzzles in need of solving are just red herrings symptomatic of a flawed theoretical foundation. We suspect that this is the case, and therefore recommend that instead of developing dual-process theories further, researchers abandon dual-process theories altogether (Melnikoff & Bargh, 2018).

What would it look like to abandon dual-process theories? Instead of asking questions about System 1 and System 2, researchers would ask questions like: How much time and effort is required to perform well on a given type of reasoning problem? Under what conditions do different components of reasoning occur spontaneously versus intentionally? How do different types of working memory load (e.g., visual versus verbal) interact with different aspects of the reasoning process? By eschewing commitment to the existence of Systems 1 and 2, questions like these avoid the obstacles that thwart dual-process theories.

Consider the central question of the target article: How do people switch between effortless ("intuitive") and effortful ("deliberative") reasoning? As De Neys shows, the answers offered by dual-process theories fail to meet even the minimum threshold of logical coherence. For instance, multiple dual-process theories claim that the activation of System 2 depends on System 2 already being activated. Such paradoxes vanish, however, when the concepts of System 1 and System 2 are abandoned. To illustrate, consider the Learned Value of Control (LVOC) model of Lieder, Shenhav, Musslick, and Griffiths (2018). This model says that people use reinforcement learning to estimate the value of exerting different amounts of effort in particular situations. For example, people may learn from prior experience that when presented with certain reasoning problems in particular contexts, they tend to obtain better outcomes when they ignore their initial hunch and invest effort in further deliberation. This learned value can be used to decide how much effort to invest when similar situations are encountered in the future.

There are no paradoxes here. The LVOC model is a perfectly coherent account of how people modulate the effort they invest in reasoning—one of many (e.g., Abrahamse, Braem, Notebaert, Verguts, 2016; Restle, 1962; Shenhav, Botvinick, & Cohen, 2013)—and the fact that it makes no reference to Systems 1 and 2 is no coincidence. Just imagine if it did. Reframed in dual-process terms, the LVOC might posit that System 2 learns the expected value of deliberating, and then uses this information to decide when to ignore System 1 processing in favor of System 2 processing. Now we have a problem: The new theory implies that the activation of System 2 is a precondition for itself, introducing an infinite regress. An alternative reframing of the LVOC might posit that whenever System 1 processing is ignored in favor of System 2 processing, System 1 updates the value of deliberation and uses this updated value to decide when to deliberate in the future. But this is paradoxical. If System 1 processing is ignored, System 1 cannot, by definition, update the value of *anything*.

The point here is that by embracing the System 1/System 2 framework, nothing is gained but confusion. The conceptual commitments of the framework only make it harder to generate coherent answers to the very questions that dual-process theorists care about.

Of course, none of this would matter if there were evidence showing that Systems 1 and 2 do in fact exist. Whereas fictional theoretical constructs can be discarded as soon as they prove unhelpful, actual features of the mind cannot be ignored simply because they introduce conceptual conundrums. So, are Systems 1 and 2 real?

There is no reason to think so. Fundamentally, System 1/System 2 is a proposed dimension along which psychological processes vary: at one end of the spectrum, processes are fast, effortless, and spontaneous, and at the other end, processes are slow, effortful, and intentional. So, the reality of the System 1/System 2 distinction hinges on whether it is true that the features of speed, effort, and intentionality are in some sense reducible to a single, more basic dimension.

Evidence supporting this idea does not exist. There has been no attempt to establish that speed, effort, and intentionality are intercorrelated to any meaningful degree, let alone to the point that they might be reducible to a single underlying dimension (Bargh, 1994; Keren & Schul, 2009; Kruglanski & Gigerenzer, 2011; Melnikoff & Bargh, 2018; Moors & De Houwer, 2006). On the contrary, countless examples of "misalignments" between processing features have been documented, such as fast processes that are intentional (Melnikoff & Bailey, 2018) and inefficient (Gilbert & Hixon, 1991), and spontaneous processes that are effortful (Kim, Kim, & Chun, 2005). Such phenomena suggest that an attempt to validate the System 1/System 2 distinction, were it ever undertaken, is unlikely to succeed.

In short, there is no evidence that Systems 1 and 2 exist in any meaningful sense, and head-scratching paradoxes vanish if we assume they do not. Therefore, we should abandon dual-process theory rather than embark on a doomed mission to save it.

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BBS-D-22-01015_ De Neys_ Newman & Thompson

Not Feeling Right about Uncertainty Monitoring

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Abstract: De Neys proposed a "switch" model to address what he argued to be lacuna in dual-process theory, in which he theorized about the processes that initiate and terminate analytic thinking. We will argue that the author neglected to acknowledge the abundant literature on metacognitive functions, specifically, the meta-reasoning framework developed by Ackerman and Thompson (2017), that addresses just those questions.

The meta-reasoning framework (Ackerman & Thompson, 2017) differentiates between object-level processes that are responsible for thinking, reasoning, and deciding, and the meta-level process that monitor and control them. Part of this theory addresses the processes that initiate and terminate analytic thinking, the so-called "switch" function proposed by De Neys. In the meta-reasoning model, the *Feeling of Rightness* (Thompson, 2009; Thompson et al., 2011; 2013) has been proposed as one way that intuitive responses can be monitored and analytic processes initiated.

Thompson argued that System 1 processing is accompanied by a metacognitive experience, a feeling of rightness or certainty that the response(s) generated by System 1 are correct (Thompson, 2009). The relative strength of one's Feeling of Rightness determines the probability one will switch to and engage System 2; when the feeling is strong, the response is often accepted with little System 2 analysis. Conversely, when the Feeling of Rightness is weak, System 2 is often engaged. In other words, the Feeling of Rightness is a cue to either accept the outcome of System 1 processing or “switch” to System 2 processing. Thompson also proposed potential determinants of the strength of a Feeling of Rightness, such as fluency of processing (speed and ease of response generation) and, importantly, the presence of conflicting responses (Thompson et al., 2011; Thompson & Johnson, 2014).

Although De Neys briefly acknowledged that his working model could be integrated with the Feeling of Rightness (section 4.4), he neglected a broad and well-established model to propose an explanation for a narrower range of phenomena. The meta-reasoning framework (Ackerman & Thompson, 2017) is a multifaceted framework that encompasses a variety of monitoring and control processes, in addition to a “switch” mechanism. Thus, De Neys’ proposal fleshed out the specific case of monitoring for conflict in the broader meta-reasoning framework. We also note the similarity between monitoring Feelings of Rightness and “uncertainty monitoring”, where one can think about “uncertainty” as the inverse of confidence or Feeling of Rightness.

De Neys also argued that leading switch accounts presuppose exclusivity, where certain types of responses (e.g., a normatively correct response) are exclusively generated by one system or the other. Thompson and Newman (2020) noted that the exclusivity assumption has been long abandoned in dual-process theorizing (Evans, 2019; Evans & Stanovich, 2013; Stanovich, 2018; Thompson, 2011) and have obtained evidence in support of this in our own lab (Newman et al., 2017). Most importantly, the Feeling of Rightness does not depend on the normative qualities of the response generated and, therefore, does not rely on an exclusivity assumption to be instantiated. Essentially, the claim that leading switch accounts presuppose exclusivity is not consistent with current metacognitive models.

We agree with De Neys that many of the processes that monitor our cognitions are likely “System 1” in character: they should not demand working memory resources and their origins are likely not subject to introspection (Koriat, 2008). However, we think there are several important differences between the uncertainty monitoring mechanisms proposed by De Neys and the types of monitoring mechanisms that are common in the metacognitive literature. First, although their origins may not be subject to introspection, their outputs are thought to enter awareness. We have hypothesized that Feelings of Rightness are felt subjectively (Thompson et al., 2011), meaning one is consciously aware, at least to some degree, that they have these feelings. Alternatively, it is not clear that uncertainty monitoring has the same properties.

This difference is subtle but crucial. From a metacognitive perspective, one can be aware of when they feel their response is completely right, completely wrong, or somewhere in between. From an uncertainty monitoring perspective, it seems that one is only aware when one feels a sufficient degree of uncertainty – either from a weakly generated response or two (or more) conflicting responses relatively similar in strength. Therefore, there is no mechanism by which an individual could be aware of when they feel extremely right or wrong, nor for how such feelings could cue the engagement of System 2. Finally, we note that while most monitoring is likely to be implicit, there is also a role for explicit beliefs about oneself, the task, the types of behaviours that constitute good reasoning, etc. (Koriat, 2008; Jost et al., 1998; Ackerman, 2019). Thus, not all monitoring processes can be lumped under the "System 1" rubric.

Of most relevance, De Neys' proposed model cannot explain the phenomenon of being highly certain that something is wrong (i.e., *Feeling of Wrongness*), such as when a firefighter has a sudden but strong feeling that something is amiss and they must get out of the building immediately (Klein, Calderwood, & Clinton-Cirocco, 2010). Similarly, I could ask you: *is Edinburgh the capital of Botswana?* You may not know the actual capital of Botswana (it is Gaborone), but you likely would have a remarkably strong feeling that it is *definitely not* Edinburgh. Similarly, one may have a strong *Feeling of Error* about a response one has given (Ackerman & Thompson, 2017; Fernandez Cruz, Arango-Muñoz, & Volz, 2016). Both dimensions of the spectrum are important because a strong feeling about a response (whether it be rightness or wrongness or error; Ackerman & Thompson, 2017) is a cue that action is necessary (Thompson, 2017).

De Neys provided a detailed analysis of how reasoners monitor for conflict. However, conflict monitoring is just one part of the role that metacognitive monitoring plays. Moreover, the proposal failed to acknowledge the more comprehensive framework developed by Ackerman and Thompson. It is ultimately an oversimplification of an existing framework that substitutes uncertainty for Feeling of Rightness, uncertainty monitoring for metacognitive monitoring, and an uncertainty criterion for the diminishing criterion model of confidence (Ackerman, 2014). We agree with much of the criticism and questions raised by De Neys here (both directly and indirectly) and acknowledge that they are important, but note that frameworks, such as the meta-reasoning framework of Ackerman and Thompson (2017), already exist to answer them.

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BBS-D-22-01016_ De Neys_ Braem et al.

Learning how to reason and deciding when to decide

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Abstract: Research on human reasoning has both popularized and struggled with the idea that intuitive and deliberate thoughts stem from two different systems, raising the question how people switch between them. Inspired by research on cognitive control and conflict monitoring, we argue that detecting the need for further thought relies on an intuitive, context-sensitive process that is learned in itself.

Research on reasoning about moral dilemmas or logical problems has traditionally dissociated fast, intuitive modes of responding from slow, deliberate response strategies, often referred to as System 1 versus System 2. For example, when deciding to take the plane versus train, our System 1 might make us decide to take the former because of its speed, while our System 2 could lead to deliberations on its environmental impact and decide for the train. De Neys (in press) proposes a new working model wherein both intuitive and deliberate reasoning are thought to originate from initial "System 1"-intuitions whose activations build up over time and potentially trigger an uncertainty signal. When this uncertainty signal reaches a certain threshold, it can trigger the need for deliberate reasoning, upon which deliberate thought or "System 2", is called upon to further resolve the reasoning problem. Here, we question the need for assuming a separate, deliberate system, that is activated only conditional upon uncertainty detection. While we are sympathetic to the idea that uncertainty is being monitored and can trigger changes in the thought process, we believe these changes may result from adaptations in decision boundaries (i.e., deciding when to decide) or other control parameters, rather than invoking qualitatively different thought strategies.

Research on cognitive control often focuses on how goal-directed control processes can help us correct, inhibit, or switch away from interfering action tendencies, such as those originating from overtrained associations (Diamond, 2013; Miller & Cohen, 2001). For example, when deciding between the train or plane, our prior habit of taking the plane might trigger the same decision at first, while our current goal to be more environment-friendly should lead us to the train. Importantly, recent theories on cognitive control have emphasized how these goal representations and control processes should not be considered as separate "higher" order processes studied in isolation, but that they are deeply embedded in the same associative network that hosts habits and overtrained responses. That is, goals and control functions can be learned, triggered, and regulated, by the same learning principles that govern other forms of behavior (Abrahamse et al., 2016; Braem & Egner, 2018; Doebel, 2020; Lieder et al., 2018; Logan, 1988). For example, much like the value of simple actions, the value of control functions can be learned (Braem, 2017; Bustamante et al., 2021; Grahek et al., 2022; Yang et al., 2022; Otto et al., 2022; Shenhav et al., 2013). This way, similar to De Neys' suggestion that we can learn intuitions for the alleged System 1 and 2 responses (or habitual versus goal-directed responses), we argue that people also learn intuitions for different control functions or parameters (see below).

One popular way to study the dynamic interaction between goal-directed and more automatic, habitual response strategies is through the use of evidence accumulation models. In these models, decisions are often thought to be the product of a noisy evidence accumulation process that triggers a certain response once a predetermined decision boundary is reached (Bogacz et al., 2006; Ratcliff et al., 2016; Shadlen & Shohamy, 2016). However, this accumulation of evidence does not qualitatively distinguish between the activation of intuitions versus goal-directed or "controlled" deliberation. Instead, both processes start accumulating evidence at the same time, although potentially from different starting points (e.g., biased towards previous choices or goals) or at different rates (e.g., Ulrich et al., 2015). Depending on how high a decision maker sets their decision boundary, that is, how cautious versus impulsive they are, the goal-directed process will sometimes be too slow to shape, or merely slow down, the decision. These models have been successfully applied to social decision making problems (e.g., Hutcherson, Bushong, & Rangel, 2015; Son, Bhandari, & FeldmanHall, 2019).

In line with the proposal by De Neys (in press), we agree that competing evidence accumulation processes could trigger an uncertainty signal (e.g., directional deviations in drift rate), once uncertainty reaches a certain threshold, similar to how it has been formalized in the seminal conflict monitoring theory (Botvinick et al., 2001), on their turn inspired by Berlyne (1960). However, in our view, the resolution of said signal does not require the activation of an independent system but rather induces controlled changes in parameter settings. Thus, unlike activating a System 2 that provides answers by using a different strategy, cognitive control changes the parameters of the ongoing decision process (for a similar argument, see Shenhav, 2017). For example, it could evoke a simple increase in decision boundary, allowing for the evidence accumulation process to take more time before making a decision (e.g., Cavanagh et al., 2011; Frömer & Shenhav, 2022; Ratcliff & Frank, 2012). The second-order parameters that determine these adaptive control processes (e.g., how high one's uncertainty threshold should be before calling for adaptations, or how much one should increase their boundary) do not need to be made in the moment, but can be learned (e.g., Abrahamse et al., 2016).

Although we focused on the boundary as closely mapping onto fast and slow processing, we believe other process parameters can be altered too. For example, the response to uncertainty may require or could be aided by directed attention (Callaway, Rangel, & Griffiths, 2021; Jang, Sharma, & Drugowitsch, 2021; Smith & Krajbich, 2019), the memory of previous computations (Dasgupta & Gershman, 2021), learned higher-order strategies (Griffiths et al., 2019; Wang, 2021), or the parsing of a problem into different (evidence accumulation) subprocesses (Hunt et al., 2021). Moreover, a decision maker might even mentally simulate several similar decisions to evaluate one's (un)certainty before making a response (e.g., by covertly solving the same problem multiple times, Gershman, 2021). In sum, we argue that both intuitive and deliberative reasoning result from similar evidence accumulation processes whose parameter adjustments rely on immanent conflict monitoring and the learning from previous experiences.

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BBS-D-22-01017_ De Neys_ Stupple & Ball

Explaining normative-deliberative gaps is essential to dual process theorizing

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Abstract: We discuss significant challenges to assumptions of exclusivity and highlight methodological and conceptual pitfalls in inferring deliberative processes from reasoning responses. Causes of normative-deliberative gaps are considered (e.g., disputed or misunderstood normative standards, strategy preferences, task interpretations, cognitive ability, mindware and thinking dispositions) and a soft normativist approach is recommended for developing the Dual Process 2.0 architecture.

Dual Process 2.0 accounts are increasingly compelling, and we welcome De Neys' proposed model, which we bolster here by noting further challenges to assumptions of "exclusivity" (the notion that intuition and deliberation generate unique responses). We additionally argue for considerable methodological care when exploring the nature of deliberative processing.

Among the most crucial considerations when devising thinking, reasoning and decision-making tasks is determining what constitutes a "correct" answer and what it means when participants produce this answer. Indeed, De Neys cautions against an "ought-is fallacy" (Elqayam & Evans, 2011), which arises when responses aligning with "normative" theories (e.g., predicate logic or Bayes' theorem) are viewed as being *diagnostic* of deliberation. We contend that normative standards, although useful for performance benchmarking, can present blind spots for experimental design and theory building. As such, we concur with Elqayam and Evans (2011) that constructing theories of reasoning around normative standards is problematic for understanding psychological processes.

To evaluate deliberative processing successfully, it seems prudent to adopt a "soft normativist" (Stupple & Ball, 2014) or "descriptivist" (Elqayam & Evans, 2011) approach. Accordingly, research programmes should acknowledge the distorting lens of normative standards (while also avoiding the trap of relativism), recognizing that although normative standards may be correlated with deliberation, they are not causally linked to it (Stupple & Ball, 2014). From a soft-normativism perspective, "normative-deliberative gaps" are expected for many reasons (e.g., disputed or misunderstood norms, strategy preferences, alternative task interpretations, cognitive ability and mindware constraints, and impoverished thinking dispositions), necessitating careful consideration.

Normative standards should also be contested and evaluated whenever multiple, candidate standards exist (Stenning & Varga, 2018). For some tasks, the normative response is uncontroversial, but for others, participants must make sense of task requirements and may not construe the task as intended. For example, Oaksford and Chater (2009) proposed an alternative normative standard for the Wason Selection Task based upon "information gain", which is consistent with the most common responses (contrasting with Wason's, 1966, logicist proposals). Oaksford and Chater (2009) extend this perspective to demonstrate that logical fallacies can be rationally persuasive. Indeed, caution is advised for researchers who associate endorsement of fallacies with a *lack* of deliberation. It is prudent not simplistically to equate standard normative responses with deliberative thinking without also considering individual goals.

In most thinking tasks, participants are not explicitly prescribed a goal or norm. Indeed, Cohen (1981) famously argued that reasoning research presents "trick" questions with minimalist instructions to naïve participants. The assumption that participants identify tasks as requiring deliberation may itself be naïve. Stupple and Ball (2014) proposed that when naïve participants attempt novel reasoning problems, they determine an appropriate normative standard and select a strategy through a process of "informal reflective equilibrium". Through this, increasing familiarity with problem forms – even in the absence of feedback – can result in participants aligning with normative responses assumed to require deliberation (Ball, 2013; Dames et al., 2022). This alignment need not be deliberative, however, but could instead entail detection of *patterns* in problems and an increasing intuition strength for normatively aligned heuristic responses.

These variations in participants' goals and strategies are captured by Markovits et al. (e.g., 2017; cf. Verschueren et al., 2005), who demonstrated individual differences in strategy preferences (probabilistic versus counterexample) that are orthogonal to preferences for intuitive versus deliberative thinking. These strategies have implications for the interplay between deliberation and normative standards. Participants adopting a counterexample strategy (based on mental models) versus a probabilistic strategy (based on information gain or probability heuristics; Beeson et al., 2019; Oaksford & Chater, 2009; Verschueren et al., 2005) may differ in their task construal and understanding of "correct" answers. Although it is unclear whether strategies necessarily entail adoption of particular normative standards, responding to a problem in terms of information gain versus a necessary truth derived from a mental model would reasonably be assumed to require differing degrees of deliberation and differing use of intuitive cues.

When judging whether deliberation has occurred, we also suggest that responses can be less reliable than response times. For example, for the lily-pad CRT problem, incorrect non-intuitive answers averaged longer response times than incorrect intuitive or correct answers (Stupple et al., 2017), which is inconsistent with "cognitive miserliness" and the absence of deliberation. Such outcomes can arise from task misinterpretation, lack of mindware or the strategy selected. When relying on responses to judge a process, we cannot know if a participant has reasoned deliberatively unless we presume the task was understood as intended, and we cannot know they understood the task as intended unless we presume they reasoned deliberatively (cf. Smedslund, 1990).

We also note that meta-reasoning studies offer vital insights into individual differences in uncertainty monitoring, facilitating a more nuanced understanding of deliberative processing on a task. For example, when participants determine how long to persevere, they may be optimizing or satisficing, and those of a miserly disposition may simply be looking to bail out through a "computational escape hatch" (Ackerman et al., 2020; Ball & Quayle, 2000). Low confidence responses after an "impasse" can also decouple the link between response time and deliberative thinking, as can uncertainty about the intended "correct" answer. As such an array of individual-differences measures are necessary to understand the nature of deliberative processes. Furthermore, unpicking such deliberative processes goes beyond the observation of fast and slow thinking. Intuitive processes are always necessary for a participant to respond and sometimes they are sufficient. Participants who understand a task as requiring the alleged System 1 response will not be prompted into deliberation by an awareness of an alleged System 2 response (as this is not necessarily the normative response or the participant's goal).

In sum, we advocate for an approach that follows Dual Process Model 2.0, but which triangulates task responses with response times, metacognitive measures and individual-difference variables, whilst aligning with a soft or agnostic view of normative standards. When deciding which responses are the product of deliberative thinking, researchers must be mindful of the myriad individual differences in task interpretations, strategies and perceived “normative” responses.

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BBS-D-22-01018_ De Neys_ Oyserman

Switching: Cultural Fluency Sustains and Cultural Disfluency Disrupts Thinking Fast

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Abstract: Culture-as-situated cognition theory provides insight into the system 1 monitoring algorithm. Culture provides people with an organizing framework, facilitating predictions, focusing attention and providing experiential signals of certainty and uncertainty as system 1 inputs. When culture-based signals convey that something is amiss, system 2 reasoning is triggered and engaged when resources allow; otherwise, system 1 reasoning dominates.

People can reason fast or slow. Slow reasoning requires more attentional resources and fast reasoning supports rapid movement through non-problematic sequences. De Neys' (in press) fast-and-slow systems perspective highlights a problem -the monitoring system that triggers switching between fast and slow thinking can only function if it resides within the fast system. Hence switching must depend on a rapid, non-resource intensive mechanism which can somehow detect when the slow system is or is not needed. De Neys focuses on the possibility that the mechanism entails a certainty algorithm that continuously compares certainty regarding fast system ideas to some certainty threshold. Metaphorically, De Neys predicts an internal thermostat that is turned on and off by a certainty threshold. It turns on when possible responses are below threshold certainty and off again when relative certainty surpasses threshold. Monitoring focuses on the quality of the proposed responses.

If the inputs are internal then looking at wedding photographs or reading an obituary should not effect cognitive reflective task scores (a classic system 2 task), but it does (Mourey et al., 2015). The researchers had participants view wedding photographs with the ostensible task of rating their quality and attractiveness, then had them respond to the cognitive reflective task (CRT). Half of participants were randomized to a culturally fluent condition in which the photographs included a groom in a black suit, a bride in a white gown, a white fondant-iced tiered wedding cake, and a wedding party. The other half of participants were randomized to a culturally disfluent condition in which photos included a bride and groom and a cake but the cake was decorated with cogs, the clothing included purple and green. Participants who saw the culturally disfluent version scored higher on the CRT. The shift to slow, system 2 reasoning was triggered not by the quality of proposed responses as De Nuy would propose but because the disfluent wedding photographs provided a situational signal that something is wrong. The implication is that system 2 is triggered by signals of a problematic state of affairs not simply by relative certainty about proposed CRT responses.

When familiar tasks are going well, vigilance is not needed and reliance on established routines and general intuitions is sufficient. When things go wrong, or tasks are unfamiliar, higher vigilance and effort are useful (Schwarz, 1990; 2001). One driver of these experiences is culture. Culture provides an organizational framework for how things will proceed, what matters, and how to make sense of experiences (Oyserman, 2011, 2017; Oyserman & Uskul, 2008/2015). People automatically use their culture-based expertise to make predictions, which typically sufficiently match what people observe that they experience a prediction-observation fit, yielding an experience of cultural fluency, a benign signal that things are as they ought to be (Lin et al., 2019).

From a culture-as-situated cognition perspective, inputs must come from features of the situation which themselves are cultural constructs. After all, thinking is for doing and doing is contextualized. People are not solving problems outside of contexts, they are solving them inside of contexts. Features of these contexts are of vital concern. An internally focused system that is not sensitive to contextual cues about certainty or uncertainty is evolutionarily implausible. From this perspective, what constitutes experienced certainty and uncertainty cannot be separated from the context in which thinking occurs. Hence, the switching mechanism must take into account what thinking feels like in the moment. The literature on the relationship between reasoning and culture provides a concretizing example as shown above.

Culture is a set of structures and institutions, values, traditions, and ways of engaging with the social and nonsocial world that are transmitted across generations in a certain time and place. Culture is thus temporally and geographically situated and multilevel. It is situated because it takes place in a certain time and place and dynamically changes as it is transmitted over time and across places. It is multilevel because its influence can be observed in societal-level constructs such as structures and institutions, group-level constructs such as traditions and ways of engaging in the world, and individual-level cultural mindsets --sets of mental representations containing culture-congruent mental content (knowledge about the self and the world), cognitive procedures, and goals (Oyserman, 2011). Considering culture highlights two paradoxes: Accessible cultural mindset and experiencing cultural fluency and cultural disfluency affects thinking (Oyserman et al., 2009; Oyserman & Yan, 2019). Each increases how confident people are in their inferences and this confidence can result mismatches between reasoning and the task at hand. Moreover, culture shapes uncertainty avoidance, the extent to which a given level of uncertainty is likely to be subjectively experienced as a problem signal (Lu, 2022).

To get through the day, people routinely process enormous quantities of information. From an ecological perspective, people should be sensitive to cues about danger, shifting attention and ratcheting up to system 2 reasoning in the face of danger signals – cues that something is not right in the situation. If fast reasoning is the default, the implication is that switching into and out of slow reasoning is a function of experiences that trigger uncertainty, suspicion, or other emotions relevant to danger. Culture-as-situated-cognition theory predicts that culture provides people with an implicit map for how everyday situations will unfold, what ambiguous situations likely mean, and why things happen (Oyserman, 2017). People use these feelings as informational inputs (Schwarz, 2002).

A culture-based perspective highlights that the metaphorical system 1 thermostat that turns on and off system 2 reasoning must receive inputs from subjective experiences drawn from the situation. First, the literature on the downstream consequences of cultural fluency and disfluency for reasoning suggests that people may switch to slow reasoning whenever they experience situations that are culturally disfluent. Disfluency provides a problem signal which should trigger system 2. Fluency provides an ‘all clear’ signal that should support remaining in or returning to system 1. A metaphorical thermostat that shut out these cues would not be evolutionarily viable (Oyserman et al., 2014).

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Deliberative control is more than just reactive: Insights from sequential sampling models

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ABSTRACT: Activating relevant responses is a key function of automatic processes in De Neys' model; however, what determines the order or magnitude of such activation is ambiguous. Focusing on recently developed sequential sampling models of choice, we argue that proactive control shapes response generation but does not cleanly fit into De Neys' automatic-deliberative distinction, highlighting the need for further model development.

We applaud De Neys' work to define a set of domain-agnostic organizing principles that better clarify discussion on dual process theories. This reformulation makes a welcome contribution to the field by proposing that (1) fast and intuitive response generation can activate multiple competing responses, leading to choice uncertainty, and (2) that this uncertainty drives subsequent activation of control-related deliberation. However, critical properties of these processes remain ambiguous in the current framework. Specifically, given the central role of fast and intuitive response generation processes, it is imperative to better specify how response options are generated, what determines their relative strength and time-course, and how these intuitions are compared to select a response. In this commentary, we draw on insights from the sequential sampling modeling literature to argue that even initial response generation and evaluation may not be exclusively driven by fast, automatic, and intuitive associative recall, but also modulated by controlled processes that operate rapidly from prior knowledge. In particular, we argue that deliberative control is deployed to prioritize information sampling and attribute evaluation, and thus response generation. We discuss how these forms of proactive control, in contrast to reactive control, pose a challenge to De Neys' current framework.

In De Neys' formulation, intuitive *responses* are the computational units that drive decisions. But these responses are themselves driven by the consideration of different cues or samples of information. Thus, the intuition generation process seems conceptually related to, if not synonymous with, the activation of relevant choice attributes in sequential sampling models. In these models, samples are drawn from noisy distributions of attribute values and accumulated as evidence for response options until the evidence passes a threshold for choice (Ratcliff & McKoon, 2008; Shadlen & Shohamy, 2016). The order in which attributes are considered can strongly influence decisions (Sullivan et al., 2015; Sullivan & Huettel, 2021). The present dual process framework appears to utilize a similar probabilistic sampling process, suggesting that insights from the growing literature on sequential sampling models could prove informative.

Recent work on sequential sampling models demonstrates that people strategically prioritize gathering more valuable information, which can change both the temporal dynamics and strength of response generation. For example, in altruistic choice under time pressure, selfish people prioritize gathering information about their own, rather than others', outcomes (Teoh et al., 2020). This systematically biases visual attention within the first few hundred milliseconds of choice presentation. In De Neys' terms, strategic allocation of attention changes the order of intuitive responses. Furthermore, this rapid reprioritization is context-sensitive: changing the incentives of a social interaction (e.g. dictator vs ultimatum game; Teoh & Hutcherson, 2022) or the framing of a risky gamble (e.g. gain vs loss frame; Roberts et al., 2022) change which information is processed first, in a goal consistent manner. Thus, prior information shapes information search patterns *prior* to information sampling and response generation, appearing to operate *independently* of the uncertainty-triggered control in De Neys' model.

Similarly, prestimulus control-related signals can also change the order or strength of information recall, proactively shaping the response generation process. For example, time-varying sequential sampling models of food choice demonstrate that instructions to focus on health-related goals-- a presumably deliberative process-- results in faster activation of health-related information (Maier et al., 2020). In addition to changing the temporal dynamics of information retrieval, holding health-related goals increases how much weight people place on health relative to taste in their food choices (Hare et al., 2011; Tusche et al., 2018). This suggests that retrieving and generating response options is not solely automatic. Instead, effortfully-maintained goals can determine which information is most relevant, and can change the order in which response-relevant attributes are considered.

These results from both attention and memory sampling highlight an important distinction between *reactive control*, which are triggered by an event and strongly resembles the uncertainty-triggered deliberation of De Neys' model, and *proactive control*, which refers to regulatory processes that occur before encountering a stimulus (Braver et al., 2007; Braver, 2012). Importantly, as we have suggested above, our own and others' work suggests that this form of control can modulate when and what intuitions are activated even in the absence of conflict, and can alter the strength or order of information processing *before* rather than *after* intuitions are retrieved.

Better specifying how prestimulus control influences response generation may not only better link the current model to the self-regulation literature, but extend it to more general models of information processing. The Iterative Reprocessing framework (Cunningham et al., 2007) is one such model which allows both stimulus-driven, bottom-up processes to inform goal-based, top-down processes, and vice versa. This echoes findings in attention (Corbetta & Shulman, 2002; Asplund et al., 2010) and memory (Ciaramelli et al., 2008; Burianová et al., 2012) which propose that there are distinct but related top-down and bottom-up processes which mutually inform each other. Under this framework, organizational, top-down processes are *always* informing what is considered most relevant by stimulus-driven processes. This top-down influence could become more effortful or directed with reflective control (Cunningham & Zelazo, 2007), but pre-existing knowledge plays an important causal role in determining the relevance of automatically retrieved information.

As uncertainty-triggered deliberative processes remain to be fully specified in De Neys' model, it is unclear whether proactive control processes should be considered a separate process, or whether it might utilize the same architecture. Regardless, considering when and how proactive deliberative processes are activated represents a fruitful area of inquiry. For example, dieters are often highly motivated to engage in healthy eating, yet may fail to spontaneously engage in proactive control (Cosme et al., 2020). While learning can automatize these priorities, as De Neys discusses, the effortful engagement of proactive control is not well incorporated into the current automatic-deliberative division. This case study thus highlights the need for a better articulation of how *both* intuitive and deliberative processes shape the initial response generation process, and points to the benefits of marrying dual process models with the richness of recent computational models of information sampling and choice.

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Could Bayesian cognitive science undermine dual-process theories of reasoning?

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Abstract: Computational-level models proposed in recent Bayesian cognitive science predict both the "biased" and correct responses on many tasks. So, rather than possessing two reasoning systems, people can generate both possible responses within a single system. Consequently, although an account of why people make one response rather than another is required, dual processes of reasoning may not be. (57 Words)

Wim de Neys makes a compelling case that recent evidence showing that System 1 can make both incorrect or biased and correct responses raises problems for the switching mechanism that moves between System 1 and System 2. In this commentary, I argue that recent work in the New Paradigm in Human Reasoning (Oaksford & Chater, 2020) or Bayesian Cognitive Science (Chater & Oaksford, 2008), more generally, shows that the so-called biased response can be correct, given the right background beliefs or in the right environment. Consequently, rather than requiring two reasoning systems, the evidence Wim cites may instead suggest that people consider more than one possible correct response.

Is it surprising that System 1 can compute the correct response? Other animals, who likely can only possess a putative System 1, are capable of rational decision-making (Monteiro, Vasconcelos, & Kacelnik, 2013; Oaksford & Hall, 2016; Stanovich, 2013). Moreover, the unconscious inferences underpinning perception and action are widely believed to be the product of the same rational Bayesian inferences (Clark, 2013; Friston, 2010) that underpin new paradigm approaches to human verbal reasoning (Oaksford & Chater, 1994, 2020; Oaksford & Hall, 2016). Within a single model (reasoning system?), these approaches can predict both the "biased" and correct responses. For example, optimal data selection predicts so-called "confirmation bias" in Wason's selection task but also, depending on the model's parameters, the reflective, falsification response (Oaksford & Chater, 1994; see also, Coenen, Nelson, &

Gureckis, 2019). These different possibilities can be unconsciously simulated by varying these parameters. The possibility that becomes the focus of attention in WM, and hence which response is made first, will depend on which is best supported by environmental cues or prior knowledge.

This pattern, whereby both the "biased" and correct response can arise from the same computational level model of the reasoning process, is common across Bayesian cognitive science. A further example is Oaksford and Hall's (2016) model of the base-rate neglect task, on which Wim comments approvingly. This model is related to models of categorisation, where categories are causally related to their features (cues) (Rehder, 2017). Both responses arise from sampling a posterior distribution when the base rates of being female in a sample are updated by the cues to femininity in the description of a person randomly drawn from that sample. Whether the prior (respond male) is washed out (respond female) depends on the perceived strength of the cues in the description of the person sampled. So, both responses can be considered correct depending on other background knowledge.

Further examples abound. In deductive reasoning, a similar variation in endorsing conditional inferences is predicted by the same probabilistic factors as in data selection (Oaksford & Chater, 2007: Fig. 5.5; Vance & Oaksford, 2021). In computational-level theories of the conjunction fallacy (Tentori, Crupi, & Russo, 2013) and argumentation (Hahn & Oaksford, 2007), responses may be based on the probability of the conclusion (Pr(C)) or the Bayesian confirmation-theoretic relation between premises and conclusion (e.g., Pr(C|P) – Pr(C), the likelihood ratio etc.). These can lead to conflicting possible responses regarding the strength of the argument and to endorsing the conjunction fallacy. In argumentation, the same Bayesian model explains when an informal argument fallacy, for example, ad hominem or circular reasoning, is fallacious and when it is not. "Biased" responses may also arise from how the brain estimates probabilities by sampling (e.g., Dasgupta, Schulz, & Gershman, 2017; Zhu, Sanborn, & Chater, 2020). Small samples may be combined with priors to produce initially "biased" responses that move towards the correct response, given more sampling time.

For many of these tasks, it is doubtful that people can explicitly calculate the appropriate responses without formal training and pencil and paper. Although, given more time or a second chance to respond, they may produce the alternative possibilities produced by their unitary reasoning system. Even for tasks where explicit computation is possible, like the bat and ball task, the “biased” response is a necessary step in computing the reflective response. This task involves solving the simultaneous equations (a) $x + y = \$1.10$, (b) $x – y = \$1$, for y (cost of the ball). The first step involves taking (b) from (a): $y - -y = \$1.10 - \$1$. The next step requires an understanding that $y - -y = 2y$, which is beyond many UG psychology students in the UK. Yet they may realise that the difference, \$1.10 - \$1, is on the way to the solution. Getting this far may also lead to their maths tutor awarding them more than 50% of the marks in a classroom test. But giving this answer may leave a feeling of unrightness because the process was not completed. Given a second chance, people respond with a figure less than 10 cents, indicating an understanding that $y - -y$ is greater than y (Bago, Raoelison, & De Neys, 2019). So, the intuitive response arises as part of computing the correct solution suggesting that heuristics are unnecessary. The two possible responses emerge from the same rational cognitive process.

In summary, so-called biases may often be a function of the same processes that lead to the reflective, rational response (see also, Kruglanski & Gigerenzer, 2011). The response depends on how prior knowledge or cues in the task materials set the parameters of the computational models. Because the environment can change, and cues are not always present, people may unconsciously simulate more than one possibility. That people do so and record the results may be the core insight of mental models theory (Oaksford, 2022). The bat and ball task shows that algebraic tasks, usually requiring pencil and paper, can be automatised and at least partially solved unconsciously. Dual-process theories and the new paradigm in reasoning were once in lockstep (Elqayam & Over, 2013). However, the specific computational-level theories developed within the new paradigm that predicts both the “biased” and the correct response on many tasks may be better interpreted as undermining the basis for this distinction on which dual-process theory depends. (Words 995)

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(Words 487)

Towards Dual Process Theory 3.0

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Abstract: This commentary is sympathetic to De Neys's revision of dual-process theory but argues for a modification to his position on exclusivity and proposes a bold further revision, envisaging a Dual Process Theory 3.0, in which System 1 not only initiates System 2 thinking but generates and sustains it as well.

Despite the huge amount of experimental work done under the dual-process banner, dual-process theory still lacks an agreed theoretical framework. One issue concerns implementation. Are the neural resources involved in supporting each type of processing discrete, or do they overlap? Another issue is coordination. How are the two types of processing related functionally, and how are their activities coordinated? Most dual-process theorists adopt a default-interventionist view, according to which System 1 generates default responses, and System 2 is activated only occasionally, generating a more considered response, which overrides the default one. (I use "System 1" as a label for the suite of intuitive processes, without assuming that they form a unified neural system; similarly for "System 2".) However, this prompts the further question of exactly how the switch between intuitive System 1 processing and deliberate System 2 processing is managed.

It is this question—the "switch issue"—that occupies De Neys. He proposes that switching is controlled by System 1: System 1 monitors its own responses, calculates a measure of their uncertainty, and initiates System 2 when the measure exceeds a certain threshold. System 1 also monitors the outputs of System 2 and terminates System 2 processing when a response with a suitably low uncertainty is generated. De Neys argues that this requires us to give up the assumption that System 2 responses are beyond the reach of System 1 (the "exclusivity assumption").

I like De Neys's revision of dual-process theory (a form of "Dual Process Theory 2.0"), but I am going to suggest that System 1 has an even bigger role in System 2 processing than De Neys recognizes. First, however, I want to make a comment about exclusivity.

De Neys argues that if switching is under System 1 control, then exclusivity cannot hold, since System 1 initiates a switch when it generates both the intuitive and the deliberate response and is uncertain which to select (target article, section, 2.2). This is too strong, however. For as De Neys acknowledges, System 1 can also initiate a switch when it has generated just one response or no response at all (target article, section 4.4). So *some* switching could occur even if exclusivity held. However, I think we should deny exclusivity all the same. De Neys presents empirical evidence against it, and he may be right that switching is *often* triggered by conflict within System 1. Moreover, as De Neys notes, System 1 may include automatized versions of System 2 processes, and if it does, then exclusivity will not hold. The upshot is that while we should reject the strong exclusivity claim that *no* System 2 response can be generated by System 1, we should not endorse the strong *inclusivity* claim that *every* System 2 response can be generated by System 1.

On now to the larger issue. I agree with De Neys that System 1 plays a role in controlling System 2, but I think we need to go further—much further. System 1, I propose, does not only initiate and monitor System 2 processes; it also *generates* them. I have developed this idea in previous work (e.g., Frankish 2009, 2018, 2021), so I shall merely sketch it here.

The core idea is that System 2 processing involves the conscious manipulation of culturally transmitted symbols—words, numerals, diagrams, and so on—either external or, more often, mentally imaged. The manipulations are generated by System 1, and they serve to break down the original problem into simpler subproblems which System 1 can solve. I have described the process as one of *deliberative mastication*. If all goes well, it culminates in a solution to the original problem.

As an example, take division. We can solve simple division problems intuitively, but we deal with more complex ones by executing a procedure for long division, writing down dividend and divisor in a certain format, solving the simpler problems the format highlights, writing down the answers to these problems, and so on, till we have our answer. This is, I suggest, an example—albeit an unusually explicit one—of slow, effortful, System 2 reasoning, and it is under continuous System 1 control. System 1 initiates the actions involved (writing and manipulating the numerals), receives relevant perceptual inputs, recognizes the subproblems posed, solves these subproblems, and so on—all the while monitoring to see if a solution to the overall problem has been reached.

All System 2 processes, I suggest, are similar, being constituted by activities that decompose a problem into intuitively solvable chunks, though these activities are usually internalized ones involving the manipulation of inner speech or other mental imagery rather than external symbols (for examples, see the works cited above).

This proposal explains why System 2 processing places heavy demands on attention and working memory (which are required for imagery manipulation) and why its processes are transparent (the images can be recalled and reported). Moreover, it offers an economical answer to the implementation question I mentioned at the start. In this view, the core cognitive resources driving System 2 processing are those of System 1, though further resources, including those of working memory, language, and perception, are employed as well. Thus, System 2 is not a separate neural system but a *virtual* system, realized in activities generated by System 1.

This view extends the approach De Neys proposes, and his speculations about how System 1 controls System 2 could be elaborated to reflect System 1's expanded role. At each stage in a System 2 process, System 1 will calculate what activity to generate next, receive perceptual or imagistic feedback, generate responses to the subproblem presented, and calculate whether and how to continue the process, using techniques of the sort De Neys describes, including uncertainty monitoring and calculation of opportunity costs.

In conclusion, De Neys's proposal not only advances theorizing about fast-and-slow thinking but also points to how it might be advanced still further, moving us towards a Dual Process Theory 3.0 in which System 1 not only initiates System 2 thinking but generates and sustains it as well.

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Individual differences and multi-step thinking

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Abstract: Deliberative thinking often consists of several steps, each involving a switch decision. These decisions may be influenced by confidence in the thinking done so far. Individuals may differ in their tolerance of low confidence and thus may arrive at unjustified high confidence too soon, either from trusting their intuition or by bolstering an initially favored conclusion.

Here I elaborate on some of the points that De Neys discussed only briefly. These concern the nature of deliberative thinking, and the sources of individual differences. This comment is largely a summary of some assertions that I have elaborated elsewhere, and some of them are speculative (Baron, 2019; Baron, Isler & Yilmaz, in press).

On the first point, the division of thinking into these two systems fits well in explaining most of the laboratory experiments discussed, where "deliberation" simply means that some controlled (i.e., not automatic or immediately intuitive) deliberation is going on. But this deliberation often involves a series of steps, each of which may draw on some automatic/intuitive processes (Ackerman & Thompson, 2014). The steps may be understood as consisting of search and inference (Baron, 1985). The goal is to find the best possibility, the best answer to the question that led to the thinking. Each step may involve the addition or deletion of a possibility from a short list of candidates (which may start with none, in the case of stumper problems), the search for of relevant evidence or arguments bearing on the strength of the various possibilities, and, in many cases, the search for additional goals.

At each step, the thinker makes inferences about the strength of each possibility. Thus, at each step, the think must make another "switch" decision, namely, whether to produce the current strongest possibility as the answer or to continue searching and making inferences. This cycle of search, inference, and deciding whether to continue is clear in such ordinary tasks as consumer purchases, some of which may require days or weeks of deliberation (e.g., buying a house). It is also part of most real-life problem solving, where one possibility is something like, "give up trying to fix it yourself and call the electrician". And it is part of thinking about moral and political issues, thinking that often occurs on the scale of years.

We can think of the switch decision at the end of each step (including the first, which is the focus of the target article) as based on a summary measure of "confidence" in the results so far (essentially the "feeling of rightness" described by Ackerman and Thompson (2014). Confidence will be high when one possibility is very strong and the others are weak. Strength of the favored option is itself a function of how the thinking done so far was done, and how the thinker responds to the various determinants. Individuals may differ in how they respond, e.g.:

1. A thinker trusts her intuition. Her confidence in the initial intuitive response may be high enough to stop at the end of the first step, this not making the switch that De Neys discusses.

2. A thinker accepts the standards of "actively open-minded thinking" (AOT, Baron, 2019, in press). Possibilities will not be considered strong unless a search has been made for other possibilities and for evidence both favoring and opposing the initially favored possibility (and for possible goals that were neglected so far).

3. A thinker begins with low strength but suffers from "uncertainty aversion". Uncertainty in this case can result of not doing much thinking. To remove the uncertainty, the thinker searches for evidence favoring the initial intuition, bolstering it, so that its strength is artificially high. This bolstering leads to the sorts of apparent failures of System 2 that are noted in the target article.

Thinking does not always have to proceed to get a conclusion with high confidence. It is often reasonable to stop thinking just because thinking is not making progress or because the answer is not worth more time and effort. At this point, an honest answer to a question about confidence, without self-deception, would be that confidence is low. Scientists, when speaking to the public, often qualify their statements with expressions of low confidence. People with uncertainty aversion could think that the scientists are bad thinkers; these people think that good thinkers should always be confident (and that is also why they are inclined to bolster their own confidence, when that is needed).

Alternatively, when thinking is not making progress, it is often reasonable to "outsource" it: e.g., consult a professional. In matters like politics, most people outsource their thinking to trusted sources. The problem then becomes how they determine who is trustworthy.

Individual differences can result in part from acceptance/rejection of AOT as a standard, and trying to conform to it (or not). Rejection of this standard consists of myside bias (confirmation bias, looking for support for an initially favored conclusion) and “uncertainty aversion,” which is a belief that uncertainty itself is undesirable. These two properties work together. One way to avoid uncertainty is to try to bolster initial conclusions so that confidence will increase. Shynkaruk and Thompson (2006) found support for such bolstering. Subjects judged the validity of each of 12 syllogisms intuitively (within 10 sec) and then deliberatively, rating their confidence in each judgment. Of interest, many subjects showed increased confidence after deliberation even though they did not change their (incorrect) answer. Other evidence, reviewed by De Neys, indicates that deliberation can serve to rationalize initial conclusions, an example of myside bias.

It would be nice to put all the pieces together through studies of individual differences in tasks like that used by Shynkaruk and Thompson.

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BBS-D-22-01063_ De Neys_ Fabio & Caprì

Advancing Theorizing about Fast-and-Slow Thinking: the interplay between fast and slow processing

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Abstract: We agree with the author's working model, but we suggest that: a) the classical distinction betweenfast and slow processes as separable processes can be softened; b) human performance might resultfrom an interplay between fast and slow processing and these processes may be mediated by systems that evolve to satisfy the need for operation in a complex environment.

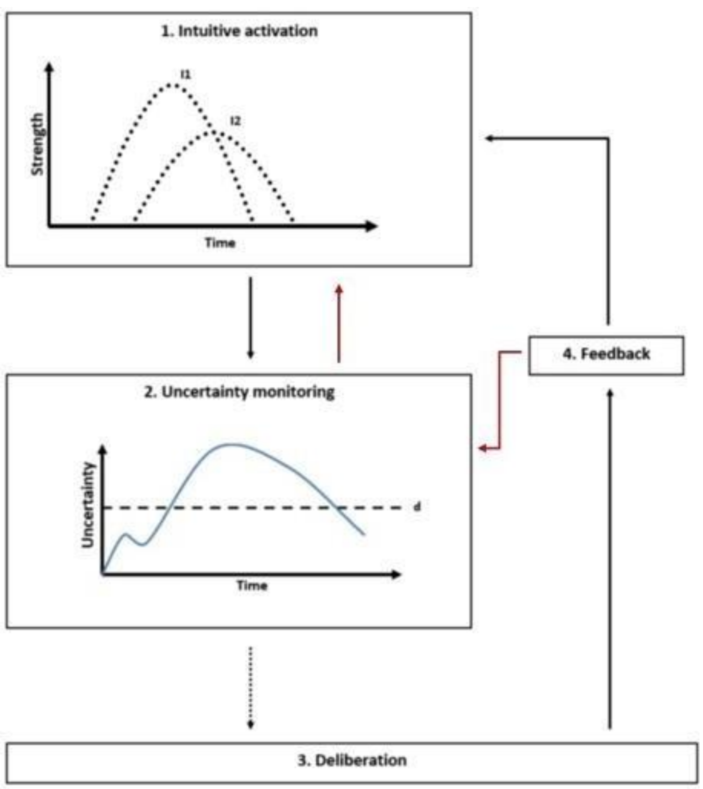
In the target article, De Neys (2022) argues that dual process models are obsolete and empirically and conceptually problematic to explain human reasoning. The author claims that problem is the tendency to conceive fast and slow processes or intuition and deliberation as two separate processes producing unique responses. So, the core problem of dual process models is toassume that fast and slow processes are based on exclusivity features. In contrast to these models,De Neys (2022) suggests the exclusivity and switch are two interconnected features of fast-and- slow processes. We agree with the author's idea, the classical distinction between fast and slow processes as separable and exclusive processes can be softened.

In literature, it has been demonstrated that the slow processes can gradually become flexible and context dependent (Fabio, Caprì & Romano, 2019). The term context refers to those perceptual features of the task setting that are not formally required for successful task performance,yet which may influence performance with practice based on contingencies with task-relevant information. Several studies (D'Angelo et al., 2012, 2013, 2014; Fabio, Caprì & Romano, 2019; Ruitenberg et al., 2012a, 2012b, 2015; Ruitenberg, Abrahamse, & Verwey, 2013) have examined if the slow processes can become flexible through reliance on contextual features, indicating that, when a task require the activation of both fast-and-slow processes, subjects can switch between both processes and context features facilitate this switching. Therefore, it is reasonable to assume that the fast and slow processes do not necessarily generate unique responses and they have not the exclusivity features, because the slow processes can become more flexible through the inclusion of context-specific features and subjects can operate a switch between these two processes. So, the idea that the exclusivity and switch are two interconnected features of fast-and-slow processes is in line with these researches.

As suggested by De Neys, and we agree with his idea, traditional dual processes models fail to explain a viable internal switch mechanism. De Neys proposes a more viable general model that can serve as theoretical groundwork to build future dual process models. The author's working model focuses on four components: intuitive activation, uncertainty monitoring, deliberation and feedback. In this model, the starting point are two intuitions that can generate a different response. This component represents an alternative and new point of view if it is compared to dual process model in which the starting point is one intuitive or deliberative process. Moreover, according to theworking model intuitive responses occur through an automatization or learning process. During development, any response might initially activate exclusive deliberation but through experience and practice this response will become automatized. This point of view is in line with the theories ofautomatization, demonstrating that after much practice the subjects show significant improvement in performing a task that initially require deliberative processes (Caprì, Santoddì, & Fabio, 2020; Fabio, 2009; 2017; Fabio & Caprì, 2019; Shiffrin & Schneider, 1977).

The second component of the De Neys' model is an uncertainty monitoring process, conceived as a mediator for access to the deliberative processes. According to the author, the uncertainty monitoring process calculates the strength difference between different activated intuitions, the more similar the activation strength and the higher the uncertainty will be. The argument on the role and functions of uncertainty monitoring process is very interesting. However, differently to De Neys' idea, we believe that it is not a problem if the uncertainty threshold is the same when there are two strong intuitions or two weak intuitions, this is correct because the uncertainty does not depend on the intensity of the two strengths. So, if both two intuitions are weakor strong it is right to achieve that the uncertainty is strong.

The third component of the De Neys' model is the deliberation that comes from the strength of the different activated intuitions. Deliberation might generate a combination of response suppression, generation, justification, or additional processes, and not necessarily a decrease in uncertainty. Consequently, it could occur a feedback loop in which System 1 and System 2 interact. The feedback stage is the last component of the De Neys' model. We agree with the argument about the third and fourth components, but we propose a change of the schematic illustration of the working model's core components. In the De Neys' illustration the arrow of fourth component goes intuitive activation (first component), we think a circular architecture in which the arrow of the feedback (fourth component) should return to uncertainty stage, and if the uncertainty is decreased, the arrow of feedback goes towards intuition; whereas if it is increased, the arrow goes towards deliberation.



Our suggestion on the change of direction of the arrow related to feedback stage is not a mere schematic suggestion, but it reflects a theoretical conceptualization of fast and slow processesas interconnected processes in which it is possible to switch between these and the uncertainty operate as mediator.

In conclusion, human performance might result from an interplay between fast and slowprocessing and these processes may be mediated by systems that evolve to satisfy the need for a decrease of uncertainty and operate in a complex environment.

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BBS-D-22-01064_ De Neys_ Handley et al.

Illusory Intuitions: Challenging the claim of non- exclusivity

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Illusory Intuitions: Challenging the claim of non- exclusivity
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Abstract: A person who arrives at correct solutions via false premises is right and wrong simultaneously. Similarly, a person who generates 'logical intuitions' through superficial heuristics can likewise be right and wrong at the same time. However, heuristics aren't guaranteed to deliver the logical solution, so the claim that System 1 can routinely produce the alleged System 2 response is unfounded.

De Neys sets out two of the key challenges for dual process theories as they have been traditionally conceived, the detection of response conflict and specification of the mechanism that controls the switch between System 1 (S1) and System 2 (S2) processing. In this commentary, we focus on first of these concerns and in particular the role of S1 in the generation of the 'alleged S2 response'; the claim that reasoners routinely generate 'logical intuitions'. Evidence for logical intuitions has been claimed across a range of paradigms, where there is evidence that conflict between knowledge based and rule-based responses, can be detected automatically, without the engagement of deliberative reasoning. According to De Neys, the proposal that S1 can generate a logical response solves one of the fundamental challenges for the dual process framework; how can conflict be detected without the prior engagement of S2 in calculating the normative response? The solution to this quandary is to posit non-exclusivity, the idea that the generation of a logical response is not the unique purview of S2.

For the past decade, our own work has similarly suggested that reasoners show intuitive sensitivity to the logical validity of simple deductive reasoning arguments. One of the most convincing pieces of evidence comes from belief-logic instructional paradigm, where, across multiple studies, we have shown that a conflict between the logical and belief status of a conclusion influences judgments of conclusion believability as much, if not more than conclusion believability influences logical judgments (Handley, Newstead & Trippas, 2011; Howarth, Handley & Walsh, 2016, 2019; Trippas, Thompson & Handley, 2017). The impact of conflict on belief judgments indicates that the logical inference is drawn automatically and intuitively and hence interferes with fast belief judgments. These findings appear to support De Neys claim for non-exclusivity, that S1 can generate logical intuitions.

However, our most recent research, together with parallel findings from other labs, suggest that the picture is not quite so straightforward. These findings suggest that 'logical intuitions' may have little to do with formal logic, but instead reflect sensitivity to superficial structural features (Ghasemi, Handley, Howarth, Newman & Thompson, 2022; Meyer-Grant, Cruz, Singmann< Winiger, Goswami, Hayes & Klauer, 2022). Converging evidence from research on the liking-logic task and the instructional paradigm show that logical intuition effects emerge because on valid arguments there is a match between the polarity of the premises and the conclusion, which is not present on invalid versions of the same arguments. Ghasemi et al. (2022) tested this explanation by utilising invalid arguments in which such a match was present, and showed that 'logical intuition' effects are equally as strong on these invalid argument forms. They concluded that reasoners are not intuitively sensitive to logical validity in a formal sense, instead they are picking up on structural cues that reflect the repetition of elements in the premises. Our most recent research further shows that training in logical principles improves discrimination between valid and invalid logical forms under logical instructions, but does not reduce the propositional matching effect under belief instructions, providing convincing evidence that logical intuitions arise because of sensitivity to non-logical features rather than logical validity per se (Ghasemi, Handley, & Stephens, 2022).

De Neys argues that although the S2 response may be generated by S1 processes, the equivalence is situated at the response level. Hence, an equivalent response generated by the intuitive and deliberative systems does not imply that the response was generated by the same mechanism or has the same features. Perhaps S1 does in fact rely on heuristics that draw on surface features but these co-vary with the logical status of the conclusion, hence on average deliver an intuition that aligns with the S2 response? So, does it matter if the intuitive response is generated by heuristics? We argue that it does, because a heuristic is no guarantee to a logical conclusion. In fact, more than half a century of work shows that heuristics regularly lead to systematic errors in reasoning and judgment tasks (Tversky & Kahneman, 1983) and the alignment of the output of a heuristic mechanism with the logically correct response can often be a matter of chance or clever experimental design (Evans & Lynch, 1973; Handley & Evans, 2000). We have recently run a series of studies in which the output of a matching heuristic and the logical response were misaligned. In these circumstances, matching dominates S1 outputs, while logic dominates S2 (Ghasemi, Handley, & Howarth, 2022). What these studies illustrate is that there is no guarantee that a response based upon superficial problem features will align with the formal logical response. You might get it right for the wrong reason, but you are as likely to get it wrong for the wrong reason also.

Is there a way of reconciling our findings with De Neys model? We think that there is at least one intriguing resolution which draws upon alternative normative accounts of human thinking that do not rely on formal logic as a normative standard. Such accounts are framed within the new paradigm in the psychology of reasoning which edifies the utilization of heuristics as an adaptative mechanism, sensitive to probabilistic logic or information gain (Oaksford & Chater, 2020). An intriguing possibility is that logical intuitions, whilst arising through the application of simple heuristics, nevertheless respect the probabilistic structure of the environment and hence deliver outputs that have a rational basis. Such outputs will often align with a S2 response that draws upon deductive logic and hence the non-exclusivity principle will often, but not always hold. Perhaps intuitive reasoners do indeed sometimes get it right, but for a different reason, not the wrong one.

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The distinction between long-term knowledge and short-term control processes is valid and useful.

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Abstract: The binary distinction De Neys questions has been put forward many times since the beginnings of psychology, in slightly different forms and under different names. It has proved enormously useful and has received detailed empirical support and careful modeling. At heart the distinction is that between knowledge in long-term memory and control processes in short-term memory.

De Neys makes a case for the lack of support and specificity of the binary conceptual distinction between fast and slow thinking. It is certainly the case that any binary distinction applied to the complexities of human cognition (including perception, memory, and decision making) could not possibly be more than a crude approximation to reality. Yet the binary distinction he questions has been put forward many times since the beginnings of psychology, in slightly different forms and under different names. It has proved enormously useful; its constant resurrection testifies to its utility; in some of its forms it has received detailed empirical support and careful modeling. One can focus on any one of these binary instantiations and find much to criticize, but there is a fundamental basis for human cognition that is being captured and a look at the history of these concepts shows many similarities and a great deal of support.

The conceptual distinction is closely related to those between automatic and controlled processing, between short-term memory (including working memory) and long-term memory, between automatic and attentive processing, between working memory and semantic memory, between the use of rules vs expertise, between the use of algorithms vs memory, between beginners vs experts in motor tasks, games, and sports, between fast and slow thinking, between intuitive vs deliberate thinking and decision making, and more along these lines.

One of the first empirical presentations of the ideas was published by Bryan and Harter in Psychological Review in 1899. They examined the development of automaticity in the receiving of telegraphy, arguing for stages in which a kind of chunking in memory took place, so that perception of the dots and dashes being sent would occur at larger and larger scales, starting for example with letters, and later with words and then phrases or sentences. That led to a number of additional explorations in the 20 years following. The basic idea was that performance at first goes step by step, dot by dot, dash by dash, letter by letter, but as learning proceeds the incoming dots and dashes are perceived in larger and larger groups, and long-term memory and knowledge can thereby greatly improve speed of receiving telegraphy. Seventy five years later, LaBerge and Samuels (1974) applied these ideas to the development of automaticity in reading.

Related distinctions proved critically important in theorizing how memory operates, as exemplified in the chapter by Atkinson and Shiffrin titled "*Human memory: A proposed system and its control processes*" (1968). A key distinction was between a relatively permanent long-term memory containing knowledge and a short-term memory, also called working memory, in which control processes controlled the operations of cognition, including access to long-term memory and knowledge.

The distinction between learned behavior stored in long-term memory and control processes in short-term memory received what surely is it most thorough and complete empirical exploration by Schneider and Shiffrin (1977) and Shiffrin and Schneider (1977) in the form of a contrast between automatic and controlled processing (later termed a distinction between automatic and attentive processing: Shiffrin, 1988). They used visual and memory search to show how step-by-step controlled processing is used initially for both forms of search, and used throughout for both forms of search when training was inconsistent (termed varied mapping), but gradually became automatized in various ways as consistent training (termed consistent mapping) would cause learning to take place; for example, a target may come to call attention to itself automatically.

Another thorough and careful empirical and theoretical investigation of these ideas was carried out by Gordon Logan and colleagues, for example as laid out by Logan in Psychological Review in 1988. In various articles about that time Logan and colleagues investigated the automatization of multi-step processes like counting dots or verifying alphabet arithmetic equations, showing that with consistent practice, the multi-step algorithm is replaced by rapid retrieval of previously encountered solutions. Slow thinking is replaced by automatic retrieval from long-term memory.

The above two examples take the form of a distinction between active use of attention and automatic processing. In these examples, as in all other binary divisions of cognition, the boundary between the two forms of processing is imprecise. For example, in the absence of automatic processing and learned attention to targets, visual objects tend to be examined one at a time; processing time rises as the number of objects increases because on average the searched-for target is found halfway through the sequence of comparisons. As consistent training proceeds, a target comes to draw attention to itself, so that the target is found in the first step, rather than at a random point in the sequence of comparisons. However that automatic attention process may be slower than a single comparison carried out by a controlled process; when only one object is presented a controlled comparison can be faster than automatic attention attraction. We note that Vim De Neys faults dual processing approaches due to lack of evidence of “exclusivity”. In much of the automaticity literature the view is both processes operate in parallel and interact.

There is a growing literature of biological separation of automatic and controlled processing. Strokes that damage structures such as the right parietal cortex can severely compromise control processes, but spare automatic processing, as seen in neglect (Mesulam, 2000). Schneider and Chein (2003) review much of this literature. Chein and Schneider (2012) highlight the way that learning alters the activity of neural networks as automatic processing develops -- see Figure 1.

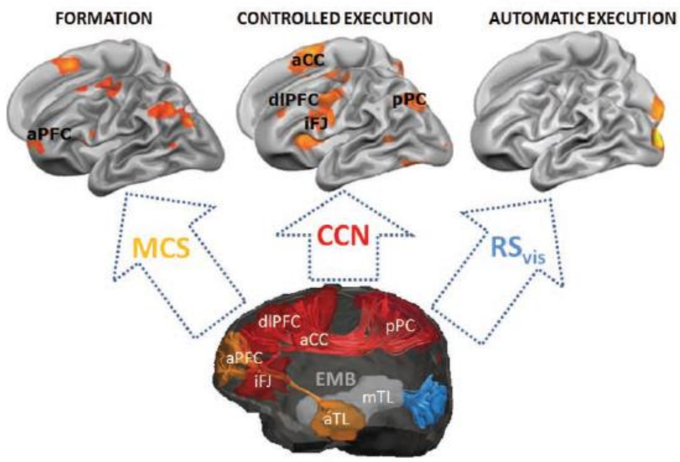

Figure 1. *How learning in the form of development of automaticity alters activity in neural networks, seen in Figure 2 of Chein & Schneider 2012. Functional MRI reveals changes in brain activation as learning proceeds in a simple visual-discrimination task. Initial performance is associated with increased activity in the anterior prefrontal cortex (aPFC), of the metacognitive system (MCS). After the first few trials, activity declines in the aPFC and increases in the interconnected regions of the cognitive control network (CCN)—the dorsolateral prefrontal cortex (dlPFC), the anterior cingulate cortex (aCC), the posterior parietal cortex (pPC), and the inferior frontal junction (iFJ)—to support controlled execution of the task. After considerable practice, automatic processes develop and activity declines generally.*

The distinctions we have been discussing have also played an important role in applications in society. To take just a few examples they have driven research and practice in reading education in children (LaBerge & Samuels, 1974; Samuels, 1997), in medical decision making (Evans, Birdwell & Wolfe, 2013), in aging (Fisk et al., 1997; Hasher & Zacks, 1979), and in clinical science (Huijbregts et al., 2003).

It would take a book rather than this commentary to trace all these closely related binary distinctions, because they have appeared and been used throughout the history of psychological research, albeit under various names. Research on them demonstrates great utility in classifying human cognition in these ways, as demonstrated by a great deal of careful empirical research, theorizing, and quantitative modeling in certain of these domains. Notwithstanding the admitted imprecision of these binary conceptual divisions of cognition, and the differences between them, we believe there is a fundamental importance and utility to the distinction between control processes carried out in short-term working memory, and automatic learned processes stored in long-term memory as knowledge. The message conveyed by De Neys to this extent misses the 'big picture' and is misleading.

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BBS-D-22-01066_ De Neys_ Sirota

When a thinker does not want to think: Adding meta-control into the working model

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Abstract: De Neys (2022) proposes an elegant solution to several theoretical problems of the dual-process theories but underspecifies the role of motivation in initiating, intensifying and ceasing deliberation. Therefore, I suggest including a meta-cognitive control component in the working model that can moderate deliberation, for instance by affecting the deliberation threshold.

I applaud Wim De Neys (2022) for proposing a new working model of the dual-process theory that solves its two theoretical conundrums. Admirably, the proposed model integrates recent evidence, offers precise, testable hypotheses, and can be computationally implemented. It provides an elegant answer to the questions of what makes us think and what makes us stop thinking. However, it primarily focuses on bottom-up processes and underspecifies top-down processes, such as the role of motivation in initiating, intensifying and ceasing deliberation. In other words, the working model should have a suite of mechanisms that help us decide when hard thinking is needed but also when it is worthwhile.

Imagine, for example, a situation where a person faces a complex mathematical problem, which does not trigger any initial intuition, and deliberation has been activated. According to the working model, it ceases only if the uncertainty parameter, U, decreases under the critical deliberation threshold, d (e.g., reaches the conflict resolution). So, deliberation cannot stop if a person cannot achieve a sufficiently significant decrease in the uncertainty parameter (e.g., it does not resolve the conflict between the two conflicting intuitions). But a thinker cannot deliberate endlessly since deliberation is costly. Simply put, the current working model does not account for situations when a thinker does not want to think—so hard, so long or at all—about the problem. Yet, prior research in higher cognition identified empirical and theoretical arguments supporting the critical importance of motivation to deliberate (e.g., Evans, 2011; Stanovich & West, 1998). For instance, in one dual-process model, motivational factors regulate the level of critical effort, which determines whether a reasoner will endorse the default answer as justified or try to correct it (Evans, 2011).

To resolve these issues, I propose expanding the "opportunity cost factor" suggestion presented in the target article (De Neys, 2022, pp. 43–44) and including a meta-cognitive component of control allocation into the working model. Such control allocation mechanisms have been proposed in the literature investigating control allocation over lower cognition tasks, such as Stroop tasks, and have been supported by behavioural and neuropsychological evidence (e.g., Kool et al., 2017; Shenhav et al., 2017; Shenhav et al., 2021). For instance, the control allocation component can compute the efficiency of the deliberation to achieve the desired outcome while taking the cost and benefits of deliberation into account. Some initial evidence points to the fact that people consider the costs and benefits of deliberation when correcting reasoning (Sirota et al., manuscript). For instance, the performance reward and imposed cost affect how much time individuals allocate to correcting their initial errors and, in turn, problem-solving accuracy. So, the meta-cognitive control component is involved in the switching (on and off) of thinking by considering the efficacy of deliberation and its cost and benefits.

There might be different pathways by which meta-cognitive control can interact with uncertainty monitoring; for instance, it can directly affect uncertainty (De Neys, 2022). It can also modulate the deliberation threshold: it might decrease or increase the critical deliberation threshold while not affecting the uncertainty parameter. For instance, it can make the deliberation threshold high and, in turn, make deliberation more challenging to switch off if the overall value of reaching the correct answer by deliberating is big (e.g., a maths problem solved during an important exam). So, the uncertainty parameter must be minimal to reach the deliberation threshold. On the other hand, the meta-cognitive control can make the threshold low and, in turn, deliberation easy to switch off if the overall value is small (e.g., a maths problem solved during an anonymous experimental session that participants found tedious). Thus, even weak intuitions generating high uncertainty can pass it. For instance, if the uncertainty initiated deliberation, but the deliberation was not as efficient as assumed with the type of problem, or the costs of deliberation were too high, then the threshold might be lowered. Here, the control's overall value is driven not only by the cost (whether intrinsic or opportunity costs) but also by the control efficacy and the reward one can ascribe to deliberation. Furthermore, to avoid the same theoretical traps outlined in the target paper, one can assume that this component computes such values more or less effortlessly, whether by retrieving cached information about the reward and cost associated with the task or by estimating the value heuristically from task cues (see Kool et al., 2018).

Finally, one can also speculate whether such a meta-cognitive component can help to resolve other open questions concerning deliberation listed in section 4.3. First, the control allocation component can modify the deliberation intensity—not only the duration. For instance, with high-stakes outcomes, control allocation can intensify, not just prolong deliberation. Second, it can also assist with deciding which type of deliberation processes are carried out (e.g., default answer justification, default answer correction). For instance, a reasoner might compare the overall values of deliberation needed to justify and correct the default answer and decide that justification is a more beneficial use of deliberation resources.

Thus, including the meta-cognitive component of control allocation into the working model can resolve several open questions of the working model. It can also better integrate research and theory on the role of motivation in thinking and be combined with the other model components.

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BBS-D-22-01067_ De Neys_ Greene

Dual-Process Moral Judgment Beyond Fast and Slow

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Abstract: De Neys makes a compelling case that the sacrificial moral dilemmas do not elicit competing "fast and slow" processes. But are there even two processes? Or just two intuitions? There remains strong evidence, most notably from lesion studies, that sacrificial dilemmas engage distinct cognitive processes generating conflicting emotional and rational responses. The dual-process theory gets much right, but needs revision.

As a proponent of the dual-process theory of moral judgment (Greene et al., 2001, 2004; 2008; Greene, 2013) I had, following Kahneman (2003, 2011), long thought of its dual processes as respectively "fast and slow". De Neys makes a compelling case that this is not so. One might conclude, then, that the dual-process theory of moral judgment should be retired. But that, I believe, would be a mistake. There remains strong evidence that moral dilemmas elicit competing responses that are supported by distinct cognitive systems, that one response is meaningfully characterized as more emotional, and that the other is meaningfully characterized as more rational. We may simply need to drop the idea that one response gets a head start in decision-making.

For the uninitiated… we are considering sacrificial moral dilemmas such as the *footbridge* case in which one can save five lives by pushing someone in front of a speeding trolley (Thomson, 1985). According to the dual-process theory, the characteristically deontological response (that it's wrong to push) is supported by an intuitive negative emotional response to the harmful action, while the characteristically utilitarian judgment (that it's morally acceptable to push) is driven by more deliberative cost-benefit reasoning. What's now in question is whether the utilitarian judgment is in fact more deliberative and less intuitive.

There is accumulating evidence that the utilitarian response is not slower (Koop, 2013; Baron & Ğürçay 2017a-b; Rosas, 2019; Bago & De Neys, 2019; Tinghog et al., 2016; Cova et al. 2021), despite a body of evidence indicating that it is (Greene et al., 2008; Suter & Hertwig, 2011; Tremoliere et al., 2012). De Neys argues that such dilemmas simply involve two competing intuitions, and he gives no reason to think that they are driven by distinct processes. And yet, if one looks beyond reaction times and cognitive load, evidence for distinct processes abounds.

I can't properly review this evidence here, but I can describe some highlights. Here I focus on studies of lesion patients, which have produced some of the most dramatic evidence supporting the dual-process theory. Koenigs et al. (2007) showed that patients with damage to the ventromedial prefrontal cortex are overwhelmingly more likely to make utilitarian judgments compared to healthy patients and brain-damaged controls. What's more, these patients have impaired emotional responses, as demonstrated by skin-conductance data. Similar results with VMPFC patients are reported by Ciaramelli et al. (2007), Thomas, Croft, & Tranel (2011), and Moretto et al. (2012). Demonstrating the opposite effect, McCormick et al. (2016) show that patients with hippocampal damage are overwhelmingly more likely to give deontological responses, and they provide parallel evidence using both skin-conductance data and patient self-reports that these responses are due to dominant emotional responses. Verfaelle et al. (2021) report similar results. (But see Craver et al. 2016). Finally, and most recently, Van Honk et al. (2022) show that patients with damage to the basolateral amygdala (implicated in goal-directed decision-making) is associated with increased deontological judgment. And here, too, the effects appear to be due to dominant emotional responses. (Note that the basolateral amygdala is distinct from the central-medial amygdala, which is associated with classic affective responses and is what psychologists typically think of as "the amygdala".)

Cushman (2013) has reconceptualized the dual-process theory as a contrast between model-based and model-free algorithms for learning and decision-making (Sutton & Barto, 1998; Balleine & O'Doherty, 2010). (See also Crockett., 2013). Model-based judgment is based on an explicit representation of cause-effect relationships between actions and outcomes, plus values attached to outcomes. Model-free judgment depends, instead, on accessing values attached directly to actions based on prior reinforcement. Cushman and colleagues have since provided compelling evidence that utilitarian judgments are model-based, while deontological judgments are driven by model-free responses (Miller & Cushman, 2013; Patil et al., 2020). Moreover, the model-based/model-free distinction specifically explains why patients with hippocampal damage and basolateral amygdala damage make fewer utilitarian judgments (McCormick et al., 2016; Van Honk et al, 2022). As Cushman emphasizes, model-based judgment is not emotion free, as value must be attached to outcomes. But as the patient data indicate, not all emotion is equally emotional.

Putting all of this together, the following picture emerges: Deontological and utilitarian judgments are driven by different processes, as indicated by the contrasting effects of damage to different brain regions. And yet the behavioral data suggest that neither of these processes is reliably faster than the other. Should we say that both responses are intuitive, as De Neys suggests? Yes, in a sense. Both responses come to mind quickly, and further processing is needed to adjudicate between them. (See Shenhav & Greene, 2014, on how these responses may be integrated.) But there is an important sense in which the deontological response is more intuitive. It is based on a feeling that the action is wrong. And, in dilemmas like the *footbridge* case, this feeling is affected by whether the action involves pushing vs. hitting a switch (Greene et al., 2009; Bago et al., 2022). This sensitivity to the physical mechanism of harm is unconscious (Cushman, Young, & Hauser, 2006) and not easy to rationally defend (Greene, 2014; 2017). By contrast, the model-based response is based on an explicit understanding of cost and benefits. This may not require much deliberation, at least when it's just 5 lives vs. 1, but it is recognizably rational. Indeed, such judgments are correlated with a range of judgments in non-moral contexts that are unequivocally rational (Patil et al., 2020).

All of this suggest that the dual-process theory's fundamental distinction between emotional and rational responses remains intact, but with the surprising twist, supported by De Neys' synthesis, that it's not about fast versus slow.

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BBS-D-22-00993R1_ De Neys_ Ferreira & Huettig

Fast and slow language processing: A window into dual-process models of cognition

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Abstract: Our understanding of dual-process models of cognition may benefit from a consideration of language processing, as language comprehension involves fast and slow processes analogous to those used for reasoning. More specifically, De Neys's criticisms of the exclusivity assumption and the fast-to-slow switch mechanism are consistent with findings from the literature on the construction and revision of linguistic interpretations.

Sometimes language processing can be hard. Just as many problems are easy to solve, many sentences are easy to interpret–for example, *the cat chased the dog*. Alternatively, just as some problems leave us stumped, some sentences defy our comprehension mechanisms–for example, the infamous *the horse raced past the barn fell*. For decades, psycholinguists have attempted to explain what makes sentences difficult to understand, with some models pointing to the costs of integrating information over long distances (Gibson, 1998), others focusing on the effects of the unexpectedness of each word as it is encountered (so-called “surprisal”-based models; Hale, 2016), and others emphasizing the consequences of ambiguity (Ferreira & Henderson, 1991). Here we concentrate on syntactic ambiguity because it highlights many of the issues associated with fast and slow processing. Specifically, in his target article, De Neys challenges researchers in decision-making to reevaluate the exclusivity assumption and to specify how the switch mechanism that triggers the switch from fast to slow reasoning works. We believe consideration of these issues from the perspective of language processing could prove useful, as they have been at the center of theoretical debates in psycholinguistics.

During comprehension, the system that assigns syntactic structure, the parser, will often encounter a sequence that can be assigned more than one grammatical analysis. In those cases, given a range of linguistic biases, the parser may select an analysis that will require revision. Take the sequence *Mary believes Tom*. On the parser’s first encounter with the postverbal noun phrase *Tom*, it will likely analyze the phrase as a direct object. But if the sentence continues with a verb such as *lied*, the parser has a problem: *lied* must be syntactically integrated but there is no grammatical place for it in the structure. The only solution is for the initial analysis to be revised so that *Tom* is not a direct object but rather the subject of a complement clause. Moreover, not only does the structure require revision, but the meaning must be recomputed as well, because Mary does not in fact believe Tom. These processes can be viewed within the dual-processing framework De Neys discusses, with the initial analysis being the output of System 1 and the revised interpretation the output of System 2. The first response is fast and automatic, and the second requires a slower, more deliberate mode of processing in which the structure and the interpretation are systematically undone and rebuilt.

Much debate has centered around the question of what determines the initial analysis. For the purposes of this commentary, we set that question aside to focus on the two issues De Neys considers in the target article: the exclusivity assumption and the switch mechanism. Taking exclusivity first, psycholinguists know that often an initial, intuitive analysis will align with what a more deliberate process would deliver. Sentences sometimes resolve themselves in a way that is consistent with initial syntactic expectations (e.g., *Mary believes Tom implicitly*), and with knowledge and experience, many experienced language users will succeed in obtaining the correct interpretation of even the more challenging sentences right from the start, with no need for revision. In other cases, the initial system will deliver multiple interpretations of an ambiguous sequence, which means revision may involve a simple shift from one analysis to another. Findings from language comprehension, then, make clear that System 1 can deliver a correct analysis.

Turning now to the switch mechanism, much is known in psycholinguistics about what triggers the switch to a more deliberate, System 2 processing mode. One critical factor is a breakdown in coherence. In the case of so-called “garden-path sentences” such as *Mary believes Tom lied*, the trigger is syntactic collapse: The tree formed for the first three words cannot accommodate the verb *lied*. This breakdown in syntactic coherence shifts the parser into a repair mode in which it revisits its previous syntactic decisions, attempts new solutions, and tries to create a revised, integrated structure. In other cases, the trigger is a breakdown in semantic coherence. For example, given *Mary believes the rain…* (as in *Mary believes the rain will stop soon*), an initial analysis on which *the rain* is analyzed as a direct object can be revised when the more deliberative system detects the semantic anomaly of believing rain. This semantic incoherence will cause the parser to review its past syntactic decisions and attempt new choices that lead to a better semantic outcome. In reasoning, a switch from fast to slow processing may similarly be triggered by a breakdown in coherence, albeit at a conceptual rather than a linguistic level of representation.

Recent work on the influence of literacy can also be interpreted according to this dual processing framework and is particularly relevant for thinking about exclusivity and the switch from System 1 to 2 modes that De Neys discusses. Literacy, for instance, uniquely predicts participants' ability to correctly accept and reject spoken sentences according to the prescriptive grammatical norms of their language (Favier & Huettig, 2021). In linguistics, such judgements are known to involve both System 1 and System 2 processes. Literacy also makes comprehension of challenging linguistic forms more automatic (as evidenced by enhanced prediction abilities, Favier et al., 2021), providing one potential mechanism for how System 2 can, over time, turn into System 1 processing. A dual-systems approach to language processing thus has the potential to provide new mechanistic answers about the automatization of System 2 responses as well as the interplay between fast and slow systems.

In summary, our view is that a domain in which the exclusivity assumption and the switch mechanism highlighted by De Neys can be profitably scrutinized is language processing, a cognitive system that has not often been invoked in discussions of System 1 and System 2 processing and the coordination of their outputs. We believe that considering language processing through the lens of this dual-processing framework will help to illuminate the issues related to thinking that De Neys discusses in the target article.

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Dual-process theory is Barbapapa

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Abstract: The biggest benefit of dual-process theory lies in its role as a benchmark theory that, regardless of its empirical plausibility, serves as a starting point for better and more domain-specific models. In this sense, dual-process theory is the Barbapapa of psychological theory—a blob-shaped creature that can be reshaped and adapted to fit in the context of any human behavior.

There is much to like about how De Neys analyzes and seeks to advance theories about fast and slow thinking. One is the emphasis on that there is no good–bad or rational–irrational analogy that can be made based on the distinction between intuition and deliberation. Another is the promotion of a non-exclusive view of dual-process theory, where intuition and deliberation do not necessarily need to generate unique responses such that one type of response is exclusively tied to deliberation and is assumed to be beyond the reach of the intuitive system. However, we think that it is important to distinguish the dual purpose of dual-process theories for (1) producing testable predictions and (2) functioning as benchmark theories that, no matter their empirical plausibility, can serve as a starting point for more refined research questions and domain-specific models. We argue that the main benefit of dual-process theories lies in the latter of these two. Thus, dual-process theories have much in common with the fictional character Barbapapa, a blob-shaped creature with the notable ability to shapeshift and thereby smoothly overcome any obstacle. Just like Barbapapa, dual-process theory is liked by many and can easily be reshaped to fit in many contexts.

De Neys argues that a core issue of dual-process theory lies in its exclusivity feature, the assumption that intuition and deliberation should result in unique responses such that one type of response is exclusively tied to deliberation and cannot be reached via intuition. We agree that this exclusivity assumption is not supported by the empirical literature; however, viewing the lack of empirical evidence as a weakness of dual-process theory implicitly assumes that the main purpose of dual-process theory is to provide empirically falsifiable predictions of human decision making and to pinpoint the exact mechanisms that explain why certain behaviors come about. Although making predictions and pinpointing mechanisms are an important ambition when developing further model specifications, we would argue that the perhaps most important function of dual process theory is in its role as a benchmark theory that, no matter the empirical falsifiability, can serve as an all-embracing framework for thinking about how people process information. In this perspective, dual-process theory does quite well. Arguably a key reason for why dual-process theory has become so popular is that it can easily be reshaped and refined to make sense of the cognitive processes underlying human behavior in specific domains. Thus, we think that dual-process theory has become so influential *thanks to* the fact that it is practically impossible to falsify, not despite it.

In some sense, dual-process theory can be seen as psychological science's equivalent of Expected Utility Theory in economics. Expected Utility Theory is an all-embracing theory for assessing decision outcomes and can be applied to all contexts and decisions. It is difficult to falsify the claim that a certain chosen behavior maximizes that person's utility, because we typically behave in a way that leads to what we expect to be the most preferred outcome. The key for any model specification is how to define and measure utility. Expected Utility theory serves as an intuitive way to organize and make sense of the costs and benefits that people assign to outcomes. However, whereas Expected Utility Theory focuses on the *outcomes* of decision making, dual-process theory provides a framework for thinking about the *process* of decision making. Dual-process theory thus adds a missing perspective to the outcome-focused framework that economists traditionally work within.

The evolution of dual process theory has brought economists and psychologists closer together in the quest to improve understanding of human behavior. Still, attempts to merge dual-process theory with utility maximization and general economic models are few. For future developments of dual-process theory it could be worthwhile to start thinking about how the growing literature on belief-based utility (Golman et al 2016; Grant et al 1998; Loewenstein & Molnar, 2018) relates to and can be incorporated into dual-process theory. These models emphasize that beliefs often fulfill important psychological needs that can influence how people assess information. People hold certain beliefs partly because it makes them feel good, not because they are necessarily correct (Sharot & Sunstein, 2020; Tinghög et al 2022). We see the feedback loop presented in De Neys's model as a potential starting point for theoretical work in this direction. In addition, the future research agenda for dual-process theory could benefit from being more inclusive and less narrow-minded in regard to qualitative methods. The workhorse methodological vehicle in the dual-process literature has been behavioral experiments testing hypotheses about the general effect of invoking more intuitive or analytical processing. However, as pointed out by De Neys, dual-process theory runs into problems when it is used as a framework to make predictions about aggregate behavior. To understand individual differences and make sense of contradicting patterns of results, qualitative approaches may be needed to provide deeper insights that can not be achieved through experiments.

Back to Barbapapa. Who is Barbapapa? He is a blob-shaped creature from a well-known cartoon who tries to fit into the human world. His most notable ability is to shapeshift at will and thereby smoothly overcome any obstacle. After various adventures Barbapapa finally meets Barbamama who has the same notable ability to shapeshift. Together, Barbapapa and Barbamama are able to merge in order to resolve even bigger obstacles. They have seven barbababies who too can shapeshift at will but who have more distinctive individual strengths that can be used to overcome particular obstacles. Barbapapa, Barbamama, and their barbababies are always ready to help and do not fear action. Dual-process theory is the theoretical equivalent of Barbapapa, since it can easily be reshaped to fit the understanding of any human behavior. In the same analogy, Expected Utility Theory is Barbamama, and the barbababies are the more domain-specific dual-process models. Describing dual-process theory in this way highlights its role as a benchmark theory to develop better and more specific models. To conclude, dual-process theory is Barbapapa. The world needs Barbapapa and social science needs dual-process theory.

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