can directly affect uncertainty (De Neys, target article). 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 article, 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, Gershman, & Cushman, 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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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.

The 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" (target article, sect. 5, para. 1). The target article omits citation of any particular dual-process theory that contained this assumption and that was published after 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 Fig. 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 (sect. 4.3, para. 1), 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" (target article, sect. 4.3, para. 1) 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 plague the traditional model" (target article, sect. 5, para. 2).

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 "although 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" (target article, sect. 3.1, para. 3). 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 straw man 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, Gibb, & Thompson, 2017; Trippas, Thompson, & Handley, 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 straw man 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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