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On Dual- and Single-Process Models of Thinking

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Abstract
Popular dual-process models of thinking have long conceived intuition and deliberation as two qualitatively different processes. Single-process-model proponents claim that the difference is a matter of degree and not of kind. Psychologists have been debating the dual-process/single-process question for at least 30 years. In the present article, I argue that it is time to leave the debate behind. I present a critical evaluation of the key arguments and critiques and show that—contra both dual- and single-model proponents—there is currently no good evidence that allows one to decide the debate. Moreover, I clarify that even if the debate were to be solved, it would be irrelevant for psychologists because it does not advance the understanding of the processing mechanisms underlying human thinking.

Keywords
dual-process model, single-process model, intuition, deliberation, System 1, System 2

One of the clearest characteristics of people's mental life is that some thought processes are easy and others are hard. If one is asked "What is your name?" or "How much is 2 + 2?" the answer pops up in a split second without any effort. However, if one is asked "What is the name of the American president who succeeded Dwight Eisenhower" or "How much is 231 × 22?" arriving at a decision will take more time and effort. This distinction between an effortless and effortful or "intuitive" and "deliberate" mode of cognitive processing lies at the heart of the influential dual-process models that have been prominent in psychological research on human thinking since the 1960s (e.g., Evans, 2008, 2016; Evans & Stanovich, 2013; Kahneman, 2011; Sloman, 1996; Smith & DeCoster, 2000).

It is presumably hard to overestimate the popularity of dual-process models. They have been applied in a very wide range of fields, including research on logical reasoning (Evans, 2002; Wason & Evans, 1975), social cognition (Chaiken & Trope, 1999; Sherman et al., 2014), morality (Greene, 2015), economic decision-making (Rand et al., 2012), time perception (Hoerl & McCormack, 2019), management science (Achtziger & Alós-Ferrer, 2014), medical diagnosis (Djulbegovic et al., 2012), religiosity (Gervais & Norenzayan, 2012; Tremlin, 2005), health behavior (Hofmann et al., 2008), theory of mind (Wiesmann et al., 2020), intelligence (Kaufman, 2011), creativity (Barr et al., 2015; Cassotti et al., 2016), and susceptibility to fake news (Bago et al., 2020). They have been featured in best-selling books (Kahneman, 2011) and popular media (e.g., Atlas, 2012) and even inspired policy recommendations by the World Bank (e.g., World Bank Group, 2015).

However, despite the extreme popularity of dual-process models, they have also been criticized. A key concern has been put forward by proponents of single-process models (or *unimodels*; e.g., Arkes, 2016; Hammond, 1996; Keren & Schul, 2009; Kruglanski, 2013; Kruglanski & Gigerenzer, 2011; Melnikoff & Bargh, 2018; Osman, 2004). The foundational dual-process assumption is that intuition and deliberation are two qualitatively different processes. Intuition and deliberation are assumed to be characterized by fundamentally different operation characteristics, principles, and functions. According to the single-process model view, there is no such qualitative difference. The single-model view does not deny that one can distinguish a more intuitive and more deliberate type of thinking and that these can be subjectively experienced as being quite different. But according to the single-model view, this difference is a matter of degree

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and not kind. The difference between intuition and deliberation is assumed to be merely quantitative in nature. Put differently, intuition and deliberation are conceived to lie on opposite ends of the same scale rather than on two completely different scales.

The dual-process model/single-process model debate has been around for a long time and continues to fill the pages of prominent journals (e.g., De Houwer, 2019; Evans & Stanovich, 2013; Keren, 2013; Kruglanski & Gigerenzer, 2011; Melnikoff & Bargh, 2018; Osman, 2018; Pennycook et al., 2018; Stephens et al., 2018). My goal in the present article is to convince the community that it is time to move on and leave the debate behind. The article is organized around two main sections. In the first section, I review and evaluate key arguments and critiques that have been put forward by single- and dual-process proponents. On the basis of this evaluation, I argue that there is currently no empirical data or theoretical principle that allows one to decide the debate. In the second section, I clarify that it can be questioned whether the debate can ever be solved and that even if it could, it would be irrelevant for understanding the psychological processing mechanisms underlying human thinking. This leads me to conclude that it is pointless for empirical scientists to continue the debate any further.

Before moving on to the main sections, I briefly clarify some points with respect to the nomenclature I will be using and the scope of the article.

Nomenclature and Scope

Single, dual, and multiple processes

Dual-process models are a special case of multiple-process models. Dual-process models assume the need for two qualitatively different processes to characterize human thinking. However, further subdivisions can be made to argue for three, four, or more qualitatively different types of processes (e.g., Evans, 2019; Houdé, 2019; Samuels, 2009; Sherman, 2006). All these multiple-process models can be compared with single-process models that argue against any qualitative difference (Gilbert, 1999). I use the popular *dual-process* label here as an umbrella term for all multiple-process models. All the arguments I make with respect to dual-process models apply to multiple-process models. Put bluntly, if we cannot decide between two qualitatively different processes, we cannot decide between multiple qualitatively different processes.

Dual process and dual systems

Dual-process models are also being referred to as *dual-system* models. These labels are often used interchangeably, but sometimes they are used to refer to a specific subclass of models. For example, some dual-process models are more specific in their scope and others more general (Gawronski & Creighton, 2013). The more specific models are developed to account for specific phenomena or tasks; the more general ones are intended to be more integrative and apply to various phenomena. Some authors use the *system* label to specifically refer to the latter, more general models. However, the *dual-system* label can also be used to refer to a further subdivision within the subclass of general models. As I will clarify, dual-process theorists have often pointed to various opposing features of intuitive (e.g., fast, effortless) and deliberate thinking (e.g., slow, effortful). Dual-systems models can then also refer to those models that assume that there is a perfect alignment between these features. To avoid confusion, I will explicitly refer to this specific view as the *perfect-alignment* dual-process view. In all other instances, the labels *process* and *system* can be used interchangeably, and all arguments apply to the more specific and general instantiations of dual-process models.

Dual-process model, theory, framework, or view

I will also use the labels *model, theory, framework*, and *view* interchangeably. In theory, these labels may carry implications about how advanced, developed, and/or specific the predictions of the "theory" are conceived to be. I take a neutral stance in this debate. My use of these labels has no further implications with respect to the specificity or generality of the claims.

Received dual-process view

Given the popularity of dual-process models, it will be no surprise that there are many different types of models. These often share some minimal superordinate family resemblance (e.g., the postulation of two qualitatively different thought processes), but the specifics can vary widely. One could indeed claim that there are as many dual-process theories as dual-process theorists. Friends and enemies of the framework often call on the generic or "received" superordinate version in their discussions (Evans & Stanovich, 2013). This can be problematic because any specific dual-process theorist can be criticized for claims he or she never explicitly made (Evans, 2017). In the present article, my generic use of the label *dual-process model* simply refers to any model that postulates that there is a qualitative difference between intuitive and deliberate thinking. Whenever making more specific claims, the authors in question will be directly cited.

Table 1. Features Often Attributed to Intuitive and Deliberate Thinking

Intuitive ("System 1")	Deliberate ("System 2")
Fast	Slow
Effortless	Effortful
Independent of cognitive ability	Correlated with cognitive ability
Automatic	Controlled
Does not require working memory	Requires working memory
Autonomous	Cognitive decoupling and mental simulation
Unconscious	Conscious
Biased responses	Correct, normative responses
Contextualized	Abstract
Associative	Rule-based
Affective	Logical
Implicit knowledge	Explicit knowledge
Evolutionarily old	Evolutionarily recent
Shared with other animals	Distinctively human

Single- and dual-process models of thinking

As I noted, dual-process models have been applied in a wide range of fields and domains. The main scope of the present article is the field of thinking (e.g., reasoning and decision-making). It most directly implies the seminal work of authors such as Kahneman (2011), Evans and Stanovich (2013), Epstein (1994), Sloman (1996), or Kruglanski and Gigerenzer (2011). Although I believe the arguments are relevant for dual-process models in other fields too (e.g., memory, learning), they will not be directly considered. Hence, as the title suggests, the scope of this article concerns the discussion between single- and dual-process models of thinking.

Dual-Model Arguments Versus Single-Model Arguments

In this section, I review key arguments around which the dual-process/single-process debate has centered: feature alignment, defining features, criterion S, parsimony, and the misinformation issue. I present an illustrative overview and clarify misconceptions that have plagued either side of the debate.

Feature alignment

An introduction to dual-process theory typically comes with a table such as Table 1, in which various alleged opposing features of intuitive and deliberate processing are listed. Intuitive thinking is characterized as, for example, fast, effortless, and independent of cognitive capacity, whereas deliberation is characterized as being slow, effortful, and dependent on cognitive capacity. Why have dual-process theorists ever referred to these "list-of-features" tables? One reason is that many features often seem to go hand in hand. If I ask you to tell me your name, you can answer in a split second, it does not take you any noticeable effort, and you do not need an Einstein-level IQ to answer correctly. In this sense, the list of features simply conveys the quite uncontroversial information or observation that many of these features can be correlated.

However, proponents of a more extreme position could argue that the features do not simply co-occur to some extent but that they necessarily have to do so. Under this extreme view, the features are perfectly aligned along the various dimensions that are listed in Table 1. A process is always, for example, fast and effortless (and so on) or slow and effortful (and so on). One cannot have one without the other. If one feature is present, all the others in the column are too, and all the opposing features in the other column are not. Under this view, the alignment is posited as a mandatory rule of nature. Such a perfect, natural alignment can then be used to argue for the existence of qualitative differences. The fact that intuition and deliberation are so perfectly contrasted on so many dimensions might give the impression that they must be two fundamentally different mental "species."

The perfect-alignment dual-process view is highly problematic in many respects. First, in essence, the "alignment = qualitative difference" argument is not sound. The fact that different features might go hand in hand does not necessarily provide any information about the nature of these differences. Even if all the features in Table 1 were indeed perfectly aligned and always co-occurred, this does not imply that the difference between intuition and deliberation therefore becomes qualitative rather than quantitative. Although it might be persuasive to argue for qualitative differences on the basis of a perfect alignment, there is no logical necessity here. In theory, perfect alignment does not preclude a mere quantitative difference per se. Likewise, at the other end of the spectrum, nonalignment does not argue against the dual-process position. The core dual-process claim is that there is a qualitative difference between intuitive and deliberate processing. Hence, as long as there exists a qualitative difference along a single dimension (e.g., speed), there is no need for such a difference along multiple features. In sum, the alignment question is independent of the dual process/single process discussion. The extent to which the different features are aligned does not allow one to decide in favor or against a single- or dual-process model.

A second fundamental problem for the perfect-alignment dual-process view is that there is a wealth of empirical evidence against it. All that is needed is a single example of a case of nonalignment (e.g., a process is slow and effortless). Such cases are not hard to find. One long-known example is the incubation phenomenon (Wallas, 1926) whereby setting a problem aside (i.e., not explicitly thinking about it) for some time facilitates solutions. The classic example is when, after a good night's sleep, one sees the light and realizes how to solve a problem one had been struggling with the evening before (for a review of recent empirical work, see Gilhooly, 2016). Incubation is effortless but also slow. One needs to quite literally "sleep on it" or set a problem aside for minutes or even hours. In this sense, it is nothing like the snap-second solving of "2 + 2 = 4." Hence, although effortless processes can be fast (as in the "2 + 2 = 4" case), they can be very slow too.

The incubation example illustrates that effort and speed do not necessarily align. Effortless processes can be fast, but sometimes they will also require extensive "cooking in the back." Obviously, cases of nonalignment are not restricted to the speed and effort features. A good example concerns the alleged alignment between reasoning accuracy and deliberation. Intuitive reasoning processes are often characterized as cuing incorrect ("biased") solutions to logical reasoning problems, whereas deliberative processes are assumed to lead to correct solutions. However, a clear counterexample against such alignment can be found in the "rationalization" phenomenon (Evans & Wason, 1976). Reasoners will often spend quite some time and effort to come up with justifications for incorrect responses. Bluntly put, they engage in deliberation to "make up excuses" and find explicit reasons to support an intuitively cued answer. After such rationalization, people will often be more convinced that their erroneous answer was in fact correct (Koehler, 1991; Shynkaruk & Thompson, 2006). Hence, this is clear example of a case in which deliberation leads to more "bias."

Over the years, critics of the perfect-alignment dual-process view have systematically identified cases of nonalignment (for reviews, see e.g., Bargh, 1994; Keren & Schul, 2009; Melnikoff & Bargh, 2018; see also Hassin, 2013; Moors, 2014; Moors & De Houwer, 2006a, 2006b). As in the above illustrative classic examples, this makes it crystal clear that the perfect-alignment view can be readily rejected. However, from here, the dual-process model/single-process model debate has become muddled. Critics of the dual-process view have tended to equate the dual-process view and the extreme, perfect-alignment view. The evidence against a perfect feature alignment has then been used to argue against the dual-process view per se (Keren & Schul, 2009; Melnikoff & Bargh, 2018; Osman, 2004, 2018). Arguably, this confusion results at least partially from the fact that the early dual-process theorists have not always been explicit at how strict or perfect the alignment was hypothesized to be (Evans & Stanovich, 2013). Nevertheless, the feature-alignment question is independent of the question of whether intuition and deliberation are qualitatively different. The case for nonalignment does not imply that the difference is quantitative in nature. As long as there exists a qualitative difference along a single dimension, there is no need for such a difference along multiple features (Evans & Stanovich, 2013; Pennycook et al., 2018). Consequently, the empirical observation of alignment or nonalignment does not allow one to decide the debate.

Defining features

In recent years, dual-process theorists have explicitly denounced the perfect-alignment view (Evans & Stanovich, 2013; Stanovich & Toplak, 2012). They have stressed that the dual-process view requires only that there is a single feature along which a qualitative difference arises. Such a critical feature is referred to as a *defining feature*. Its presence or absence allows one to decide whether one is dealing with an intuitive or deliberate process. All other features in the list are merely correlated features. Under specific conditions, they might co-occur with the defining feature, but their presence or absence is neither necessary nor sufficient for intuition or deliberation.

So a first question is this: What are the defining features? In theory, a qualitative difference might arise along any of the listed features. Various dual-process theorists can have different opinions about which specific feature or features they conceive as defining. Nevertheless, the discussion has typically centered around three specific features: working memory involvement, cognitive decoupling-mental simulation, and autonomy. Some authors have posited but a single defining feature

(Pennycook, 2017; Thompson, 2013), others multiple (e.g., Evans & Stanovich, 2013). But in general, dual-process proponents have argued that there is clear evidence for qualitative processing differences along at least one or some of these three specific features (Evans & Stanovich, 2013; Pennycook, 2017; Thompson, 2013). Single-process proponents have questioned this claim (Keren, 2013; Kruglanski, 2013; Osman, 2013).

A central issue in the debate—next to the question as to what the defining features are—is that the various defining features are not dichotomous but continuous in nature. A dichotomous feature can take only two values; it is either present or absent (e.g., dead/alive, solid/liquid, male/female[1]). If a feature is dichotomous, its presence or absence can be measured, and one can consequently decide whether one is dealing with an intuitive or deliberate thought process. A continuous feature lies on a continuum and can take an infinite number of values. Consequently, to establish whether one is looking at an intuitive or deliberate process, a cutoff point or threshold needs to be determined. As long as there is *X* amount of feature A, processing is intuitive in nature; above threshold *X*, processing will be deliberate in nature. The general problem is that determining this threshold is far from straightforward (e.g., Moors, 2014; Moors & De Houwer, 2006b).

I will illustrate the problem with the speed feature. There is little discussion that speed is continuous in nature. No matter how fast intuitive processing is assumed to be, given that it is instantiated in a physical substrate (the brain), it will always take some time. Hence, to determine whether one is dealing with an intuitive or deliberate process, one cannot simply check whether the feature is present (the process takes time) or absent (the process takes no time). This implies that one needs to define and empirically determine a threshold at which the qualitatively different type of processing arises. In the case of speed, this implies that a process that takes less than *X* time will be intuitive and that a process that takes a nanosecond more will have a completely different quality and become deliberative. Although it might not be easy to imagine how such a difference would arise, in theory, one cannot exclude that processes below and above the threshold will indeed be qualitatively different. In practice, the problem is that there is no principled way of determining and testing where the threshold lies. How to know whether processes that take less and longer than *X* time have different qualities? At this point, the alignment issue rears its head again. Presumably, one will need to look at correlated features. For example, one might establish that processes above and below the speed threshold are experienced as effortful and effortless. Or that they load differently on working memory. Clearly, this cuts the ground under the defining feature argument: One assumes that speed is the defining feature, but to test this empirically, effort (or another correlated feature) is measured. Hence, speed itself is not the defining feature; effort is.

To be clear, I used speed as an illustrative example. To my knowledge, no dual-process theorist has claimed that speed should be considered a defining feature. However, as I will readily demonstrate, the exact same problems plague each of the three features that have been explicitly put forward as defining features. Moreover, the postulated defining features face an additional problem: Whereas what speed is and how to measure it (see again Note 1) are known, the alleged defining features are conceptually vague and less well defined. I will clarify how this complicates the threshold issue further.

Working memory. In their seminal 2013 article, Evans and Stanovich posited that a first defining feature of deliberate processing is that it loads on working memory, whereas intuitive processing does not. They characterized working memory as the limited-capacity, controlled, or executive attention system as has been put forward in the influential work of Baddeley (2007) or Engle (Barrett et al., 2004; Engle, 2018). At a very general level of description, it is clear what Evans and Stanovich have in mind. Few scholars would contest that attentional resources play a critical role for many higher order functions, including reasoning (e.g., Vandierendonck, 2018). However, if one wants to use working memory engagement as a defining feature to argue for qualitative differences in a two-process model, one needs a more fine-grained definition and operationalization. The problem is that there are quite different views and theories on the nature and characteristics of working memory (for an excellent overview, see Oberauer et al., 2018). This theoretical vagueness complicates drawing a clear, sharp distinction between a process that burdens working memory and one that does not. Put bluntly, if it is not clear how the defining feature needs to be defined, it is hard to know whether it has been engaged and whether the postulated qualitatively different type of processing should be observed.

In this light, it is also illustrative to take recent evolutions in the working memory—or more specifically, controlled attention (i.e., one of the processes assumed to underlie working memory; Barrett et al., 2004; Engle, 2018)—research into account. It has been shown that various processes that had long been considered the hallmark of controlled attention can also operate unconsciously (e.g., Desender et al., 2013; Jiang et al., 2015, 2018; Linzarini et al., 2017). For example, traditionally, controlled attention was believed to be critical to override or inhibit interfering stimuli. A classic illustration can be found in the Stroop task in which participants have to name the color of the ink in which a word is written. People are slower to do this and make more errors when the ink color conflicts with the written word (e.g., the word *white* written in black ink) than when the ink color and word are congruent (e.g., the word *black* written in black ink). The standard rationale is that because reading is so automated for educated adults, it is hard to refrain from doing it. Therefore, not giving in to the tendency to read the color word is assumed to require effortful controlled processing.

A classic finding in Stroop-task research is that people will perform better on an incongruent trial when it is preceded by a previous incongruent (vs. congruent) trial. The fact that one will already recruit cognitive control when trying to solve the first incongruent trial will facilitate the solving of the subsequent incongruent problem (Braem & Egner, 2018). However, in recent years, it has become clear that this “adaptation” effect is also observed when the first trial is presented subliminally, outside of conscious awareness (Desender et al., 2013; Jiang et al., 2015, 2018; Linzarini et al., 2017). Hence, even when one cannot consciously perceive the first trial, one will show facilitation on the subsequent, consciously presented trial. This suggests that control was unconsciously exerted on the subliminal trial without any intent of the participant. These and related findings have resulted in broader theoretical advances that indicate how attentional control mechanisms can simply result from low-level associative mechanisms (Abrahamse et al., 2016; Algom & Chajut, 2019; Braem & Egner, 2018).

Against this backdrop, it becomes clear that working memory and, more broadly, attentional control engagement need to be conceived on a continuum. Obviously, there might be differences in complexity. Deliberate thinking can still be characterized as requiring more extensive attentional control than intuitive thinking. However, the problem then becomes to determine the precise splitting point. Exactly what level of attentional control defines deliberate thinking? How does one test whether people’s thinking above the threshold is really qualitatively different? These are the exact same problems I highlighted with the speed example above.

Note that dual-process proponents may be tempted to reply to this critique by pointing to findings with experimental cognitive constraints paradigms (Evans & Stanovich, 2013; see Osman, 2013). For example, during a reasoning task, participants may be given a secondary task (e.g., memorizing a complex visual pattern; e.g., De Neys, 2006) that requires controlled attention resources. Because the secondary task will take up some attentional control resources, fewer of these resources can be allocated to the reasoning task. If reasoning accuracy decreases under the secondary task load, one can therefore conclude that the reasoning process requires attentional control resources. This allows one to operationally classify the reasoning process as deliberate. However, dual-process theorists are mistaken when arguing that this shows that the process is qualitatively different from intuitive processing. Obviously, even if one assumes that there is a mere quantitative difference between intuition and deliberation, one can still posit that a deliberate process will need more attentional control (i.e., working memory) resources than an intuitive one. If the required amount of resources for proper deliberation is not available, the process cannot be completed successfully. Consequently, the qualitative and quantitative view can make the exact same prediction with respect to the impact of cognitive constraints (e.g., Keren & Schul, 2009). In sum, the cognitive constraints paradigm is a great tool to help one decide whether a process is more intuitive or deliberate in nature, but it does not allow one to conclude anything with respect to the qualitative versus quantitative nature of the two processes.

Cognitive decoupling and mental simulation. According to Evans and Stanovich (2013), a second defining feature of deliberate thinking is that it involves cognitive decoupling and mental simulation. Mental simulation is the process of envisioning a situation that is not factually the case. To mentally simulate an event, one must be able to prevent the representation of the imaginary, simulated, or hypothetical situation to become confused with one’s representation of the real world (otherwise, one would no longer know what is real and simulated). Therefore, the representation of the real world needs to be decoupled from the representation of the simulated event. This decoupling process enables mental simulation. Both go hand in hand (and presumably this is why Evans & Stanovich, 2013, listed them as a single defining feature).

At a general descriptive level, this characterization is again making good sense. Few scholars would disagree with the claim that deliberate thinking will often involve a process whereby one imagines alternative possibilities and hypotheses (i.e., “hypothetical thinking”) and decouples representations (e.g., dissociating semantic beliefs and the underlying logical structure of a statement). However, the problem is that if one puts this characterization forward as the defining feature that qualitatively differentiates deliberation and intuition, a much more specific processing specification is needed. Stanovich (2011) went to great length to characterize and describe the cognitive decoupling and simulation process. However, to date, this theorizing has not clarified how one can operationally measure whether a mental simulation process has occurred. The available empirical evidence focuses on measuring correlated features such as the effortful, cognitively demanding nature of mental simulation (e.g., the fact that it will be less likely among people lower in cognitive capacity or under cognitive load; e.g., Evans & Stanovich, 2013; Stanovich, 2011; Stanovich & West, 2000).

At this point, it might be worthwhile to clarify some potential confusion with respect to the specification of multiple defining features. As I noted, in theory, a dual-process model requires only that there is a qualitative difference along a single dimension. Hence, a single defining feature may suffice. Alternatively, one can also argue that multiple defining features need to be present. For example, a process will need to both engage working memory and involve mental simulation before it can be classified as deliberate. This is the position that Evans and Stanovich (2013) seem to be taking. Hence, the two defining features they identified are necessary conditions for a process to be classified as deliberate; they need to co-occur. This is not trivial because as soon as one posits multiple defining features, there might be cases of nonalignment between the defining features. That is, a process might require mental simulation but not engage working memory. One clear example involves cases of regret. Imagine a story about someone who usually drives their son to school. One day, they very exceptionally decide to walk to school, and the boy gets run over by a truck. Here one typically engages in counterfactual thinking (i.e., "If only I had taken the car . . . "). One readily starts imagining alternative states of affairs. This process involves mental simulation, but it is not cognitively demanding. Experimental studies show that people still engage in it when their attentional resources are burdened with a secondary task (Goldinger et al., 2003). Indeed, it is precisely refraining from engaging in this counterfactual reasoning process that seems to be demanding. Hence, there can be cases in which the two defining features will be dissociated (Osman, 2013). In and of itself, this is not a problem. If a deliberate process is defined as requiring both features, a process that has only one of the features will simply not be considered a deliberate process. At a practical level, it does become clear that this further complicates the issues that plague each defining feature in isolation. To falsify whether the alleged qualitatively different intuitive and deliberate processing occurs, not only one but two imprecisely defined concepts must be conjointly measured.

Autonomy. Dual-process theorists have also pointed to the autonomy of intuitive processes as a critical defining feature (Pennycook, 2017; Thompson, 2013). In general, autonomous processes are conceived as those processes whose execution is mandatory when their triggering stimuli are encountered. Whenever the stimulus is perceived, the response will be executed irrespective of the intent of the reasoner. In other words, whenever an autonomous process is initiated, it will run to completion whether or not one wants it to; the outcome is not under control of the reasoner (e.g., Braem & Egner, 2018; Diamond, 2013).

Note that Evans and Stanovich (2013) characterized autonomous processes as the opposite of processes that require mental simulation. However, this this does not need to be the case. As Thompson (2013) argued, intuitive processes can be defined as being autonomous and deliberate processes as nonautonomous processes without making any further assumptions about the nature of the nonautonomous processing (i.e., whether it involves a mental simulation process).

A popular example to illustrate the difference between an autonomous and nonautonomous process is the difference between algebraic problems such as (a) "|+| = ?" and (b) "236 × 42 = ?" When faced with the problem in (a), any educated adult cannot help but think of the answer "2." The "2" instantly pops to mind whether or not one wants it to. With the second problem, this is not the case. Merely encountering it does not suffice to think of the answer (i.e., 9,912); the reasoner will need time and effort to compute it. Clearly, even if one wants to, one might not always manage to arrive at the answer. However, the point is that one can actively decide to refrain from computing it. With the first problem, we do not have this choice; the outcome is not under one's control.

As with the other defining features I reviewed, it will be clear that at a general, descriptive level, the autonomy suggestion is far from unreasonable. From a phenomenological point of view, few would disagree that the two problems above indeed feel quite different. However, whenever one needs a more precise, testable operationalization, it becomes readily clear that the autonomy concept also remains too vague.

A key issue is that people are always surrounded by gazillion potential stimuli. Sound, light, and pressure waves constantly hit humans' retinas, ear drums, and skin. Only a fraction of these are consciously perceived and attended to. Hence, encountering the stimulus per se is not sufficient to define autonomy. One needs to attend to the stimulus and consider it relevant in the current processing context. To illustrate, consider the inattentional blindness phenomenon (e.g., the famous "invisible gorilla" studies, Simons & Chabris, 1999). Imagine you are watching a group of people who are passing a basketball to each other. Your job is to count the number of times the ball is being passed. Unbeknown to you, at a certain point, the experimenters will let a man dressed in a gorilla suit run through the court. Most laypeople expect that they would readily notice

a. | + | + | + | = ____

b. | + | + | = ___

c. | + | + | + | + | + | + | = ________

d. | + | = ?

Fig. 1. Illustration of the line-length-estimation task.

and attend to such a weird event. However, the experimental data show they do not. The vast majority of participants simply fail to notice the gorilla. Because one's attention is focused on the passes-counting task, one is blind to any stimuli that are not relevant to the task. Hence, autonomy is never absolute or universal but always contingent on the context (e.g., task goals).

To illustrate the point further, imagine you are shown a number of matchsticks in vertical position (e.g., "|") and are asked to mentally rotate them horizontally (e.g., "—") and "glue" them together. You are then asked to estimate how long the resulting summed horizontal line is. You get items such as in Figure 1. After doing a couple dozen of these, you presumably will get pretty good at the task. Imagine now that at a certain point you are given the item in Figure 1d. This is physically the exact same stimulus as the stimulus to which you answered "2" in the algebraic task above. However, during the line estimation task, you will not readily think of the Arabic numeral "2" but rather of the image "—."

The point is that there are no universally autonomous processes. Whether a stimulus *X* will mandatorily lead to response *Y* depends on the current task or "goal" context. Hence, to use autonomy as a defining feature, how attention and goal selection are operationalized need to be pinpointed. Imagine a dual-process theorist makes claims about a critical autonomous process that cannot be intentionally controlled. On testing, one finds that the process can be controlled. In this case, the dual-process theorists can always argue that the subject did not construe the proper goal context. Hence, falsifiable autonomy claims require an independent test to establish the goal context. Putting forward autonomy as a defining feature necessitates specifying an attention and goal-selection mechanism. This is far from straightforward. Currently, no dual-process theorist has provided such a specification.

Note that my discussion of defining features relied heavily on the arguments put forward in Evans and Stanovich (2013). Evans (2017, 2019) has since updated his views. Evans's (2017, 2019) key point is that a defining feature such as "autonomy" is too broad a defining feature for intuitive thinking. Because many low-level perceptive or digestive processes might in theory operate autonomously, they would also need to be classified as intuitive reasoning processes—which Evans conceives as problematic. Hence, Evans has proposed additional criteria to characterize intuitive thinking. In addition to being autonomous, one is typically also conscious of the output of prototypical intuitive-reasoning processes. For example, if you are asked "How much is 2 + 2?" the answer will be accompanied by a subjective feeling of correctness (or rightness; e.g., Thompson et al., 2011). As Evans (2019) put it, intuitive thought processes do not require working memory for their operation, but they do post their products into working memory in a way that other autonomous processes of the brain do not. Hence, according to the narrower updated definition, the defining feature of intuitive thinking is that it is autonomous and posts its output into working memory.

This framework is an interesting attempt at a more detailed processing specification of intuitive thinking. It allows differentiation between different types of intuitive processes (and different types of deliberate processes; for that matter, see Evans, 2019). Unfortunately, however, it does not help to settle the fundamental single-process model/dual-process model debate. Indeed, by positing an additional criterion, one again needs to measure two imprecisely established concepts: to determine whether a process is autonomous and whether its output (and only its output) is posted in working memory. The problems I highlighted for each individual traditional defining feature in isolation are back in full swing here.

Defining feature conclusion. Taken together, the defining features arguments and evidence that dual-process proponents have put forward do not suffice to support the claim that intuition and deliberation are qualitatively different. The general problem is that the features are not well defined and do not allow one to establish a precise threshold at which a continuous feature gives rise to a qualitatively different processing. To avoid confusion, as Keren (2013) noted, this does not imply that there is no such threshold and that there are no qualitative differences. The point is that it is extremely hard to establish the threshold empirically, and dual-process proponents have failed to provide clear evidence for it.

Criterion S

People can sometimes hold simultaneous contradictory beliefs. At the same time, one might be convinced that *X* and not-*X* are both the case. Consider, for example, superstitious beliefs (Risen, 2016). Sport fans might be very well aware that it is physically impossible that the shirt they are wearing affects the performance of their favorite football team, but they might nevertheless be convinced that their team will lose if they do not wear their team jersey while watching the game.

Contradictory beliefs can also occur during reasoning. Consider, for example, the ratio bias problem (Denes-Raj & Epstein, 1994). Imagine you are being presented with a small and large tray containing red and white jelly beans. In the small tray, there are one white and nine red jelly beans. In the large tray, there are nine white jelly beans and 91 red jelly beans. You can draw one jelly bean from one of the trays (without looking). If you draw a white jelly bean, you win $10. From which tray should you draw to maximize your chances of winning? Logically speaking, you should obviously pick the small tray. The probability of drawing a white jelly bean is 10% (1/10) for the small tray and only 9% (9/100) for the large tray. Nevertheless, many people prefer to draw from the large tray (Epstein, 1994). Intuitively, people tend to focus on the absolute number of white beans. Because there are more white beans in the large tray, people intuitively feel it is more likely they will end up with a white bean. When questioned, participants sometimes indicate they realize their preference is illogical. They report they "know" the odds are against them but nevertheless "feel" that the large tray is giving them a better chance of winning (Denes-Raj & Epstein, 1994; Epstein, 1994).

In an influential article, Sloman (1996) argued that the observation of simultaneously held contradictory beliefs (i.e., *criterion S*) supports the dual-process model. Sloman reasoned that any qualitatively homogeneous reasoning system[2] can provide but a single response at a time. Hence, if there are two conflicting responses at the same time, they must have been generated by two qualitatively different reasoning systems. This argument has been repeatedly criticized (Gigerenzer & Regier, 1996; Keren & Schul, 2009; Osman, 2004) but keeps on being used to justify dual-process models (Hoerl & McCormack, 2019).

It should be clear that the basic deductive logic of Sloman's (1996) argument is sound. If one posits by definition that a system cannot provide but a single response at a time, then criterion S entails the need for dual reasoning systems. However, the problem is that the assumption can be questioned. There is no empirical evidence that indicates that simultaneous contradictory responses necessarily result from two qualitatively different reasoning processes (Keren & Schul, 2009). That is, the same qualitative system can also produce simultaneous contradictory responses (Kelso & Engstrom, 2006). Hence, one should be able to empirically determine whether two responses are generated simultaneously.[3] However, the key point is that the claim that such co-occurrence results from two qualitatively different processes does not itself rely on empirical data and can be questioned.

Parsimony

The previous subsections indicated that it is hard to decide the single-process/dual-process debate on the basis of empirical data. The evidence does not suffice to conclude that there are qualitative differences, but we cannot exclude it either. Given the empirical ambivalence, one may also try to decide the debate with more theoretical arguments. For example, some scholars have argued in favor of a single-process account on the basis of parsimony (e.g., Hammond, 1996; Hayes et al., 2018; see also Gawronski & Creighton, 2013).

The principle of parsimony, or "Occam's razor," posits that when two hypotheses are equally well (or badly, if you wish) supported by the data, one should favor the hypothesis that makes the least assumptions. Put differently, simpler models are more likely to be true. The dual-process model assumes there are two qualitatively different types of reasoning; the single-process account postulates only a single process. Because one is less than two, parsimony might seem to favor the single-model account. However, although this argument might be appealing in its simplicity, it is fallacious. An easily overlooked aspect of parsimony is that it refers to the *total* number of theoretical assumptions that are required to explain a given finding (Gawronski & Creighton, 2013; Gawronski et al., 2014). That is, single-process models make additional assumptions beyond the simple claim that there is no qualitative difference between intuitive and deliberate processing. For example, Kruglanski's single-process models (Kruglanski et al., 2006; Kruglanski & Gigerenzer, 2011) feature numerous parameters that will modify the activation within the model. Without these parameters, the empirical findings cannot be fully accounted for. Any contrast between a single- and dual-process model needs to take the full range of assumptions or parameters into account. Consequently, the fact that a dual-process model postulates two qualitatively different processes does not make it less parsimonious per se.

Because the parsimony argument is often misapplied, it is worthwhile to clarify the point with an illustrative example. Imagine a single-process model. Intuitive and deliberate processing are conceived as opposite ends of the same scale. In and of itself, this model is not very useful. If the model wants to have any predictive and explanatory value, it will need to make additional assumptions and propose further specifications. For example, can reasoners engage in both types of processing simultaneously (i.e., can more intuitive and deliberate processes run in parallel)? Are the amount of simultaneous intuitive and deliberate processing independent of each other (e.g., can we engage in full-blown intuitive and deliberate processing at the same time, or does more intuitive reasoning necessarily imply less deliberate processing)? Imagine a single-process model in which intuitive and deliberate thinking are posited to be fully interdependent. The amount of activation at one level is the complement of the activation at the other level. So if a person is at 70% of maximum intuitive processing, that person is necessarily at 30% of maximum deliberate processing. In this model, a single parameter would suffice to model the activation state of the reasoner. But one can also imagine an alternative single-process model in which the activation levels are independent. Intuitive activation might be at 60% and deliberate processing at, say, 5% of their maximum activation. In this case, although one assumes that there is no qualitative difference between intuition and deliberation, the single-process model would still need two independent parameters to track the activation state of the reasoner.

At the other end of the spectrum, in theory, one can also construct dual-process models with independent and interdependent activation.[4,5] The interdependent dual-process model would assume that there are qualitative differences between intuition and deliberation but that their activation is linked. In this case, a single parameter can suffice to represent the activation state of a dual-process model. Alternatively, a dual-process model might also posit independent activation, and—just as its single-process independent activation cousin—it would require two parameters.

In sum, the parsimony of models is determined by the specific processing assumptions they make, not simply by the fact of whether one posits qualitative or quantitative differences. Processing assumptions such as the activation dependency question can be tested empirically (see the section, A Trivial Debate), but they do not allow one to decide between a single-process and dual-process view per se.

Scientific-misinformation argument

Another popular practical argument that is often used against dual-process models is that they are bound to lead to misinformation and halt scientific progress (e.g., Cokely, 2009; Melnikoff & Bargh, 2018; Osman, 2004, 2018). The argument goes that because intuition and deliberation are subjectively experienced as quite different, people are readily tempted to conclude that they are qualitatively different. Although there is no factual evidence for the duality, because of its simplicity, it is bound to slip into scientists' mind and—through science communication—into popular culture. Hence, the unsupported dichotomization will distort scientists' conceptualizations and misinform the general public. Because a single-process model does not posit a duality, it would fare better in this respect.

There are various points to make against this argument. First, the scientifically sound conclusion is that there is currently no empirical evidence to decide between a single-process or dual-process model view. Hence, logically speaking, one might indeed argue that a dual-process model misrepresents the scientific knowledge by positing that there *is* a qualitative difference between intuition and deliberation. But obviously, by the same logic, a single-process model equally misrepresents the scientific knowledge by positing that there is *no* qualitative difference.

Second, any scientific claim can be misinterpreted (Chater, 2018). It is indeed not hard to imagine how the dual-process duality might distort some people's judgment (Melnikoff & Bargh, 2018). But the same is true for the single-model view. For example, in a single-process model, people might be tempted to infer that if intuition and deliberation are not really different, it does not matter whether they do one or the other. Hence, this might give people the perfect excuse to refrain from engaging in demanding deliberation altogether. To date, there is no systematic comparative empirical data that speak to the issue. The claim that a dual-process model is more dangerous than a single-process model when it comes to misinforming the public (or vice versa) relies on personal opinion and anecdotes. In the absence of hard data, scientists should refrain from making strong claims here.

Third, the strong general claim that the dual-process conceptualization halts scientific progress per se is easily disproven in practice. One example is work on conflict detection during reasoning (e.g., Bonner & Newell, 2010; De Neys & Glumicic, 2008; Gangemi et al., 2015; Mata et al., 2017; Pennycook et al., 2014; Stupple et al., 2011; Swan et al., 2018; Travers et al., 2016). At least since the 1960s, it has been well established in reasoning and decision-making research that people's intuitions can cue so-called heuristic answers that can lead them to violate logical principles (Evans, 2002; Kahneman, 2011). Traditionally, it was assumed that this "bias" results from a failure to detect that one's intuitions conflict with more logical considerations (Morewedge & Kahneman, 2010). In the past decade, empirical studies on conflict or bias detection have forced scholars to revise the view. Response latency, confidence, and brain-activation data obtained with new experimental paradigms indicated that biased reasoners often show some minimal sensitivity to their errors (for review and discussion, see De Neys, 2012, 2017).

The vast majority of the work on conflict detection has used a dual-process conceptualization (e.g., Bago & De Neys, 2020; De Neys, 2012; De Neys & Glumicic, 2008; Pennycook et al., 2014, 2015; Swan et al., 2018; Thompson & Johnson, 2014; Travers et al., 2016). Indeed, the findings have been critical in the development of revised dual-process models (for review, see De Neys, 2017; De Neys & Pennycook, 2019). To avoid confusion, the point I am making here is not that the conflict detection work supports the dual-process view. One could readily present a single-model variant to account for the findings. One might argue that the dual-process framework in research and theorizing on conflict detection has been used as a communicative tool. It has been a handy vehicle to conceptualize key points and facilitate communication among scholars. However, the point is that the use of the dual-process lingo per se has not prevented scholars from making advances in answering outstanding questions. More is known about the conflict-detection process than was known a decade ago. The work has resulted in new empirical findings, the development of new methodology, and theoretical advances (De Neys & Pennycook, 2019). This presents a clear counterexample against the claim that adopting a dual-process framework is necessarily bound to block scientific progress.

In conclusion, whether scholars adopt a dual- or single-process model, they obviously need to make sure that people are not misinformed about the scientific findings and their implications. One might question whether dual-process theorists have done enough to avoid possible misinterpretation of their ideas in the past (Melnikoff & Bargh, 2018). But in and of itself, the claim that the mere adoption of a dual-process/single-process view endangers scientific advances or misinforms the public is unsupported. There is no ground to favor a single-process model over a dual-process model (or vice versa) on the basis of this argument.

An Irrelevant Debate

The first part of this article clarified that after 30 years of debate, there is currently no good evidence that would allow one to decide between the single-process and dual-process model view. Therefore, some might be tempted to conclude that researchers need to increase their efforts to find such empirical evidence. Much to the contrary, I believe that we should move on and let the debate lie. As I clarify in this section, first, it can be questioned whether the debate can ever be solved. Second, and more critically, even if it can be solved, the debate will not advance the psychological understanding of human thinking.

A nonempirical debate

Can the single-process/dual-process debate ever be solved? I already highlighted the complexity involved in specifying a defining feature, determining a feature threshold, and testing whether processing above and below the threshold is qualitatively different. At the very least, this indicates that it is far from clear how one would go about setting up an experiment to address these issues. However, more generally, one can also argue that it is—by definition—impossible to settle the debate with empirical data.

As Gawronski et al. (2014) noted, there is a long tradition in philosophy that argues that existence claims—such as the question as to how many reasoning processes (one, two, . . .) there “really” are—are metaphysical in nature and cannot be tested empirically (e.g., Popper, 1959; Quine, 1960). Philosophers such as Whitehead (1978) have long pointed to the limitations of language in these discussions. For example, one may argue that, semantically speaking, there is a point at which a mere quantitative difference becomes qualitative. To illustrate, think, for example, of a game of basketball. I can call some friends; we can go to a court, make two teams, and start passing and shooting. In one sense, there is no qualitative difference between what my friends and I are doing on the court and what professional teams such as the Los Angeles Lakers and Golden State Warriors do when they play each other. It is not the case that my friends and I are playing ice hockey and the Lakers and Warriors are playing football. Both of us can be playing a game of basketball. However, in another sense, one may argue that the mere quantitative difference in physical, technical, and tactical skills can be so extreme that the two games become qualitatively different. In that sense, LeBron James and I *are* playing a different game.

To illustrate further, think of the same person at different life stages, say, at age 10 and age 40. In one sense, this individual is qualitatively the same, and changes are merely quantitative in nature. One might be taller and smarter at age 40 than at age 10, but it is not the case that at age 10 one is an insect and at age 40 one is a horse. However, at the same time, one can argue that a person’s accumulated experiences result in a qualitative difference in the way the person perceives the world at the two life stages. In this sense, one is not the same person at age 10 and age 40. These examples illustrate how debates about qualitative and quantitative differences are intertwined with semantic discussions in which empirical data will be of little avail.

A trivial debate

The dual process/single process debate has not yet been settled, and it can be questioned whether it can ever be decided. Is this a problem for the psychological study of intuitive and deliberate thinking? I believe not. To illustrate, consider what could be learned if researchers were to find that intuition and deliberation are qualitatively different or not. How would this knowledge advance theorizing? The goal of any psychological theory of thinking is to identify the operating principles and mechanisms that allow people to think. Scientists need to know how intuition and deliberation work and how they interact. My point is that merely knowing that intuition and deliberation are qualitatively rather than quantitatively different does not allow a single prediction in this respect. This is readily clarified by looking at some of the key outstanding questions in the field.

For example, one critical question concerns what one can do at the more intuitive compared with deliberate end of the processing spectrum. Irrespective of whether intuition and deliberation are qualitatively different, what can be accomplished through intuition or deliberation? Are certain behaviors and decisions affected by the fact that one deliberates more or less? For example, to arrive at sound logical conclusions, does one need to deliberate more or less (e.g., Bago & De Neys, 2017, 2019; Evans, 2019; Gigerenzer et al., 2011; Kahneman, 2011)? Do intuition and deliberation tend to cue different types of moral decisions (e.g., Greene, 2015)? Do people behave more altruistically when they intuit more or less (e.g., Rand et al., 2012)? Are people more or less susceptible to fake news when they deliberate more (e.g., Bago et al., 2020)?

Second, how do people decide to engage more or less deliberation (e.g., Kruglanski & Gigerenzer, 2011; Pennycook et al., 2015; Stanovich, 2018; Thompson et al., 2011)? If there are things people do better (or more) at each end of the intuition-versus-deliberation spectrum, how do people know they need to switch from one to the other? Do people make these decisions randomly? Which cues or mechanisms do people use to detect they need to deliberate more or less?

Third, what is the time course of intuitive and deliberate thinking? Can people do both at the same time (e.g., Evans, 2007; Gilbert, 1999; Handley & Trippas, 2015)? Is the amount of intuitive processing inversely proportional to the amount of deliberate processing? Are both completely independent?

Fourth, can people's reasoning be optimized? How does one get people to intuit more or less whenever it is useful to do so (e.g., Morewedge et al., 2015)?

It will be clear that knowing whether intuition and deliberation are qualitatively different per se does not bring researchers a single step closer to formulating an answer to these critical questions. Whether intuition and deliberation are qualitatively or merely quantitatively different does not describe, for example, what people can still do when they minimize deliberation or how they switch from one to the other. Hence, whether the difference between intuition and deliberation is conceived as quantitative or qualitative in nature has no further restrictions on psychological theory development. It is in this sense that the single-process model/dual-process model debate is irrelevant. The debate does not inform or restrict theorizing about the underlying psychological processing mechanisms. The key outstanding questions are independent of the question of whether the difference between the postulated intuitive and deliberative processes is qualitative or quantitative in nature.

An example might be helpful to illustrate the basic point. Consider the outstanding question with respect to the optimization of people's reasoning. Imagine that in a specific task, one finds that deliberation leads to more optimal performance than intuitive thinking. Assume that it was known that there is a qualitative difference between intuition and deliberation in that deliberation loads working memory but intuition does not. One hypothetical intervention approach would be to train people's working memory because this would allow them to deliberate better. Now assume that there is a mere quantitative difference between intuition and deliberation. Intuition requires but a minimal amount of working memory, whereas deliberation taxes it heavily. Obviously, in this case, too, it will be beneficial to train people's working memory. Given deliberation's quantitatively higher demands on working memory, the larger the resource pool, the better one will manage to deliberate. Hence, there is no unique connection between the answer to the quantity versus quality question and choice of intervention. One does not inform the other. It is in this regard that I perceive the quality versus quantity debate to be irrelevant.

Time to Move on

The dual-process model/single-process model debate has not been resolved; it can be questioned whether the debate can be resolved, and even if it were to be resolved, it will not inform theory development about the critical processing mechanism underlying human thinking. This implies that the debate is irrelevant for the empirical study of thinking. In a sense, the choice between a single-process model and dual-process model boils—quite literally—down to a choice between two different religions. Scholars can and may have different personal beliefs and preferences as to which model serves their conceptualizing and communicative goals best. However, what they cannot do is claim there are good empirical or theoretical scientific arguments to favor one over the other.

I do not contest that the single-process model/dual-process model debate might have been useful in the past. For example, the relentless critique of single-process proponents helped to discard the erroneous perfect feature-alignment view. Likewise, the work of

Evans and Stanovich in trying to pinpoint defining features was helpful to start sketching the descriptive building blocks of the mental simulation and cognitive decoupling process. Hence, I do believe that the debate has had some positive by-products.

To avoid confusion, I also do not argue that the study of intuitive and deliberate thinking per se is pointless. Much to the contrary, I believe this is one of the most fascinating and important challenges for psychological scientists. Above, I pointed to critical outstanding questions for the field. These questions can be addressed with empirical research, and critical advances have been made over the past decades. But my argument is precisely that the answer to these questions is independent of whether intuition and deliberation differ qualitatively. Hence, my claim is that trying to answer the core single-process model/dual-process model debate is pointless for empirical scientists. This does not imply that we cannot study or should stop studying intuitive and deliberate thinking.

The ultimate problem is that researchers have but limited time and resources. Time and resources spent arguing about qualitative or quantitative differences are not spent on the other, more pressing outstanding issues. In terms of opportunity costs, continuing this debate is not warranted. It is high time for the field to move on and focus its energy on more critical questions concerning the nature of intuitive and deliberate thinking.

Transparency

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Notes

1. I am using these as illustrative-, descriptive-, or phenomenological-level examples. I fully realize that quantum physicists and biologists can readily argue that even in these cases there can be mixed states and the examples are consequently not fully discrete. This strengthens the point that determining an exact splitting point is highly problematic.

2. There is a long and muddled discussion about what constitutes a reasoning "system" (e.g., Evans & Stanovich, 2013; Keren & Schul, 2009). By all means, *dual system* and *dual process* can be used as synonyms here. A dual-system model posits two qualitatively different processes (see Nomenclature and Scope section).

3. More generally, in discussions concerning the criterion S argument, there might be some confusion between the quality and time course of mental processes. If at the exact same point in time two conflicting responses become available, most scholars will presumably agree that one may claim that the two responses are computed by different processes. One process might be more intuitive, the other more deliberate. Hence, this indicates that in this case, the intuitive and deliberate processes run in parallel (i.e., simultaneously) rather than serially (i.e., one after the other). However, this does not imply that both processes are qualitatively different. In a single-process model, intuitive and deliberate processing might be activated at the same time too (Kruglanski & Gigerenzer, 2011). Hence, the quality and time course question are orthogonal. Criterion S, or the empirical observation of simultaneous contradictory beliefs, might inform one about the time course of different processes, but it does not allow one to argue in favor or against the existence of qualitative differences.

4. Some might want to equate single-process models with a dependent activation assumption and dual-process models with an independent one. Under this specific operationalization, a single-process model would necessarily be defined as an activation dependent model (and vice versa). However, whether intuition and deliberation are qualitatively different and whether their activation is interdependent are two orthogonal questions (Gilbert, 1999; Kruglanski & Gigerenzer, 2011).

5. There can also be some confusion here because of a possible misunderstanding concerning the interdependency of intuitive and deliberate processing. As noted, some may tend to spontaneously equate a dual-process model with an independent activation model. If two processes are qualitatively different, people assume that their activation levels cannot depend on each other. However, this assumption is not correct. It can be helpful to illustrate the point with an example. Imagine there are two machines. One is powered by steam power. Water flows from a water tank in a boiler, gets heated, and the resulting steam moves a piston and drives the machine. The second machine is driven by muscle power. The machine is connected to the sprocket wheel of a stationary bike on which a human is pedaling. Most scholars will presumably agree that one can say that both machines are being powered by qualitatively different mechanisms. However, clearly, to keep on pedaling, the cyclist needs to stay hydrated and drink. Imagine the cyclist is being hydrated with water from the same tank the steam engine is being fed with. The harder the cyclist pedals, the more water he or she will need, and the less water will be available for the steam engine. Hence, although the machines are driven by a qualitatively different type of engine, their activation might show some minimal dependency. The same conceptual point can be made about cognitive processes. Ultimately, these are instantiated in the brain. Imagine that intuitive and deliberate processing are qualitatively different and instantiated by two different brain regions *X* and *Y*. Because both regions need oxygen to function, depending on the specific wiring of the two regions, it might be that increased activation in region *X* necessarily results in a lower activation in region *Y*. Clearly, these are hypothetical examples. I do not want to make claims about the

localization of intuitive and deliberate processing or their neural instantiation. The point is simply to illustrate that assuming that processes are qualitatively different does not necessarily imply that their activation level cannot be interdependent to some extent.

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