Perspectives on Psychological Science
8(3) 223–241

DOI: 10.1177/1745691612460685
pps.sagepub.com

Dual-Process Theories of Higher Cognition: Advancing the Debate

Jonathan St. B. T. Evans[1] and Keith E. Stanovich[2]
[1]School of Psychology, University of Plymouth, England; and [2]Department of Applied Psychology and Human Development, University of Toronto, Ontario, Canada

Abstract

Dual-process and dual-system theories in both cognitive and social psychology have been subjected to a number of recently published criticisms. However, they have been attacked as a category, incorrectly assuming there is a generic version that applies to all. We identify and respond to 5 main lines of argument made by such critics. We agree that some of these arguments have force against some of the theories in the literature but believe them to be overstated. We argue that the dual-processing distinction is supported by much recent evidence in cognitive science. Our preferred theoretical approach is one in which rapid autonomous processes (Type 1) are assumed to yield default responses unless intervened on by distinctive higher order reasoning processes (Type 2). What defines the difference is that Type 2 processing supports hypothetical thinking and load heavily on working memory.

Keywords

dual processes, dual systems, rationality, individual differences, working memory

> "Evidence used to support dual theories is consistent with single-system accounts."
>
> (Osman, 2004, p. 1006)

> "Dual-process theories of reasoning exemplify the backwards development from precise theories to surrogates."
>
> (Gigerenzer, 2011, p. 739)

> "We propose that the different two-system theories lack conceptual clarity, that they are based upon methodological methods that are questionable, and that they rely on insufficient (and often inadequate) empirical evidence."
>
> (Keren & Schul, 2009, p. 534)

> "In this article, we presented a number of convergent arguments and empirical evidence for a unified theoretical approach that explains both intuitive and deliberative judgments as rule based, as opposed to the dual-systems approach of qualitatively different processes."
>
> (Kruglanski & Gigerenzer, 2011, p. 106)

The distinction between two kinds of thinking, one fast and intuitive, the other slow and deliberative, is both ancient in origin and widespread in philosophical and psychological writing. Such a distinction has been made by many authors in many fields, often in ignorance of the related writing of others (Frankish & Evans, 2009). Our particular interest is in dual-process accounts of human reasoning and related higher cognitive processes, such as judgment and decision making. Such theories have their origins in the 1970s and 1980s (Evans, 1989; Wason & Evans, 1975) and have become the focus of much interest in contemporary research on these topics (Barbey & Sloman, 2007; Evans, 2007a, 2008; Evans & Over, 1996; Kahneman, 2011; Kahneman & Frederick, 2002; S. A. Sloman, 1996; Stanovich, 1999, 2011; Stanovich & West, 2000). Over a similar period, dual-process theories have proved popular in the psychology of learning (e.g., Dienes & Perner, 1999; Reber, 1993; Sun, Slusarz, & Terry, 2005) and especially in social cognition, which has the greatest proliferation of dual-processing labels and

Corresponding Author:
Jonathan St. B. T. Evans, School of Psychology, University of Plymouth, Plymouth PL4 8AA, England
E-mail: j.evans@plymouth.ac.uk

theories (see Chaiken & Trope, 1999; Epstein, 1994; Kruglanski & Orehek, 2007; Smith & DeCoster, 2000). Originally, dual-process theories in these different fields developed independently, although there have more recently been attempts to connect them. One consequence has been the development of broad dual-system theories that attempt to link a wide range of attributes to two systems of thought that are believed to underlie intuitive and reflective processing, respectively (Epstein, 1994; Evans & Over, 1996; Reber, 1993; Stanovich, 1999). Following Stanovich (1999), these are often referred to as Systems 1 and 2.

As the popularity of dual-process and dual-system theories has increased, so too have the voices of criticism, as illustrated in the opening quotations. Critics have pointed to the multitude of dual-processing accounts, the vagueness of their definition, and the lack of coherence and consistency in the proposed cluster of attributes for two-system accounts. They have questioned the evidence on which such claims are made and have argued that single-process accounts can explain the data (Gigerenzer & Regier, 1996; Keren & Schul, 2009; Kruglanski et al., 2003; Kruglanski & Gigerenzer, 2011; Osman, 2004). Here we collaborate for the first time to respond to these various critiques. It is important that we do so, as although a number of these criticisms have some force to them (and have been acknowledged in our own recent writing), we believe that the dual-processing distinction is nonetheless strongly supported by a wide range of converging experimental, psychometric, and neuroscientific methods.

In general, these critiques are problematic because they attack not any particular theory but rather a class of theories, effectively treating all dual-process and dual-system theories alike. However, all dual-process theories are not, by any means, the same. Our own work has developed dual-process theories of reasoning and decision making, but even in this domain, there is much in the writings of other authors with which we have disagreements. Thus, we do not set ourselves the impossible task of defending some generic received version of dual-process theory that the critics apparently have in mind. In fact, we agree that many of the problems they discuss do, indeed, apply to a number of applications of dual-process theories. Instead, our purpose is to show that there is a clear empirical basis for a dual-process distinction in the fields of reasoning and decision making that can withstand the various arguments that are being set, by implication, against it.

There are many applications in which authors have proposed that two forms of processing are competing or combining in order to produce the behavior observed. We shall call these Type 1 and Type 2 processes here, corresponding roughly to the familiar distinction between intuition and reflection. Attributes commonly claimed for the two types of processing are listed in the top part of Table 1. Some authors have gone further, suggesting that there are two evolutionarily distinct brain systems responsible for these two types of processing (see especially Epstein, 1994; Evans, 2010b; Evans & Over, 1996; Reber, 1993; Stanovich, 1999, 2004). Such theories generally inherit the Type 1 and 2 feature lists but add additional characteristics, such as the idea that there is an evolutionarily old and animal-like form of cognition and also a recently evolved and uniquely (or distinctively) human system for thinking. Following Stanovich (1999), these are often referred to as Systems 1 and 2 or sometimes as an old and new mind (Evans, 2010b; Stanovich, 2004). For a glossary summarizing the meaning of several terminological distinctions used in this article, see Table 2.

In this article, we will focus our discussion on the main list of Type 1 and 2 processing features shown in Table 1, which are also referred to by some authors as System 1 and 2 attributes. However, the discussion of the more broadly based two-minds hypothesis and the additional features shown at the bottom of Table 1 is beyond the scope of the current article.

Self-Identified Problems With the Dual-Process Approach

We ourselves are critics as well as supporters of dual-process theories. Over the past 15 years or so, each of us have striven to improve and clarify our theoretical proposals, responding to the fast-accumulating evidence as well as analyzing the coherence of current theoretical claims. As will become clear, we actually agree with a number of the points made in the recent critiques, many of which we had already anticipated in our own publications. Hence, before we discuss the points argued in the published critiques, we summarize briefly how our own thinking and writing has attempted to identify and resolve problems.

Dual types, systems, and modes

Over a decade ago, in order not to show a preference for one particular theory, Stanovich (1999) used the generic terms *System 1* and *System 2* to label the two different sets of properties. Although these terms have become popular, we both have recognized problems with this terminology in our recent writing (e.g., Evans, 2010a; Stanovich, 2011). First, the term *dual systems* is ambiguous as it can sometimes act as a synonym for a two-minds hypothesis but has been used by other authors to convey little more than a distinction between two types of processing (e.g., Kahneman, 2011; S. A. Sloman, 1996). Second, this terminology may appear to suggest that exactly two systems underlie the two forms of processing, which is a stronger assumption than most theorists wish to make. For these reasons, we both have recently

Table 1. Clusters of Attributes Frequently Associated With Dual-Process and Dual-System Theories of Higher Cognition

Type 1 process (intuitive)	Type 2 process (reflective)
Defining features	
Does not require working memory	*Requires working memory*
Autonomous	*Cognitive decoupling; mental simulation*
Typical correlates	
Fast	Slow
High capacity	Capacity limited
Parallel	Serial
Nonconscious	Conscious
Biased responses	Normative responses
Contextualized	Abstract
Automatic	Controlled
Associative	Rule-based
Experience-based decision making	Consequential decision making
Independent of cognitive ability	Correlated with cognitive ability
System 1 (old mind)	System 2 (new mind)
Evolved early	Evolved late
Similar to animal cognition	Distinctively human
Implicit knowledge	Explicit knowledge
Basic emotions	Complex emotions

Note. Italicized attributes are the proposed defining characteristics in the current article. Authors proposing two systems include the features attributed to Type 1 and 2 processing but may also include the additional features named.

discontinued and discouraged the use of the labels System 1 and 2 (e.g., Evans, 2010a; Stanovich, 2004, 2011).

Both Evans (2008, 2010a) and Stanovich (2004, 2011) have discussed how terms such as *System 1* or *heuristic system* are really misnomers because they imply that what is being referred to is a singular system. In actuality, the term *System 1* should be plural because it refers to a set of systems in the brain. Stanovich (2004, 2011), for example, noted the wide diversity of autonomous

Table 2. A Glossary of Dual-Process Terminologies Used in This Article

Term	Definition
Dual processes	The assumption by many theorists that cognitive tasks evoke two forms of processing that contribute to observed behavior. Unless otherwise indicated, the term refers in this article to dual-type theories.
Dual types	Terminology that implies that the dual processes are qualitatively distinct. Type 1 processes are (broadly) intuitive and Type 2 processes reflective (see Table 1).
Dual systems	It is common in the literature to use the terms *System 1* and *System 2* to refer to the Type 1 and 2 distinction. Some but not all authors associate these with an evolutionary distinction. The current authors now prefer to avoid this terminology as it suggests (falsely) that the two types of processes are located in just two specific cognitive or neurological systems.
Modes of processing	Modes of processing are forms of Type 2 thinking that may differ on a continuum. Individual differences on such continua are often assessed with thinking-disposition measures.
The autonomous set of systems (TASS)	The proposal that there are multiple Type 1 systems of different kinds, including modular, habitual, and automated forms of processing.

processes that were being lumped together under the heading of System 1, abandoning that term in favor of TASS—the autonomous set of systems—in order to indicate that they do not belong to a single system with a single set of attributes. For these reasons, we both have recently reverted to the older terminology of Type 1 and 2 processing. These terms indicate qualitatively distinct forms of processing but allow that multiple cognitive or neural systems may underlie them.

We also believe it is essential to avoid confusion between dual *types* and dual *modes* of thinking (Table 2; see Evans, 2010a). Modes of processing are cognitive styles and are manifest within the domain of what we regard as Type 2 thinking. Unlike types, they typically represent two poles of a continuum of processing styles. The confusion between modes and types is at the core of one of the main criticisms of dual-process theories, which we discuss later.

Misalignment of attributes

A change in terminology is not the only corrective we have recommended for dual-process theories. Evans (2006; see also 2008) identified a number of problems with the older dual-system accounts, including several misalignments of the features shown in Table 1: For example, the source of Type 1 processing in the brain is not always in areas regarded as evolutionarily old; conscious thinking is not necessarily in control of behavior; rules can be concrete and contextualized as well as abstract. He concluded that "The difficulties identified in this paper arise from attempts to map dual processes on to underlying systems. . . . [I]t is far from evident at present that a coherent theory based on two *systems* is possible" (Evans, 2006, pp. 205–206). In more recent writing, Evans (2012) has identified several key fallacies in what he terms the *received* view of dual-process/dual-system theories, including the beliefs that (a) Type 1 processes are always responsible for cognitive bias and Type 2 processing is always responsible for correct responses, (b) Type 1 processing is contextualized and Type 2 processing abstract, and (c) fast processing is necessarily indicative of Type 1 processing.

We are aware that what we call the "received" or generic form of dual-system theory clusters attributes (see Table 1) in ways that are not always sustainable. We will argue that only the features italicized in Table 1 are defining characteristics of the two types of processing. Specifically, Type 2 processing is distinguished from autonomous Type 1 processing by its nature—involving cognitive decoupling and hypothetical thinking—and by its strong loading on the working memory resources that this requires. By contrast, other features are simply correlates that occur under well-defined conditions and are neither necessary nor defining features. We are, in fact, very concerned that casual assumptions about the attributes of Type 1 and 2 thinking by even sympathetic authors may be damaging to the progress of dual-process research (for recent examples of our comments on this, see Evans, 2012; Stanovich, West, & Toplak, 2011). However, we must also stress that overly casual inferences about the assumptions behind such theories should not be allowed to obscure the fact that a very important scientific distinction about the nature of the human mind is supported by the evidence. For this reason, we believe that the critics overstate their case and that it is necessary for us to restore balance to the debate.

Not All Dual-Process Theories Are the Same

It may be convenient for critics to give the impression that all dual-process theorists appeal to the same two systems (especially Keren & Schul, 2009), but this is simply not true. A true dual-process theory that distinguishes two *types* of process will, by our definition, imply the engagement of distinct cognitive and neurological systems. However, this does not mean that all dual-process theories are appealing to the same underlying systems with the same proposed cluster of attributes. Both of us have argued against the sustainability of the System 1 and 2 distinction (Evans, 2006; Stanovich, 2004) prior to many of the critical reviews (e.g., Keren & Schul, 2009; Kruglanski & Gigerenzer, 2011; Osman, 2004). Moreover, some so-called dual-process theories are really concerned with what we have defined as dual modes of processing (see Table 2).

Each of us has defined the distinction between Type 1 and 2 processing in a different but compatible manner in our recent writing. We elaborate on these in a later section of this article, but in brief, Evans has maintained that Type 2 thinking engages a singular central working memory resource, whereas Stanovich has emphasized that a decoupling operation involved in all tasks with substantial Type 2 processing is highly correlated with fluid intelligence. We show later why these are fully compatible definitions. The assortment of autonomous processes that fail to meet these definitions are described as Type 1. Hence, Type 2 processing has a more consistent and coherent definition, whereas the nature of Type 1 processing can vary considerably between different dual-process theories and applications.

In this article, we defend our view that the Type 1 and 2 distinction is supported by a wide range of converging evidence. However, we emphasize that not all dual-process theories are the same, and we will not act as universal apologists on each one's behalf. Even within our specialized domain of reasoning and decision making, there are important distinctions between accounts. S. A. Sloman (1996; Barbey & Sloman, 2007), for example, proposed an architecture that has a *parallel-competitive* form. That is, Sloman's theories and others of similar structure (e.g., Smith & DeCoster, 2000) assume that Type 1 and 2 processing proceed in parallel, each having their say with conflict resolved if necessary. In contrast, our own theories (in common with others, most notably that of Kahneman & Frederick, 2002; see also, Kahneman, 2011) are *default-interventionist* in structure (a term originally coined by Evans, 2007b). Default-interventionist theories assume that fast Type 1 processing generates intuitive default responses on which subsequent reflective Type 2 processing may or may not intervene. Likewise, we disagree with other aspects of Sloman's account—for example, the contention that simultaneous contradictory belief is a necessary condition for the existence of dual processes in conflict (his Criterion S).

Five Criticisms of Dual-Process Theories: A Discussion

We shall now discuss five major themes that we have identified in the leading critiques of dual-process and dual-system theories: (1) Multiple and vague definitions are offered by various theorists; (2) attribute clusters associated with dual systems do not consistently hold together; (3) distinctions refer to a continuum of processing type rather than qualitatively distinct processes; (4) single-process accounts can be offered for apparent dual-process phenomena; and (5) the evidence base for dual-process theory is questionable. Our objective is to assess each argument on its merits, not simply to deny or refute the various accusations. We discuss and assess each of these in turn, before providing our own positive proposals of a clear theoretical basis for the Type 1 and 2 processing distinction.

Criticism 1: Dual-process theorists have offered multiple and vague definitions

We agree that the proliferation of dual-process labels has not been helpful. Not only are there many such labels—for example implicit/explicit, associative/rule-based, impulsive/reflective, automatic/controlled, experiential/rational, nonconscious/conscious, intuitive/reflective, heuristic/analytic, reflexive/reflective, and so on—but each carries with it some semantic baggage. Reading such a list tempts readers to align all of these so that, for example, it seems that one kind of thought process must be conscious, controlled, reflective, and rule-based, whereas another is nonconscious, automatic, impulsive, and associative. We agree that this is the "received view" shared by a number of supporters as well as critics of the paradigm. (See Evans, 2012, for a discussion of a number of fallacies embedded in the received view.) The assumption that such attributes necessarily co-occur is the clustering problem discussed below (Criticism 2). This received view seems to have arisen inadvertently from the attempt by various authors, including previously ourselves, to group various dual-process theories together (Evans, 2003; Smith & Collins, 2009; Smith & DeCoster, 2000; Stanovich, 1999). Although this seemed a good idea at the time, we can see now the problems that seeking a family resemblance has caused.

Are a number of these attributes vague or ambiguous as the basis for defining dual-process theories? Yes, we agree that they are. Let us take a few examples. The conscious/nonconscious distinction, popular in social psychology (e.g., Wilson, 2002), is highly problematic on account of both vague and disputable definitions of consciousness (Churchland, 2002; Dennett, 1991) and the observation that both Type 1 and 2 processing can have conscious and nonconscious aspects (Evans, 2010b, Chapter 7). The suggestion that Type 2 processes are rule-based although Type 1 processes are not has attracted particular criticism (see Criticism 4), as has the proposal that some processes are controlled and intentional whereas others are automatic (Bargh, 2005; Wegner, 2002). We will not labor the point. We agree with the critics that the proliferation of dual-process theories and labels has been confusing and that many of the distinctions are hard to pin down when examined closely. That is why neither of us have relied on such labels or distinctions in our recent writings as defining characteristics of the two types of processing.

Criticism 2: Proposed attribute clusters are not reliably aligned

The main critics of dual-process theories, and especially Keren and Schul (2009), dispute the idea that there are two cognitive systems with a cluster of defining attributes. Their main argument is that the different features of the cluster are not always observed together. This observation is certainly correct, but it creates a problem only if all the features shown in Table 1 are assumed to be necessary and defining features. Critics (see especially Kruglanski & Gigerenzer, 2011) do, indeed, talk as though all correlated features of dual processes discussed by theorists must be necessarily and invariably observed together and that any observed counterexample will provide a falsification of (apparently) any dual-process theory. There are two reasons for regarding this as a straw-man argument (Stanovich & Toplak, 2012). First, this standard of proof, requiring a perfect, deterministic level of conjoined features, is higher than that generally applied in any field of psychology. Second, from a theoretical point of view, although there is a clear basis for predicting a strongly correlated set of features, very few need be regarded as essential and defining characteristics of Type 1 and 2 processes (we will propose those that should in a later section). Again, we question the legitimacy of attacking dual-process theories as a global category. The fact is that some authors (including both of us) have recognized the distinction between defining and correlated features in their writing, whereas others have not.

History and Origin of the Cluster Problem. In order to bring some coherence and integration to this literature, Stanovich (1999) brought together the dozen or so theories that had proliferated over the decade by listing them and their different names for the two processes (by the time of a similar list published in Stanovich, 2004, the number of such theories had grown to 23). More important, the same table in Stanovich (1999) attempted to bring together some of the pairs of properties that had been posited in the literature to indicate the differences between the two processes (a number of which appear in our Table 1). Many other investigators have published lists of the complementary properties of the two processes (see Evans, 2008, for a particularly complete list).

Unfortunately, these tables of properties in the early literature have misled some theorists. The main misuse of such tables of properties is to treat them as strong statements about necessary co-occurring features. The longer the list of properties in any one table, the easier it is to create the straw-man claim that if all of these features do not always co-occur, then the dual-process view is incorrect. For example, Kruglanski and Gigerenzer (2011) recently claimed that dual-process views fail because "these dimensions are unaligned rather than aligned" (p. 98). They construct six dichotomies and carry through the strong assumption that all are defining and always co-occur: "assuming six dichotomies, one would end up with a $2^6 = 64$ cell matrix of which only two cells (those representing the conjunction of all six dichotomies) had entries" (p. 98). But assumption of perfect alignment of features is not attributed to any specific dual-process theorist in their article. We doubt that a prediction as strong as "only two cells out of 64" could be fulfilled by any theory in psychological science, no matter how rigorous.

Defining versus correlated features. It has long been recognized that Type 1 processing might involve subprocess properties that are, empirically, somewhat separable. The history of the concept of automaticity (a Type 1 processing term) provides an example. It became clear many years ago that the properties ascribed to automatic processes (modularity, speed, autonomy, resource-free processing, nonconscious processing, and so forth) might not all co-occur (many of these, and other, correlated, properties being merely incidental correlates). By 1990, Stanovich wrote that

> LaBerge and Samuels had implicitly equated the obligatory nature of an automatic process . . . with capacity-free processing. In addition, the use of processing resources was conflated with the idea of conscious attention, and conversely, lack of conscious attention was viewed as synonymous with resource-free processing. Only later was the necessity of theoretically separating the issues of obligatory execution, resource use, and conscious attention fully recognized. . . . The tendency to intertwine resource use with conscious attention in reading theory was reinforced by the popularity of Posner and Snyder's (1975) two-process model of cognitive expectancies. (Stanovich, 1990, pp. 74–75)

In short, over two decades ago, one of us argued that the concept of automaticity (the term for Type 1 processing in reading theory) did not entail all of the correlated lists of properties that had appeared in the literature.

Nonetheless, the tendency persists to criticize dual-process theories because of the less than perfect co-occurrence of the many properties thrown into the theoretical stew by over two dozen theorists prior to 2000. For example, Osman (2004) argued that the constructs of implicit processing, automaticity, and consciousness do not cohere in the manner that she infers they should from tables such as that in Stanovich (1999). Likewise, Keren and Schul (2009) stated that they "wonder whether the dichotomous characteristics used to define the two-system models are uniquely and perfectly correlated" (p. 537), and they further argued that "the use of dichotomies to characterize the systems seems an important feature of the models, as it allows the researchers to propose that the systems are qualitatively different" (p. 538). But all of these dichotomies were never necessary to establish the two types of processing. The only thing needed is at least one dichotomous property that is necessary and sufficient. In a later section of this article, we discuss our preferred candidates for the defining features of Type 1 and Type 2 processing.

We ourselves have argued that many of the features in these property lists are only correlates (and not defining features) and that others have been mistakenly associated with Type 1 or Type 2 processing (Evans, 2012; Stanovich & Toplak, 2012). Thinking about some features has also been revised. For example, it is no longer the case that Type 2 thinking is regarded as abstract and context-free in contemporary theories. There have been dual-process accounts in the literature for some time in which both Type 1 and Type 2 processing are assumed to be content laden (Evans, Handley, & Harper, 2001; Klauer, Musch, &

Naumer, 2000; Verschueren, Schaeken, & d'Ydewalle, 2005; Weidenfeld, Oberauer, & Hornig, 2005). However, prior knowledge affects Type 1 and 2 processing in qualitatively different ways, and such theories specify different mechanisms for content effects in the two types of processing. So although the evidence supports the view that engagement of Type 2 reasoning is often necessary for the kind of abstract and elaborated forms of reasoning needed to solve typical laboratory tasks, such a conclusion does not make decontextualization a defining characteristic of Type 2 processing.

Normativity and rationality. Perhaps the most persistent fallacy in the perception of dual-process theories is the idea that Type 1 processes (intuitive, heuristic) are responsible for all bad thinking and that Type 2 processes (reflective, analytic) necessarily lead to correct responses. Thus, various forms of dual-process theory have blamed Type 1 processing for cognitive biases in reasoning and judgment research and for prejudice and stereotyping in social psychology (for discussion of the last, see Evans, 2010b, pp. 140–146). Correspondingly, logical reasoning, rational decision making, and nonstereotypical judgments have been attributed to Type 2 processing.

So ingrained is this good–bad thinking idea that some dual-process theories have built it into their core terminology. For example, Epstein's (1994) distinction between an experiential system and rational system mistakenly implies that Type 2 processing always yields a response that is normatively rational (and perhaps pragmatically that the experiential system does not). Gibbard's (1990) labeling of Type 2 processing as emanating from a "normative control system" mistakenly implies the same thing (that Type 2 processing is always normative), as does Klein's (1998) labeling of Type 2 strategies as "rational choice strategies." Rationality is an organismic-level concept and should never be used to label a subpersonal process (i.e., a *type* of processing). As an example, people's face recognition systems are neither rational nor irrational. They are, instead, either efficient or inefficient. Subprocesses of the brain do not display rational or irrational properties per se, although they may contribute in one way or another to personal decisions or beliefs that could be characterized as such.

We both have been explicit in our recent publications in pointing out that it is a fallacy to assume that Type 1 processing is invariably nonnormative and Type 2 processing invariably normative. In fact, Type 1 processing can lead to right answers and Type 2 processing to biases in some circumstances (see Evans, 2007a; Stanovich, 2011). Although the correlation between nonoptimal responses and Type 1 processing is no doubt modest in benign environments, it can be quite high in hostile environments. A benign environment is an environment that contains useful cues that, via practice, have been well practiced by Type 1 mechanisms. Additionally, for an environment to be classified as benign, it must not contain other individuals who will adjust their behavior to exploit those relying only on Type 1 processing. In contrast, a hostile environment for Type 1 processing is one in which there are no overpracticed cues that are usable (thus causing the substitution of an attribute only weakly correlated with the true target; see Kahneman, 2011). Another way that an environment can turn hostile is if other agents discern the simple cues that are triggering Type 1 processing—and the other agents start to arrange the cues for their own advantage (e.g., advertisements or the deliberate design of supermarket floor space to maximize revenue).

Criticism 3: There is a continuum of processing styles, not discrete types

The dual-process theories of both Evans (2007a, 2010a, 2010b) and Stanovich (1999, 2004, 2011) draw a clear distinction between what we will term *types* and *modes* of processing. Modes, which are often confused with types, are actually different cognitive styles applied in Type 2 processing. Unlike types, modes can vary continuously. For example, if we regard Type 2 analytic reasoning as the explicit processing of rules through working memory, then such processing could be engaged in a slow and careful but also a quick and casual manner or any point in between. The degree of effort that an individual expends on such processing is known to be a function of personality characteristics measured by scales such as Need for Cognition (Cacioppo & Petty, 1982) or Active Open Minded Thinking (Stanovich & West, 1997, 2007). Modes, unlike types, can also be culturally sensitive and must underlie the holistic and analytic styles observed to differ between those living in Eastern and Western cultures (Nisbett, Peng, Choi, & Norenzayan, 2001). Some authors have confused these with the two types of thinking proposed by dual-process theorists (for discussion and proposed resolutions of this problem, see Buchtel & Norenzayan, 2009; Evans, 2009).

The implication by some critics (Newstead, 2000; Osman, 2004) that the mere demonstration of processing continua in some contexts undermines dual-process models is not correct. Because Type 2 processing is the only type of processing that is characterized by flexible goals and flexible cognitive control, it is variation in this type of processing that all thinking disposition measures are assessing. Hence, thinking dispositions are not expected to be differentially associated with Type 1 or Type 2 processing, as implied in some writings. For example, implying that it signals some kind of inconsistency in dual-process views, Newstead (2000) argued that "Epstein, Pacini, Denes-Raj, and Heier (1996) found that superstitious and categorical thinking, which might be supposed to be part of System 1, produced no significant correlations, either positive or negative, with Faith in Intuition (System 1)" (p. 690). But superstitious thinking signals a mode of thought, not a type—and this disposition is not at all an indicator of the functioning of Type 1 processing. It is a thinking disposition involving epistemic regulation—a Type 2 function.

Modes of processing—more commonly termed *thinking dispositions*—are well represented in Stanovich's (2009a, 2009b, 2011) tripartite model of mind displayed in its simplest form in Figure 1. In the spirit of Dennett's (1996) book *Kinds of Minds*, the set of autonomous systems (the source of Type 1 processing) is labeled as the autonomous mind, the algorithmic level of Type 2 processing the algorithmic mind, and the reflective level of Type 2 processing the reflective mind. Dennett's "kinds of minds" terminology refers to hierarchies of control rather than separate systems. Two levels of control are associated with Type 2 processing and one with Type 1 processing. The autonomous set of systems (TASS) will implement their short-leashed goals unless overridden by an inhibitory mechanism of the algorithmic mind. But override itself is initiated by higher level control. That is, the algorithmic level is subordinate to higher level goal states and epistemic thinking dispositions. These goal states and epistemic dispositions exist at what might be termed the *reflective level of processing*—a level containing control states that regulate behavior at a high level of generality. Such high-level goal states are common in the intelligent agents built by artificial intelligence researchers (A. Sloman & Chrisley, 2003).

The difference between the algorithmic mind and the reflective mind is captured in the well-established distinction in the measurement of individual differences between cognitive ability and thinking dispositions (and represented in Fig. 1). The former are measures of the ability of the algorithmic mind to sustain decoupled representations (for purposes of inhibition or simulation, see Stanovich, 2011). In contrast, thinking dispositions are measures of the higher level regulatory states of the reflective mind: the tendency to collect information before making up one's mind, the tendency to seek various points of view before coming to a conclusion, the disposition to think extensively about a problem before responding, the tendency to calibrate the degree of strength of one's opinion to the degree of evidence available, the tendency to think about future consequences before taking action, and the tendency to explicitly weigh pluses and minuses of situations before making a decision.

Thus, thinking disposition measures are telling us about the individual's goals and epistemic values—and they are indexing broad tendencies of pragmatic and epistemic self-regulation at a high level of cognitive control. Continuous variation in both cognitive ability and thinking dispositions can determine the probability that a response primed by Type 1 processing will be expressed—but the continuous variation in this probability in no way

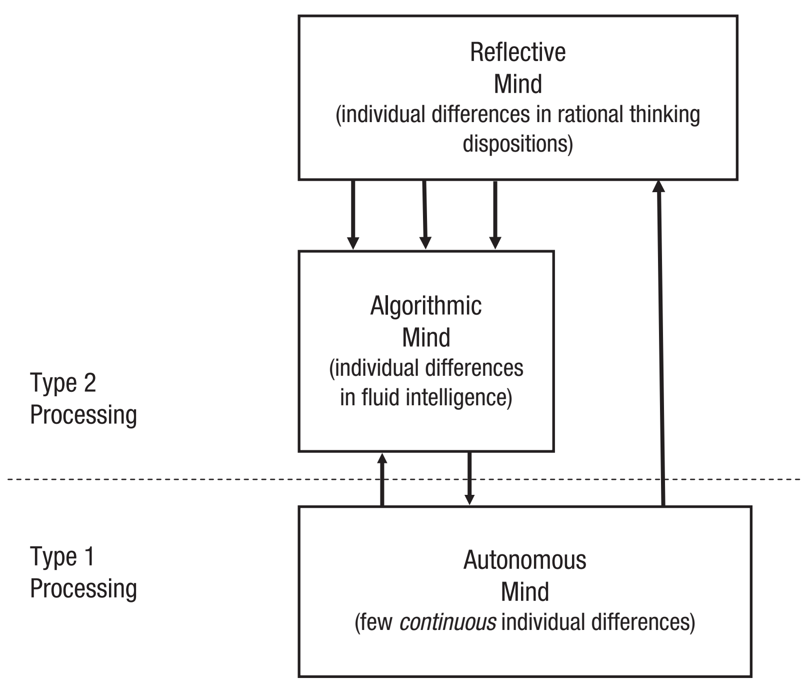

Fig. 1. The locus of continuous individual differences in Stanovich's tripartite model of the mind.

invalidates the discrete distinction between Type 1 and Type 2 processing.

Criticism 4: Single-process accounts may be offered for dual-process phenomena

Like Osman (2004), Kruglanksi and Gigerenzer (2011) believe that dual-process theories are not necessary to account for the data. Kruglanski and Gigerenzer proposed that a unified theory of decision making can be made on the basis of rule processing and that attempts to separate rule-based processing from other kinds (typically "associative," S. A. Sloman, 1996; Smith & DeCoster, 2000) are misconceived. They are correct in the latter argument, but we shall show it is beside the point. As Evans (2006) put it,

> I am not sure it is wise to describe System 2 as "rule-based" . . . if only because it implies that System 1 cognition does not involve rules. Rules can be concrete as well as abstract and any automatic cognitive system that can be modeled computationally can in some sense be described as following rules. (p. 204)

So yes, we agree that all behavior attributed to Type 1 and 2 processes by dual-process theorists can be described using rules and modeled by computer programs. But no, we do not agree at all that this means there is no basis to the claimed differences between the two kinds of processing. Kruglanksi and Gigerenzer's (2011) conclusion that they "presented a number of convergent arguments and empirical evidence for a unified theoretical approach that explains both intuitive and deliberative judgment as rule based, as opposed to the dual-systems approach of qualitatively different processes" (p. 106) makes no sense to us. Evidence that intuition and deliberation are both rule-based cannot, by any logic, provide a bearing one way or the other on whether they arise from distinct cognitive mechanisms. And their claim that both types of judgment are rule-based is, in any case, another strawman argument against dual systems. To our knowledge, no dual-process theorist has ever claimed that Type 1 processing is noncomputational. Associative processing can, of course, be modeled by neural networks that are implemented using rules. However, these "rules" are not what people generally mean when they refer to Type 2 rule-based processing. So calling both cases "rules" would just be a semantic device to encourage the view that Type 1 and Type 2 processing can be collapsed into one entity.

Kruglanski and Gigerenzer (2011; see also Gigerenzer, 2011) suggested that dual-process theories often do no more than redescribe the data. They used, as an example, the belief bias effect in syllogistic reasoning. In this paradigm, participants are asked to judge whether conclusions necessarily follow from premises, using syllogisms that differ in both actual validity and the believability of their conclusions (see Table 3). The two factors appear to compete for influence on responding (Evans, Barston, & Pollard, 1983; Klauer et al., 2000), but dual-process theorists apparently make a false inference of two underlying processes rather than simply observing a case of rule conflict (according to Kruglanski & Gigerenzer, 2011, p. 104). It is true that dual-process theories of reasoning and decision making arose historically from attempts to

Table 3. Examples of the Four Types of Syllogism Used by Evans, Barston, and Pollard (1983) Together with Participant Acceptance Rates (as Valid Arguments) Combined Over 3 Experiments

Type	Argument	Acceptance rate
Valid–believable	No police dogs are vicious. Some highly trained dogs are vicious. Therefore, some highly trained dogs are not police dogs.	89% yes (correct)
Valid–unbelievable	No nutritional things are inexpensive. Some vitamin tablets are inexpensive. Therefore, some vitamin tablets are not nutritional.	56% yes (correct)
Invalid–believable	No addictive things are inexpensive. Some cigarettes are inexpensive. Therefore, some addictive things are not cigarettes.	71% yes (incorrect)
Invalid–unbelievable	No millionaires are hard workers. Some rich people are hard workers. Therefore, some millionaires are not rich people.	10% yes (incorrect)

Note. The data illustrate the typical findings that both belief and logic significantly influence responding. Also, the belief-bias effect is larger for invalid arguments. This interaction has been the cause of much theoretical debate but is not discussed in the present article.

provide plausible cognitive accounts of such conflicts (Evans, 1989; Kahneman & Frederick, 2002), and we understand Kruglanksi and Gigerenzer's (2011) point as meaning that conflict data provide evidence only for dual sources of variance (Klauer, Beller, & Hutter, 2010), not for dual processes. We agree but show in the next section why contemporary evidence for dual processing goes well beyond the identification of conflict.

Criticism 5: Evidence for dual processing is ambiguous or unconvincing

The critics of dual-process theories would have readers believe that the evidence for dual processes is weak or ambiguous, that it can be explained away by single-process theory accounts that do not implicate qualitatively distinct types of mental processing. To us, this is by far the least convincing aspect of the various critiques as in general they all ignore the stronger forms of evidence for dual processing. We will discuss only illustrative examples here, bearing in mind that we have provided extensive reviews of relevant evidence in our recent publications (Evans, 2008, 2010b; Stanovich, 2011). The strong (and converging) evidence comes from three separate sources and all involve direct efforts to dissociate Type 1 and 2 processing.

First, there are experimental manipulations designed to affect one type of processing while leaving the other intact. Common manipulations are designed either to increase Type 2 processing effort (by instruction or motivation) or to suppress it by use of concurrent tasks that load working memory or by use of speeded tasks that allow little time for reflective thought. The second, increasingly popular method is to apply neural imaging in order to show that different brain areas are active when Type 1 or 2 processing is being observed. The final method is the psychometric approach, which demonstrates selective correlations, especially to show that Type 2 processing has a strong relation with cognitive ability whereas Type 1 processing does not.

Experimental manipulations. As noted above, Kruglanski and Gigerenzer (2011) claimed that research in the belief bias paradigm simply shows rule conflict and provides no evidence for dual processing. What Kruglanksi and Gigerenzer overlooked, however, is the kind of evidence that does, in fact, make the case for qualitatively distinct types of processing in this paradigm. This has actually been shown using all three major types of methods. For example, in the experimental approach, belief bias has been shown to be increased and logical accuracy decreased when people operate under time pressure (Evans & Curtis-Holmes, 2005) or concurrent working memory load (De Neys, 2006b), both of which are assumed to inhibit Type 2, reflective reasoning. If these manipulations were simply making the task more difficult, then we might expect guessing and random error. What is actually observed is opposite effects on accuracy and beliefs biases. On these tasks, accuracy and belief bias are measured orthogonally, so that is quite possible that both could have been eliminated had responding been random. In addition, similar findings have been reported for other reasoning and judgment tasks. For example, De Neys (2006a) showed in one experiment that participants making the conjunction fallacy on the famous Linda problem[1] (Tversky & Kahneman, 1983) responded quicker than those who did not. In a second experiment, they showed a sharp decrease in correct responding on this task when a concurrent working memory load was used. Also, on the Wason selection task, the intuitive "matching bias" (Evans, 1998), which accounts for typical responding (see Fig. 2), is found to be increased by use of speeded tasks (Roberts & Newton, 2001) or concurrent working memory loads (De Neys, 2006a).

It has been known for some years that instructions to reason in a deductive or pragmatic manner can have a big influence. For example, in drawing classical conditional inferences, such as Modus Ponens and Modus Tollens, participants are influenced by the degree to which they believe the conditional statement, often leading them to withhold a valid inference when it is unbelievable (e.g., George, 1995; Stevenson & Over, 1995). However, belief-based responding is clearly attenuated when strong deductive reasoning instructions are used. Belief biases are observed to be less commonly manifest in those of higher cognitive ability (Evans, Handley, Neilens, Bacon, & Over, 2010; Stanovich & West, 1997), who are, by the theory, more able to engage effective Type 2 thinking. But those of higher ability will reason better only if motivated and disposed to do so (Stanovich, 2011). Accordingly, an important interaction has been demonstrated: Higher ability participants will suppress belief biases only when specifically instructed to reason logically and draw necessary conclusions (Evans et al., 2010). Similarly, De Neys, Schaeken, and d'Ydewalle (2005a, 2005b) have shown that although participants of higher working memory capacity are better able to retrieve counterexamples to all conditional inferences, they use these selectively to block fallacies but not valid inferences when instructed to reason logically. Type 2 reasoning may also be biased by beliefs but in a different manner from that affecting Type 1 processing. Although the latter kind of processing produces a response bias to endorse believable conclusions, Type 2 processing motivates selective search for supporting and refuting models of the premises (Evans et al., 2001; Klauer et al., 2000).

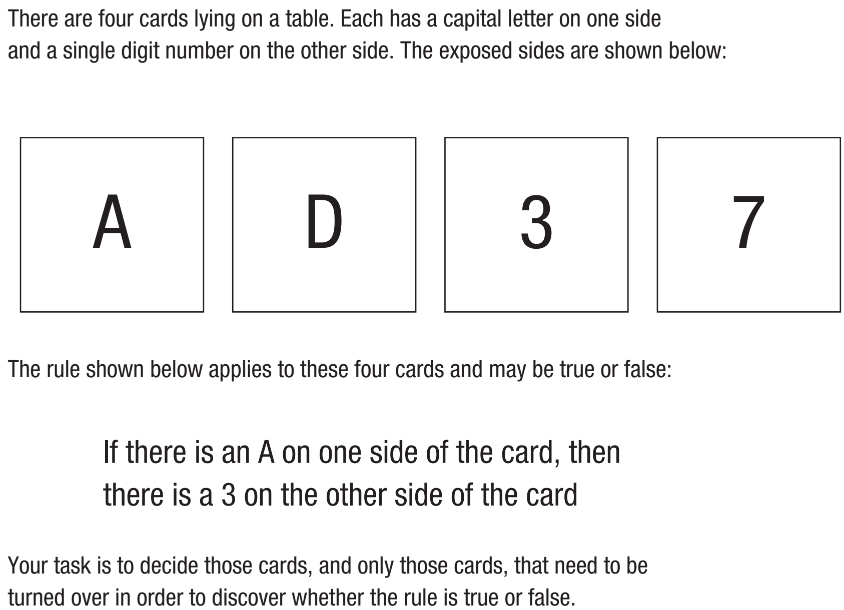

Fig. 2. The standard abstract Wason selection task with a conditional statement of the form *if P, then Q*. The generally agreed correct answer is to select A and 7 (P and not-Q), but this is chosen by only around 10% of participants. Typical choices are A (P) alone or A and 3 (P and Q), often attributed to an intuitive "matching bias" as these items are named in the conditional sentence.

Neuroscientific evidence. Neural imaging is an increasingly popular method for testing dual-process hypotheses in both the psychology of reasoning (Goel, 2008) and social cognition (Lieberman, 2007a, 2007b). Although the studies are still relatively few in number, they generally provide strong support for the claims of the dual-process theorists. Again, belief bias has received particular attention, and studies support the qualitative distinction between belief- and reason-based responding. Neural imaging studies have shown (a) that belief–logic conflict is detected by the brain and (b) that when reason-based responses are observed, different brain areas are activated than when responses are belief-based (De Neys, Vartanian, & Goel, 2008; Goel & Dolan, 2003; Tsujii & Watanabee, 2009) than when they are responsive to the logic of the problems. In particular, conflict detection is indicated by activation of the anterior cingulate cortex and the override of belief-based responding with reasoning signaled by activation of the regions of the right prefrontal cortex known to be associated with executive control. These findings are entirely consistent with default-interventionist forms of dual-process theory, which we discuss further below.

Evidence for dual processing has also been observed in studies of decision making that use neural imaging. For example, McClure, Laibson, Loewenstein, and Cohen (2004) reported that distinct neurological systems were associated with monetary decisions made on the basis of immediate or deferred reward. In our dual-process theories, the latter would involve mental simulation of future possibilities and hence require Type 2 processing. Consistently, the authors reported that prefrontal and frontal cortical regions were activated here, whereas immediate decisions were associated with the limbic system. Similarly, in a study of decision making involving moral dilemmas, Greene, Nystrom, Engell, Darley, and Cohen (2004) found that when consequentialist moral reasoning overrode deontological reasoning, participants took an inordinately long time to make their responses. More important, Greene and colleagues found that the areas of the brain associated with overriding the emotional brain—the dorsolateral prefrontal cortex and parietal lobes—displayed more activity on such trials. What was happening with these individuals was that they were using Type 2 processing to override Type 1 processing coming from brain centers that produce emotion.

In a recent essay, Lieberman (2009) has made an important theoretical argument for the reality of the dual-processing distinctions supported by these studies. In common with many other social psychologists, he uses the questionable nonconscious–conscious distinction, but we believe that the logic of his argument nevertheless applies to the Type 1 and 2 debate. He suggests that if Type 2 thinking (which he associates with conscious processing) were epiphenomenal and actual processing based on a unitary mechanism, this might be indicated in a couple of ways. For example, (a) people might become conscious of an activity when the same neural regions were activated to larger degree; or (b) it could be that regions associated with consciousness might be activated independently of other regions that did the actual work on the tasks. But neither hypothesis is supported by his studies and those he reviews. Instead, activities described as involving implicit social cognition (e.g., stereotypical thinking) involve activation of different neural regions than those associated with conscious reasoning. Earlier, we cited evidence that this is the case also in the belief-bias paradigm. Lieberman reviewed evidence from a wide range of different tasks in the cognitive and social literatures that provide parallels, even providing evidence for mutual inhibition when one kind of processing—and associated neural structures—takes over from the other.

Individual differences. We have already mentioned that differences in working memory capacity and intelligence can influence responsiveness to instructions and resistance to belief biases. More generally, studies of individual differences in reasoning have shown that for many tasks in the heuristics and biases literature, the modal response displays negative correlations with cognitive sophistication. Dual-process theory provides an explanation of this seemingly paradoxical data pattern that recurs in the great rationality debate in cognitive science (Stein, 1996).

As is well known, a substantial research literature has established that people's responses sometimes deviate from the performance considered normative on many reasoning tasks (Baron, 2008; Evans, 2007a; Kahneman & Tversky, 2000; Stanovich, 2009b). Demonstrating that descriptive accounts of human behavior diverged from normative models was a main theme of the heuristics and biases research program inaugurated by Kahneman and Tversky in the early 1970s (Kahneman & Tversky, 1972, 1973; Tversky & Kahneman, 1974). However, over the last two decades, an alternative interpretation of the findings from the heuristics and biases research program has been championed. Contributing to this alternative interpretation have been evolutionary psychologists, adaptationist modelers, and ecological theorists (Anderson, 1990; Cosmides & Tooby, 1996; Gigerenzer, 2007; Oaksford & Chater, 2007). They have reinterpreted the modal response in most of the classic heuristics and biases experiments as indicating an optimal information processing adaptation on the part of the subjects.

Stanovich (1999, 2011) has shown, however, that there are other data patterns to be considered—those concerning individual differences. Specifically, what had long been ignored was that although the average person in heuristics and biases experiments might well display an overconfidence effect, underutilize base rates, ignore P(D/~H), violate the axioms of utility theory, choose P and Q in the Wason selection task (see Fig. 2), probability match, commit the conjunction fallacy, and so on—on each of these tasks, some people give the standard normative response. For example, in knowledge calibration studies, although the mean performance level of the entire sample may be represented by a calibration curve that indicates overconfidence, almost always some people do display near perfect calibration. Likewise, in probabilistic assessment, although the majority of subjects might well ignore the noncausal base rate evidence, a minority of subjects often makes use of this information in exactly the way prescribed by Bayes's theorem. A few people even respond correctly on the notoriously difficult abstract selection task illustrated in Figure 2 (Evans, Newstead, & Byrne, 1993).

Earlier, we argued that normativity is not a defining feature of Type 2 processing. However, the dual-process theories that we support do predict that it will be a strong correlate in experiments using tasks that are hard to solve directly from previous experience or from previously stored cue validities. In addition, participants are usually motivated by instructions and context to get the right answers. Hence, explicit processing effort and hypothetical thinking (or cognitive decoupling) are generally required for success. It follows that those who are better able (by cognitive ability) or better motivated (by thinking dispositions) will be more likely to find the normatively correct answers. And that is generally what the evidence shows. What has been found, more often than not, is that intelligence displays positive correlations with the response traditionally considered normative on the task and negative correlations with the modal response (Stanovich & West, 1998b, 1999; Toplak, West, & Stanovich, 2011; West & Stanovich, 2003; West, Toplak, & Stanovich, 2008). However, our theories also predict clear exceptions. These will occur when participants are not appropriately motivated or when success can be achieved by Type 1 processing. For example, if pragmatic cues to a correct answer provide a low-effort route to success, as when the Wason selection task is presented with certain realistic contents, the correlation with ability measures largely disappears (Stanovich & West, 1998a). Cognitive ability assists only when a problem requires difficult abstract reasoning that loads heavily on cognitive resources—the same reason that experimental manipulations such as working memory loads and speeded tasks are observed to inhibit the ability to perform the same tasks.

What is classically noted in these literatures is that the alternative to getting a problem right is not simply to make random errors. Were that the case, then a dual-process account would not have been merited. In a large range of tasks, the modal and "thoughtless" response (Kahneman, 2011) is a systematic intuitive bias of some kind (see Stanovich, 2011, for a systematic taxonomy of many such tasks). A unimodel theorist might retort that these are lower effort "rules" (Kruglanski & Gigerenzer, 2011) to which their single-system resorts when the high-effort strategy is blocked, for example, by a speeded task or working memory load. However, we are aware of too much specific evidence of qualitative differences between reasoned and intuitive responding to find this argument plausible (see, for example, Kahneman, 2011). Also, when given the opportunity, most participants can explain the reasoning that led to a correct answer, but we are not aware of a single instance of a participant reporting an established bias like belief bias or matching bias (Evans, 1998) as the basis for a wrong one. On the contrary, participants giving a matching response on the Wason selection task are known to rationalize their answer with reference to the logic of the task (Evans & Wason, 1976; Lucas & Ball, 2005; Wason & Evans, 1975). And, as already mentioned, the two kinds of answers are associated with different neural regions and differentially correlated with cognitive ability.

This dual-process account accommodates both the views of the original heuristics and biases literature and their critics who have championed alternative construals of the tasks in terms of evolutionarily adaptive responses. The original heuristics and biases researchers were clear that they deliberately designed tasks in order to put two response tendencies in conflict (see Kahneman, 2000, 2011; Kahneman & Frederick, 2002). Dual-process theorists posit that one of these is quickly triggered by Type 1 processing. The evolutionary psychologists are probably correct that this response is an adaptive response in an evolutionary sense, and it is a credit to their models that they predict it to be the modal one. However, in many of these tasks, it is the alternative response that is the instrumentally rational one (Kahneman & Tversky, 1996; Stanovich, 1999, 2004) and both the generation of the alternative response and the inhibition of the Type 1 response take cognitive capacity of the type that is indexed by intelligence tests. This synthesis of views is supported by the finding that the correlations with intelligence greatly attenuate when evolutionarily "friendly" versions of heuristics and biases tasks are used that do not require the override of Type 1 processing (Stanovich, 1999).

Summary

Having examined the five major lines of criticism, we can summarize our arguments to date. First, we recognize that there are a number of problems with the proliferation of dual-processing theories of higher cognitive processes. Many of the criticisms have force for a number of theories. However, the critics are misguided when they attack dual-process theories as a category and fail to deal with the specific details of any particular theory.

We have pointed out that it is easy to attack a simplified received version of the theory in which all typical correlates to the two types of processing are assumed to be necessary and defining features. To our knowledge, no specific theory proposes this and we see no clear theoretical basis for so doing. As we have shown above, the better defined theories do, indeed, predict particular strong correlations (e.g., of Type 2 processing with cognitive ability and with normatively correct solutions) but only under specified conditions. These theories also predict the conditions under which such associations will not be observed, and the evidence concurs. However, we do concede that there must be at least some clear theoretical basis for the Type 1 and 2 distinction—one or more features that are, indeed, defining. We explain in the final section what we believe these features to be.

Our View: The Defining Features of Type 1 and 2 Processing

The definition of Type 2 processing

The large literatures on working memory and executive function (Baddeley, 2007) have established that there is a general purpose system used in many higher cognitive functions and that the capacity of this system varies reliably between individuals. Measures of working memory capacity have been shown to be predictive of performance in a wide variety of cognitive tasks (L. F. Barrett, Tugade, & Engle, 2004) and highly correlated with fluid intelligence (Colom, Rebollo, Palacios, Juan-Espinosa, & Kyllonen, 2004; Kane, Hambrick, & Conway, 2005). It is the engagement of this system specifically that Jonathan Evans (e.g., 2008, 2010a) has emphasized in the definition of Type 2 processing and which underlies many of its typically observed correlates: that it is slow, sequential, and correlated with measures of general intelligence. He has also suggested that Type 2 thinking enables uniquely human facilities, such as hypothetical thinking, mental simulation, and consequential decision making[2] (Evans, 2007a, 2010b).

As reviewed above, Keith Stanovich, together with his collaborator Rich West, has focused much of his research program on individual differences in both cognitive ability (linked with IQ) and thinking dispositions, showing selective correlations with responses on a wide range of reasoning and decision-making tasks (Stanovich, 1999, 2009b, 2011; Stanovich & West, 2000). Central to his dual-processing argument is that Type 2 aspects of performance on such tasks are selectively correlated with intelligence measures, whereas features attributed to Type 1 processing are largely independent of such measures. Because working memory capacity and general intelligence are known to be highly correlated, this framework is easily reconciled with Evans's emphasis on the engagement of working memory in Type 2 processing. Stanovich (Stanovich, 2011; Stanovich & Toplak, 2012) has also strongly emphasized the features that he calls "cognitive decoupling" in his definition of Type 2 processing. This is again compatible with Evans's (2007a, 2010b) view that such processing is necessary for hypothetical thought. In order to reason hypothetically, we must be able to prevent our representations of the real world from becoming confused with representations of imaginary situations. The so-called cognitive decoupling operations are the central feature of Type 2 processing that makes this possible according to Stanovich (2009b, 2011).

The definition of Type 1 processing

We both agree that the defining characteristic of Type 1 processes is their autonomy. They do not required "controlled attention," which is another way of saying that they make minimal demands on working memory resources. Hence, Stanovich (2004, 2009a, 2011) has argued that the execution of Type 1 processes is mandatory when their triggering stimuli are encountered and they are not dependent on input from high-level control systems. Autonomous processes have other correlated features—their execution tends to be rapid, they do not put a heavy load on central processing capacity, they tend to be associative—but, once again, these correlated features are not defining. Into the category of autonomous processes would go some processes of emotional regulation; the encapsulated modules for solving specific adaptive problems that have been posited by evolutionary psychologists; processes of implicit learning; and the automatic firing of overlearned associations (see H. C. Barrett & Kurzban, 2006; Carruthers, 2006; Evans, 2008; Kahneman & Klein, 2009; Samuels, 2005, 2009; Shiffrin & Schneider, 1977; Sperber, 1994).

These disparate categories make clear that the categories of Type 1 processing have some heterogeneity—encompassing both innately specified processing modules or procedures and experiential associations that have been learned to the point of automaticity. The many kinds of Type 1 processing have in common the property of autonomy, but otherwise, their neurophysiology and etiology might be considerably different. For example, Type 1 processing is not limited to modular subprocesses that meet all of the classic Fodorian (Fodor, 1983) criteria or the criteria for a Darwinian module (Cosmides, 1989; Sperber, 1994). Type 1 processing also encompasses (general) processes of implicit learning and conditioning. Also, many rules, stimulus discriminations, and decision-making principles that have been practiced to the point of automaticity (Kahneman & Klein, 2009; Shiffrin & Schneider, 1977) are processed in a Type 1 manner.

Evolutionary linkage

Although rudimentary forms of higher order control can be observed in mammals and other animals (Toates, 2006), the controlled processing in which they can engage is very limited by comparison with humans, who have unique facilities for language and meta-representation as well as greatly enlarged frontal lobes (Evans, 2010b). We are in agreement that the facility for Type 2 thinking became uniquely developed in human beings, effectively forming a new mind (in the sense of Dennett, 1996), which coexists with an older mind based on instincts and associative learning and gives humans the distinctive forms of cognition that define the species (Evans, 2010b; Evans & Over, 1996; Stanovich, 1999, 2004, 2011). It is evident that humans resemble other animals in some respects but are very different in others. Quite obviously, no other animal can engage in the forms of abstract hypothetical thought that underlie science, engineering, literature, and many other human activities. More basically, we propose that other animals are much more limited in their metarepresentational and simulation abilities (Penn, Holyoak, & Povinelli, 2008), thus leading to limitations (compared with humans) in their ability to carry out forms of behavior that depend on prior appraisal of possible consequences. Thus, a key defining feature of Type 2 processing—the feature that makes humans unique—is cognitive decoupling: the ability to distinguish supposition from belief and to aid rational choices by running thought experiments.

Default interventionism

Our joint view is that reasoning and decision making sometimes requires both (a) an override of the default intuition and (b) its replacement by effective Type 2, reflective reasoning. The disposition to override intuitions is a function of several factors, including the meta-cognitive feeling of rightness in the initial intuition (Thompson, 2009; Thompson, Turner, & Pennycock, 2011). The evidence shows that when people are confident of an initial intuitive answer, they are less likely to spend time rethinking it or to change their answer after reflection (Thompson et al., 2011). This applies on tasks where there is no relation at all between confidence and accuracy (Shynkarkuk & Thompson, 2006). Another factor, already mentioned, is the existence of measurable thinking dispositions that are inclined toward rational thinking and disinclined to accept intuitions without checking them out (Stanovich, 2009b, 2011). The evidence suggests that cognitive ability is also involved in the ability effectively to intervene with Type 2 reasoning and solve the problem.

In common with Kahneman (Kahneman, 2011; Kahneman & Frederick, 2002), we both favor forms of dual-process theory that are *default-interventionist* in form. In general, we believe that intuitive answers are often prompted rapidly and with little effort when people are confronted with novel problems. Where they lack relevant experience, however, these answers may be inappropriate and fail to meet the goals set. Thus, a key concept in this kind of dual-process theory is that of intervention with reflective (Type 2) reasoning on the default (Type 1) intuition. Often, humans act as cognitive misers (an old theme in cognitive and social psychology) by engaging in attribute substitution—the substitution of an easy-to-evaluate characteristic for a harder one, even if the easier one is less accurate (Kahneman & Frederick, 2002). However, when the decision matters, being a cognitive miser may lead us astray. For example, when we are evaluating important risks—such as the risk of certain activities and environments for our children—we do not want to substitute vividness for careful thought about the situation. In such situations, we want to use Type 2 override processing to block the attribute substitution of the cognitive miser.

One difficulty with parallel-competitive forms of dual-process theory (e.g., S. A. Sloman, 1996; Smith & DeCoster, 2000) is that, in general, Type 1 processing is very much quicker than Type 2 processing. Thus, if both types of processing are to have their say, the fast horse must wait for the slow horse to arrive before any potential conflict can be resolved. A more fundamental problem, perhaps, is that Type 2 processing requires extremely limited and precious working memory resources, according to the definitions we are putting forward. These must be selectively allocated to the most important task at hand. Default interventionism allows that most of our behavior is controlled by Type 1 processes running in the background. Thus, most behavior will accord with defaults, and intervention will occur only when difficulty, novelty, and motivation combine to command the resources of working memory. Hence, we see no feasible way to combine parallel-competitive assumptions with our own definitions of Type 1 and 2 processing. Default interventionism seems much more consistent with an overall framework of humans as cognitive misers (Kahneman, 2011).

We do not believe that default-interventionist dual-process theories can be reduced simply to terms of "rule conflict" (Kruglanski & Gigerenzer, 2011). Given the limited capacity of central cognitive resources, we believe it is inevitable that most behavior will be under autonomous control and that rapid, default responses will be prompted in most situations. However, it is also the case that unless reflective reasoning making full use of our central resources can also be recruited when required, the forms of abstract representational thought that distinguishes human intelligence could not be displayed.

Conclusions

In summary, our view is that the defining features of Type 1 processing and of Type 2 processing are not the conjunction of eight different binary properties ("2 cells out of 64"). Furthermore, research has advanced considerably since the "suggestive list of characteristics" phase of over a decade ago. Our view of the literature is that autonomous processing is the defining feature of Type 1 processing. Even more convincing is the converging evidence that the key feature of Type 2 processing is the ability to sustain the decoupling of secondary representations—a key feature of all working memory tasks. The latter is a foundational cognitive requirement for hypothetical thinking. In short, we do not support dual-processing approaches on the basis of whim and fashion. We do so both because the evidence is compelling and because a very clear theoretical basis for the two-process distinction has now emerged. Such theories can account for a wide range of phenomena in the reasoning, judgment, and decision-making literatures that have been the subject of several recent books (Evans, 2007a; Kahneman, 2011; Stanovich, 2011).

We do, however, view the development of dual-process theories as an evolving project. Just as they have developed and changed a great deal in the past decade, we expect this process to continue. It is a complex and demanding effort, and the critical appraisals by those both sympathetic and unsympathetic to the enterprise provide an important stimulus to this process.

Acknowledgment

We would like to acknowledge Bobbie Spellman's considerable assistance in improving the final presentation of this article.

Declaration of Conflicting Interests

The authors declared that they had no conflicts of interest with respect to their authorship or the publication of this article.

Notes

1. In the famous Linda problem, participants are given a thumbnail description of a woman called Linda that is consistent with the stereotype of a feminist and inconsistent with that of a bank teller. They are then observed to judge that Linda is more likely to be both a feminist and a bank teller than she is to be a bank teller—a logical impossibility.

2. By "consequential decision making," we mean choices that are determined by reasoning about or simulation of future consequences of anticipated actions, as opposed to choices driven by experiential learning and associative strength.

References

Anderson, J. R. (1990). *The adaptive character of thought*. Hillsdale, NJ: Erlbaum.

Baddeley, A. (2007). *Working memory, thought and action*. Oxford, England: Oxford University Press.

Barbey, A. K., & Sloman, S. A. (2007). Base-rate respect: From ecological validity to dual processes. *Behavioral and Brain Sciences*, *30*, 241–297.

Bargh, J. A. (2005). Bypassing the will: Demystifying the nonconscious control of social behavior. In R. R. Hassin, J. S. Uleman, & J. A. Bargh (Eds.), *The new unconscious* (pp. 37–58). Oxford, England: Oxford University Press.

Baron, J. (2008). *Thinking and deciding* (4th ed.). Cambridge, MA: Cambridge University Press.

Barrett, H. C., & Kurzban, R. (2006). Modularity in cognition: Framing the debate. *Psychological Review*, *113*, 628–647.

Barrett, L. F., Tugade, M. M., & Engle, R. W. (2004). Individual differences in working memory capacity and dual-process theories of the mind. *Psychological Bulletin*, *130*, 553–573.

Buchtel, C., & Norenzayan, A. (2009). Thinking across cultures: Implications for dual processes. In J. St. B. T. Evans & K. Frankish (Eds.), *In two minds: Dual processes and beyond* (pp. 217–238). Oxford, England: Oxford University Press.

Cacioppo, J. T., & Petty, R. E. (1982). The need for cognition. *Journal of Personality and Social Psychology*, *42*, 116–131.

Carruthers, P. (2006). *The architecture of the mind*. Oxford, England: Oxford University Press.

Chaiken, S., & Trope, Y. (Eds.). (1999). *Dual-process theories in social psychology*. New York, NY: Guilford Press.

Churchland, P. S. (2002). *Brain-wise: Studies in neurophilosophy*. Cambridge, MA: MIT Press.

Colom, R., Rebollo, I., Palacios, A., Juan-Espinosa, M., & Kyllonen, P. C. (2004). Working memory is (almost) perfectly predicted by g. *Intelligence*, *32*, 277–296.

Cosmides, L. (1989). The logic of social exchange: Has natural selection shaped how humans reason? *Cognition*, *31*, 187–276.

Cosmides, L., & Tooby, J. (1996). Are humans good intuitive statisticians after all? Rethinking some conclusions from the literature on judgment under uncertainty. *Cognition*, *58*, 1–73.

De Neys, W. (2006a). Automatic-heuristic and executive-analytic processing during reasoning: Chronometric and dual-task considerations. *Quarterly Journal of Experimental Psychology*, *59*, 1070–1100.

De Neys, W. (2006b). Dual processing in reasoning: Two systems but one reasoner. *Psychological Science*, *17*, 428–433.

De Neys, W., Schaeken, W., & d'Ydewalle, G. (2005a). Working memory and counterexample retrieval for causal conditionals. *Thinking & Reasoning*, *11*, 123–150.

De Neys, W., Schaeken, W., & d'Ydewalle, G. (2005b). Working memory and everyday conditional reasoning: Retrieval and inhibition of stored counterexamples. *Thinking & Reasoning*, *11*, 349–381.

De Neys, W., Vartanian, O., & Goel, V. (2008). Smarter than we think: When our brains detect that we are biased. *Psychological Science*, *19*, 483–489.

Dennett, D. (1991). *Consciousness explained*. London, England: Allen Lane.

Dennett, D. (1996). *Kinds of minds: Toward an understanding of consciousness*. New York, NY: Basic Books.

Dienes, Z., & Perner, J. (1999). A theory of implicit and explicit knowledge. *Behavioral and Brain Sciences*, *22*, 735–808.

Epstein, S. (1994). Integration of the cognitive and psychodynamic unconscious. *American Psychologist*, *49*, 709–724.

Epstein, S., Pacini, R., Denes-Raj, V., & Heier, H. (1996). Individual differences in intuitive-experiential and analytic-rational thinking styles. *Journal of Personality and Social Psychology*, *71*, 390–405.

Evans, J. St. B. T. (1989). *Bias in human reasoning: Causes and consequences*. Brighton, England: Erlbaum.

Evans, J. St. B. T. (1998). Matching bias in conditional reasoning: Do we understand it after 25 years? *Thinking & Reasoning*, *4*, 45–82.

Evans, J. St. B. T. (2003). In two minds: Dual process accounts of reasoning. *Trends in Cognitive Sciences*, *7*, 454–459.

Evans, J. St. B. T. (2006). Dual system theories of cognition: Some issues. Proceedings of the 28th Annual Meeting of the Cognitive Science Society, Vancouver, Canada. Retrieved from http://www.cogsci.rpi.edu/CSJarchive/proceedings/2006/docs/p202.pdf

Evans, J. St. B. T. (2007a). *Hypothetical thinking: Dual processes in reasoning and judgement*. Hove, England: Psychology Press.

Evans, J. St. B. T. (2007b). On the resolution of conflict in dual-process theories of reasoning. *Thinking & Reasoning*, *13*, 321–329.

Evans, J. St. B. T. (2008). Dual-processing accounts of reasoning, judgment and social cognition. *Annual Review of Psychology*, *59*, 255–278.

Evans, J. St. B. T. (2009). How many dual-process theories do we need: One, two or many? In J. St. B. T. Evans & K. Frankish (Eds.), *In two minds: Dual processes and beyond* (pp. 31–54). Oxford, England: Oxford University Press.

Evans, J. St. B. T. (2010a). Intuition and reasoning: A dual-process perspective. *Psychological Inquiry*, *21*, 313–326.

Evans, J. St. B. T. (2010b). *Thinking twice: Two minds in one brain*. Oxford, England: Oxford University Press.

Evans, J. St. B. T. (2012). Dual-process theories of reasoning: Facts and fallacies. In K. Holyoak & R. G. Morrison (Eds.), *The Oxford handbook of thinking and reasoning* (pp. 115–133). New York, NY: Oxford University Press.

Evans, J. St. B. T., Barston, J. L., & Pollard, P. (1983). On the conflict between logic and belief in syllogistic reasoning. *Memory & Cognition*, *11*, 295–306.

Evans, J. St. B. T., & Curtis-Holmes, J. (2005). Rapid responding increases belief bias: Evidence for the dual-process theory of reasoning. *Thinking & Reasoning*, *11*, 382–389.

Evans, J. St. B. T., Handley, S. J., & Harper, C. (2001). Necessity, possibility and belief: A study of syllogistic reasoning. *Quarterly Journal of Experimental Psychology*, *54*, 935–958.

Evans, J. St. B. T., Handley, S. J., Neilens, H., Bacon, A. M., & Over, D. E. (2010). The influence of cognitive ability and instructional set on causal conditional inference. *Quarterly Journal of Experimental Psychology*, *63*, 892–909.

Evans, J. St. B. T., Newstead, S. E., & Byrne, R. M. J. (1993). *Human reasoning: The Psychology of deduction*. Hove, England: Erlbaum.

Evans, J. St. B. T., & Over, D. E. (1996). *Rationality and reasoning*. Hove, England: Psychology Press.

Evans, J. St. B. T., & Wason, P. C. (1976). Rationalization in a reasoning task. *British Journal of Psychology*, *63*, 205–212.

Fodor, J. (1983). *The modularity of mind*. Scranton, PA: Crowell.

Frankish, K., & Evans, J. St. B. T. (2009). The duality of mind: An historical perspective. In J. St. B. T. Evans & K. Frankish (Eds.), *In two minds: Dual processes and beyond* (pp. 1–30). Oxford, England: Oxford University Press.

George, C. (1995). The endorsement of the premises: Assumption-based or belief-based reasoning. *British Journal of Psychology*, *86*, 93–111.

Gibbard, A. (1990). *Wise choices, apt feelings: A theory of normative judgment*. Cambridge, MA: Harvard University Press.

Gigerenzer, G. (2007). *Gut feelings: The intelligence of the unconscious*. London, England: Penguin.

Gigerenzer, G. (2011). Personal reflections on theory and psychology. *Theory & Psychology*, *20*, 733–743.

Gigerenzer, G., & Regier, T. (1996). How do we tell an association from a rule? Comment on Sloman (1996). *Psychological Bulletin*, *119*, 23–26.

Goel, V. (2008). Anatomy of deductive reasoning. *Trends in Cognitive Sciences*, *11*, 435–441.

Goel, V., & Dolan, R. J. (2003). Explaining modulation of reasoning by belief. *Cognition*, *87*, B11–B22.

Greene, J., Nystrom, L. E., Engell, A. D., Darley, J. M., & Cohen, J. D. (2004). The neural basis of cognitive conflict and control in moral judgment. *Neuron*, *44*, 389–400.

Kahneman, D. (2000). A psychological point of view: Violations of rational rules as a diagnostic of mental processes. *Behavioral and Brain Sciences*, *23*, 681–683.

Kahneman, D. (2011). *Thinking, fast and slow*. New York, NY: Farrar, Straus and Giroux.

Kahneman, D., & Frederick, S. (2002). Representativeness revisited: Attribute substitution in intuitive judgement. In T. Gilovich, D. Griffin, & D. Kahneman (Eds.), *Heuristics and biases: The psychology of intuitive judgment* (pp. 49–81). Cambridge, MA: Cambridge University Press.

Kahneman, D., & Klein, G. (2009). Conditions for intuitive expertise: A failure to disagree. *American Psychologist*, *80*, 237–251.

Kahneman, D., & Tversky, A. (1972). Subjective probability: A judgment of representativeness. *Cognitive Psychology*, *3*, 430–454.

Kahneman, D., & Tversky, A. (1973). On the psychology of prediction. *Psychological Review*, *80*, 237–251.

Kahneman, D., & Tversky, A. (1996). On the reality of cognitive illusions: A reply to Gigerenzer's critique. *Psychological Review*, *103*, 582–591.

Kahneman, D., & Tversky, A. (Eds.). (2000). *Choices, values and frames*. Cambridge, MA: Cambridge University Press.

Kane, M. J., Hambrick, D. Z., & Conway, A. R. A. (2005). Working memory capacity and fluid intelligence are strongly related constructs: Comment on Ackerman, Beier, and Boyle (2005). *Psychological Bulletin, 131*, 66–71.

Keren, G., & Schul, Y. (2009). Two is not always better than one: A critical evaluation of two-system theories. *Perspectives on psychological science*, *4*, 533–550.

Klauer, K. C., Beller, S., & Hutter, M. (2010). Conditional reasoning in context: A dual-source model of probabilistic inference. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *36*, 298–323.

Klauer, K. C., & Kellen, D. (2011). Assessing the belief bias effect with ROCs: Reply to Dube, Rotello & Heit (2010). *Psychological Review*, *118*, 164–173.

Klauer, K. C., Musch, J., & Naumer, B. (2000). On belief bias in syllogistic reasoning. *Psychological Review*, *107*, 852–884.

Klein, G. (1998). *Sources of power*. Cambridge, MA: MIT Press.

Kruglanski, A. W., Chun, W. Y., Erb, H. P., Pierro, A., Mannett, L., & Spiegel, S. (2003). A parametric unimodel of human judgment: Integrating dual-process frameworks in social cognition from a single-mode perspective. In J. P. Forgas, K. R. Williams, & W. von Hippel (Eds.), *Social judgments: Implicit and explicit processes* (pp. 137–161). New York, NY: Cambridge University Press.

Kruglanski, A. W., & Gigerenzer, G. (2011). Intuitive and deliberative judgements are based on common principles. *Psychological Review*, *118*, 97–109.

Kruglanski, A. W., & Orehek, E. (2007). Partitioning the domain of social inference: Dual mode and system models and their alternatives. *Annual Review of Psychology*, *58*, 291–316.

Lieberman, M. D. (2007a). Social cognitive neuroscience: A review of core processes. *Annual Review of Psychology*, *58*, 259–289.

Lieberman, M. D. (2007b). The X- and C-Systems: The neural basis of automatic and controlled social cognition. In E. Harmon-Jones & P. Winkleman (Eds.), *Social neuroscience* (pp. 290–315). New York, NY: Guilford Press.

Lieberman, M. D. (2009). What zombies can't do: A social cognitive neuroscience approach to the irreducibility of reflective consciousness. In J. St. B. T. Evans & K. Frankish (Eds.), *In two minds: Dual processes and beyond* (pp. 293–316). Oxford, England: Oxford University Press.

Lucas, E. J., & Ball, L. J. (2005). Think-aloud protocols and the selection task: Evidence for relevance effects and rationalisation processes. *Thinking & Reasoning*, *11*, 35–66.

McClure, S. M., Laibson, D. I., Loewenstein, G., & Cohen, J. D. (2004). Separate neural systems value immediate and delayed monetary rewards. *Science*, *306*, 503–507.

Newstead, S. E. (2000). Are there two different kinds of thinking? *Behavioral and Brain Sciences*, *23*, 690–691.

Nisbett, R., Peng, K., Choi, I., & Norenzayan, A. (2001). Culture and systems of thought: Holistic vs. analytic cognition. *Psychological Review*, *108*, 291–310.

Oaksford, M., & Chater, N. (2007). *Bayesian rationality. The probabilistic approach to human reasoning*. Oxford, England: Oxford University Press.

Osman, M. (2004). An evaluation of dual-process theories of reasoning. *Psychonomic Bulletin & Review*, *11*, 988–1010.

Penn, D. C., Holyoak, K. J., & Povinelli, D. J. (2008). Darwin's mistake: Explaining the discontinuity between human and nonhuman minds. *Behavioral and Brain Sciences*, *31*, 109–178.

Reber, A. S. (1993). *Implicit learning and tacit knowledge*. Oxford, England: Oxford University Press.

Roberts, M. J., & Newton, E. J. (2001). Inspection times, the change task, and the rapid-response selection task. *Quarterly Journal of Experimental Psychology*, *54*, 1031–1048.

Samuels, R. (2005). The complexity of cognition: Tractability arguments for massive modularity. In P. Carruthers, S. Laurence, & S. Stich (Eds.), *The innate mind* (pp. 107–121). Oxford, England: Oxford University Press.

Samuels, R. (2009). The magic number two plus or minus: Some comments on dual-processing theories of cognition. In J. St. B. T. Evans & K. Frankish (Eds.), *In two minds: Dual processes and beyond* (pp. 129–146). Oxford, England: Oxford University Press.

Shiffrin, R. M., & Schneider, W. (1977). Controlled and automatic human information processing II: Perceptual learning, automatic attending and a general theory. *Psychological Review*, *84*, 127–189.

Shynkarkuk, J. M., & Thompson, V. A. (2006). Confidence and accuracy in deductive reasoning. *Memory & Cognition*, *34*, 619–632.

Sloman, A., & Chrisley, R. (2003). Virtual machines and consciousness. *Journal of Consciousness Studies*, *10*, 133–172.

Sloman, S. A. (1996). The empirical case for two systems of reasoning. *Psychological Bulletin*, *119*, 3–22.

Smith, E. R., & Collins, E. C. (2009). Dual-process models: A social psychological perspective. In J. St. B. T. Evans & K. Frankish (Eds.), *In two minds: Dual processes and beyond* (pp. 197–216). Oxford, England: Oxford University Press.

Smith, E. R., & DeCoster, J. (2000). Dual-process models in social and cognitive psychology: Conceptual integration and links to underlying memory systems. *Personality and Social Psychology Review*, *4*, 108–131.

Sperber, D. (1994). The modularity of thought and the epidemiology of representations. In L. A. Hirschfield & S. A. Gelman (Eds.), *Mapping the mind: Domain specificity in cognition and culture* (pp. 39–67). Cambridge, England: Cambridge University Press.

Stanovich, K. E. (1990). Concepts in developmental theories of reading skill: Cognitive resources, automaticity and modularity. *Developmental Review*, *10*, 72–100.

Stanovich, K. E. (1999). Who is rational? *Studies of individual differences in reasoning*. Mahwah, NJ: Erlbaum.

Stanovich, K. E. (2004). *The robot's rebellion: Finding meaning the age of Darwin*. Chicago, IL: University of Chicago Press.

Stanovich, K. E. (2009a). Distinguishing the reflective, algorithmic and autonomous minds: Is it time for a tri-process theory? In J. St. B. T. Evans & K. Frankish (Eds.), *In two minds: Dual processes and beyond* (pp. 55–88). Oxford, England: Oxford University Press.

Stanovich, K. E. (2009b). *What intelligence tests miss: The psychology of rational thought*. New Haven, CT: Yale University Press.

Stanovich, K. E. (2011). *Rationality and the reflective mind*. New York, NY: Oxford University Press.

Stanovich, K. E., & Toplak, M. E. (2012). Defining features versus incidental correlates of type 1 and type 2 processing. *Mind & Society*, *11*, 3–13.

Stanovich, K. E., & West, R. F. (1997). Reasoning independently of prior belief and individual differences in actively open-minded thinking. *Journal of Educational Psychology*, *89*, 342–357.

Stanovich, K. E., & West, R. F. (1998a). Cognitive ability and variation in selection task performance. *Thinking & Reasoning*, *4*, 193–230.

Stanovich, K. E., & West, R. F. (1998b). Individual differences in rational thought. *Journal of Experimental Psychology: General*, *127*, 161–188.

Stanovich, K. E., & West, R. F. (1999). Discrepancies between normative and descriptive models of decision making and the understanding acceptance principle. *Cognitive Psychology*, *38*, 349–385.

Stanovich, K. E., & West, R. F. (2000). Individual differences in reasoning: Implications for the rationality debate. *Behavioral and Brain Sciences*, *23*, 645–726.

Stanovich, K. E., & West, R. F. (2007). Natural myside bias is independent of cognitive ability. *Thinking & Reasoning*, *13*, 225–247.

Stanovich, K. E., West, R. F., & Toplak, M. E. (2011). The complexity of developmental predictions from dual process models. *Developmental Review*, *31*, 103–108.

Stein, E. (1996). *Without good reason: The rationality debate in philosophy and cognitive science*. Oxford, England: Oxford University Press.

Stevenson, R. J., & Over, D. E. (1995). Deduction from uncertain premises. *Quarterly Journal of Experimental Psychology, 48A*, 613–643.

Sun, R., Slusarz, P., & Terry, C. (2005). The interaction of the explicit and the implicit in skill learning: A dual-process approach. *Psychological Review*, *112*, 159–192.

Thompson, V. A. (2009). Dual-process theories: A metacognitive perspective. In J. St. B. T. Evans & K. Frankish (Eds.), *In two minds: Dual processes and beyond* (pp. 171–196). Oxford, England: Oxford University Press.

Thompson, V. A., Turner, J. P., & Pennycock, G. (2011). Intuition, reason and metacognition. *Cognitive Psychology*, *63*, 107–140.

Toates, F. (2006). A model of the hierarchy of behaviour, cognition and consciousness. *Consciousness and Cognition*, *15*, 75–118.

Toplak, M. E., West, R. F., & Stanovich, K. E. (2011). The cognitive reflection test as a predictor of performance on heuristics-and-biases tasks. *Memory & Cognition*, *39*, 1275–1289.

Tsujii, T., & Watanabee, S. (2009). Neural correlates of dual-task effect on belief-bias syllogistic reasoning: A near-infrared spectroscopy study. *Brain Research*, *1287*, 118–125.

Tversky, A., & Kahneman, D. (1974). Judgement under uncertainty: Heuristics and biases. *Science*, *185*, 1124–1131.

Tversky, A., & Kahneman, D. (1983). Extensional vs. intuitive reasoning: The conjunction fallacy in probability judgment. *Psychological Review*, *90*, 293–315.

Verschueren, N., Schaeken, W., & d'Ydewalle, G. (2005). A dual-process specification of causal conditional reasoning. *Thinking & Reasoning*, *11*, 239–278.

Wason, P. C., & Evans, J. St. B. T. (1975). Dual processes in reasoning? *Cognition*, *3*, 141–154.

Wegner, D. M. (2002). *The illusion of conscious will*. Cambridge, MA: MIT books.

Weidenfeld, A., Oberauer, K., & Hornig, R. (2005). Causal and noncausal conditionals: An integrated model of interpretation and reasoning. *Quarterly Journal of Experimental Psychology*, *58*, 1479–1513.

West, R. F., & Stanovich, K. E. (2003). Is probability matching smart? Associations between probabilistic choices and cognitive ability. *Memory & Cognition*, *31*, 243–251.

West, R. F., Toplak, M. E., & Stanovich, K. E. (2008). Heuristics and biases as measures of critical thinking: Associations with cognitive ability and thinking dispositions. *Journal of Educational Psychology*, *100*, 930–941.

Wilson, T. D. (2002). *Strangers to ourselves*. Cambridge, MA: Belknap Press.