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REVIEW

Reflections on reflection: the nature and function of type 2 processes in dual-process theories of reasoning

Jonathan St. B. T. Evans

School of Psychology, University of Plymouth, Plymouth, UK

ABSTRACT
I present a critical discussion of dual-process theories of reasoning and decision making with particular attention to the nature and role of Type 2 processes. The original theory proposed that A: Type 2 processes serve to rationalise and support intuitive choices. For most of its history, however, such accounts have emphasised instead B: Type 2 processes reason to conclusions or decisions. B is part of the "received theory" of dual processing, often inaccurately linked to the idea that Type 2 reasoning is necessary for correct solutions. While not mutually exclusive, the evidence for each proposition is assessed. I then present a default-interventionist model which incorporates both propositions A and B. This is consistent with evidence that reasoning to support the default intuition is the norm, although intervention may also occur. Other issues discussed include (1) whether we should treat Type 2 as well as Type 1 processing as originating from multiple systems, (2) whether we need to separate postulate "Type 3" processes to explain underlying cognitive control and attention switching, and (3) whether recent experimental observations of "logical intuitions" undermine the default-interventionist approach. I point to some new directions in which research on dual processes may proceed.

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The notion that there are two kinds of thinking, one fast and intuitive, the other slow and reflective is pervasive. This distinction has been around for centuries in philosophical writing, and dual-process theories abound in modern psychology, often developed independently (Frankish & Evans, 2009). In the psychology of reasoning, the first account was that of Wason and Evans (1974) who used the terms "dual processes" as well as the labels Type 1 and 2 to distinguish them. These labels have stuck, although following the proposal of dual systems for reasoning (Evans & Over, 1996;

CONTACT Jonathan St B T Evans j.evans@plymouth.ac.uk

Sloman, 1996) the terms System 1 and 2 (introduced by Stanovich, 1999) became popular. Some authors still refer to two systems (Kahneman, 2011) but I no longer do so and will stick with the Type 1 and 2 terminology here as it begs fewer theoretical questions. It seems implausible that the gamut of autonomous processes that have been labelled as Type 1 could in any meaningful way be described as belonging to a single system (Evans & Stanovich, 2013a).

While popular, dual-process theories in cognitive and social psychology are also controversial, having been subject to a number of critical papers by leading authors (Gigerenzer, 2011; Keren & Schul, 2009; Kruglanski & Gigerenzer, 2011; Melnikoff & Bargh, 2018; Osman, 2004). Critics have suggested that the theory is incoherent, not supported by the evidence or can be accounted for by a more parsimonious single process approach. In response, dual-process theorists have claimed that critics have misunderstood or misrepresented the theories and failed to take into account some strong empirical support in the literature (Evans & Stanovich, 2013a; Pennycook, De Neys, Evans, Stanovich, & Thompson, 2018). A particular issue is the representation of dual-process accounts by critics as a single generic "received" theory (Evans & Stanovich, 2013a) in which all typical features attributed to the two kinds of processing are assumed to be necessary and defining. However, it is not my intention to engage with these arguments in the current article which have been fully addressed in the cited sources. For those who take issue with the Type 1 and 2 distinction, I can say that while I use the term Type 2 processing in the current article, one can take that simply to refer to thinking which is slow and reflective and which engages working memory. Few authors would deny the existence of such thought and the theoretical purpose of this article is to examine its nature and particularly its function.

My main concern in this article is with Type 2 processes, which historically have been described as having two very different functions. First, however, I want to comment briefly on the nature of Type 1 processing which was covered by the broad label "autonomous" in the definition offered by Evans and Stanovich (2013a). I now believe that a narrower definition is required. While Type 1 processes do not require the resources of working memory or controlled attention for their operation (or they would be Type 2) they do post their products into working memory in a way that many autonomous processes of the brain do not. Specifically, they bring to mind judgements or candidate responses of some kind accompanied by a feeling of confidence or rightness in that judgement, as proposed by Valerie Thompson and colleagues (Thompson, 2009; Thompson, Prowse Turner, & Pennycook, 2011). This more restricted definition of Type 1 processing has two benefits, the first of which is that allows more accurate description of the contrasting types of processing postulated by dual-process theorists in the literature. In addition, it permits us to posit a separate class of autonomous *control* processes, also implicitly assumed in these theories, which I call Type 3 processes (Evans, 2009) and discuss later in the article.

The first dual-process theory in the psychology of reasoning was proposed by Wason and Evans (1974) who described Type 1 and 2 processes as unconscious and conscious processing respectively – an idea which was short-lived in the cognitive literature but is common in the parallel social cognition literature on dual processing (see, e.g., Bargh, 2006; Wilson, 2002). Type 2 thinking was conceived from the start to be slow and deliberative but its original function was proposed to be very different from that of the bulk of theories that followed. The assigned purpose of Type 2 reasoning in the original theory was to rationalise an intuitive response. By contrast, most dual-process theories of reasoning and decision making from the 1980s onwards have emphasised a quite different function of Type 2 processing, that of effective reasoning to a conclusion or a decision. It seems to me that this dramatic change has been obscured somewhat by the passage of time and is in need of re-examination. (A rare example of a recent paper that explicitly distinguishes these two functions of Type 2 processing is that of Pennycook, Fugelsang, & Koehler, 2015, which I discuss later.)

In this article, I am going to consider the case for each of these functions and ask also if they can be reconciled within a single dual-process framework. I will label the following as two *propositions* about Type 2 processing, in order not to prejudge by conclusions:

Proposition A (rationalisation function)

> Type 2 processes find reasons and justifications to support or rationalise intuitions

Proposition B: (decision function)

> Type 2 processes engage reasoning to draw conclusions or make decisions

The difference in these propositions lies not in the nature of Type 2 processing (e.g. slow, serial, engaging working memory) but rather in its function. Somewhere between the first proposal of dual processing and the "received version" discussed in many more recent papers (Evans & Stanovich, 2013a), a dramatic transition occurred. Reasoning to justify one's intuitions instead became reasoning to support a conclusion or decision to *replace* an intuitive judgement, which is often considered to be biased. The original theory started to change in this direction very early in my own writing (Evans, 1982, Chapter 12). One comment of interest concerns consciousness. As mentioned earlier, Wason and Evans talked of Type 1 processes being unconscious and Type 2 processes conscious. Evans (1982, p. 240) with reference to some papers I published in 1980 states:

> … the reference to Type 1 processes as unconscious and Type 2 processes as conscious has been rejected. If by 'unconscious' one means non-introspectable then both processes are unconscious. Type 2 processes underlie so-called introspective reports but they are not, themselves, reportable.

Note that we could also say that both processes are conscious in that some product is registered consciously – either an intuition which provides both a potential response and feeling of rightness (FOR) which come to mind quickly (Thompson et al., 2011) – or a slower reasoning which registers intermediate products in working memory, giving some conscious sense of the process. In the same chapter, it is clear that the change of assumed function of Type 2 processing from rationalisation to decision making was already happening: "In the Wason/Evans version all reasoning responses were attributed to Type 1 processing. In the revised version, the dual processes are linked to the Evans two-factor theory of reasoning" (Evans, 1982, p. 240).

The two-factor theory, expounded at length in the same book, was based on the evidence that people were influenced both by the logic of reasoning problems and by logically irrelevant biasing factors. It might these days be called a "dual source" theory (Klauer, Beller, & Hutter, 2010). A very clear case was published shortly after this book by Evans, Barston, and Pollard (1983) who showed that in syllogistic reasoning, people's judgements of logical validity were influenced in almost equal part by the actual logic of the syllogism and the believability of the conclusion. An important transition from dual sources to dual processes was made in this article, with the suggestion that there are two conflicting cognitive processes responsible for the logical evaluations on the one hand (Type 2) and for the belief bias on the other (Type 1). As a result, we now have a very different concept of Type 2 processing from that of Wason and Evans, corresponding to Proposition B above.

Structurally, there are two main forms of dual-process theory. Some authors have proposed that Type 1 and 2 processes operate in parallel and may produce conflicting answers, typically describing them as associative and rule-based (Sloman, 1996; Smith & DeCoster, 1999). However, in this article, I will focus on what I have termed *default-interventionist* dual-process theories (Evans, 2007b). These have been proposed by several authors in the fields of reasoning and decision making (Evans, 2006, 2007a; Kahneman, 2011; Kahneman & Frederick, 2002; Stanovich, 1999, 2011). I will later provide a model of this type which attempts to incorporate both Propositions A and B which are not, after all, mutually exclusive. However, it is fair to say that Proposition B has dominated writing about dual processes since the 1980s and is that which features in the received version – a kind of generic theory constructed in the minds of authors in the field but advocated by no one author in particular.

The simplified and generic received theory incorporates a number of fallacies which I have discussed elsewhere (Evans, 2012, 2018; Evans & Stanovich, 2013a) the most important of which I call the *normative fallacy*. This is the false belief that Type 1 processes are biased and Type 2 processes normatively correct. In its most extreme from, authors attempt to diagnose the type of process used by the correctness of the answer. This cannot possibly be correct for both *a priori* and empirical reasons. Rationality is a philosophical, not psychological concept, and the literatures on reasoning and decision making included many examples of multiple norms, that is rival and conflicting theories about what are the right and wrong answers (Elqayam & Evans, 2011). But it also takes little observation and imagination to realise that intuitions may often lead to correct judgements, especially when expert judges are able to draw upon relevant associations and experience. It is equally clear that reflective reasoning can fail to find a correct answer (even if we can agree what that is) for a variety of reasons. Both Stanovich and I have been at pains to point out in numerous publications that Type 2 reasoning will only result in correct decisions (in and out of the laboratory) if people have the motivation to apply it carefully, the relevant knowledge of the rules of reasoning (mindware) and the cognitive capacity to apply it without mistakes (see Evans & Stanovich, 2013a). Nevertheless, I must admit that our own previous work, using both experimental and correlational approaches, often did effectively pin the blame for cognitive biases on Type 1 processes and the praise for correct solutions on Type 2 processing in the paradigms studied. So I must accept my share of responsibility for the inadvertent creation of this fallacy, even though I never associated Type 2 processing (then called analytic) with normative correctness, even in my early work (see Evans, 1984).

Having briefly considered the historical origins of the two propositions about Type 2 processing, I now consider in more detail the evidence which supports each, taking them in historical order.

Type 2 processing: evidence for the core propositions

Proposition A: Type 2 processes find reasons and justifications to support or rationalise intuitions

The Wason and Evans (1974) paper was both experimental and theoretical. The experiment concerned *matching bias* on the abstract version of the

Wason selection task, which had been demonstrated previously by Evans and Lynch (1973). On the standard abstract version of the task people may be shown four cards and told that each has a capital letter on one side and a single figure number on the other. They are then asked to test the truth of a rule such as

> If there is an A on one side of the card then there is a 3 on the other side of the card

The cards shown displayed A, D, 3 and 7 on the visible sides and the task to choose to turn over those cards and only those cards which would show if the rule is true or false. A common choice is A and 3 (or A only) but the correct answer, most authors agree, is the A and the 7. The rule is only true if it cannot be shown to be false. To do that one would have to discover a card with an A on one side that did *not* have a 3 on the other. What Evans and Lynch had shown, by adding negations, was that people were simply choosing the cards that matched the items in the statement. For example, if the rule was

> If there is an A on one side of the card then there is NOT a 3 on the other side of the card

then people would still choose A and 3 which are now logically correct (only a card with A and 3 would disprove this rule).

Wason and Evans gave participants both versions (with random lexical content) and also asked them to write down their reasons for either selecting or rejecting each of the four cards. They found that regardless of whether they received the affirmative or negative version first, they tended to select matching cards. However, the reasons given were very different and always consistent with the choices made. So, on the affirmative rule, someone might say "I am turning the A card because a 3 on the back would prove the rule true." But the same participant on the negative rule might state "I am turning the A card because a 3 on the back would prove the rule false." (All essential findings were later replicated by an independent study by Lucas & Ball, 2005.) We thought it highly implausible that adding a negative could provide genuine insight into the need for falsification, which disappeared when it was removed. So we argued that matching bias reflected a Type 1 process of which people were unaware but which was responsible for their selections. We also proposed that a Type 2 rationalisation process accounted for the justifications given. We were able to draw parallels with several previously puzzling findings in Wason's earlier studies of the 2 4 6 and selection task problems (see also Evans, 2016).

In a follow-up study, four groups of participants were presented with different but plausible "solutions" to the standard selection task and asked to justify them. All did so, and none protested that they had been given the wrong answer (Evans & Wason, 1976). A few other directly related studies are worth mentioning. In a paper entitled "Deciding before you think," I asked people to point a mouse at cards they were *thinking of selecting* before actually clicking do so (Evans, 1996). All findings were later replicated using an improved eye-tracking method by Ball, Lucas, Miles, and Gale (2003). Both studies found that people mostly pointed or looked only at the cards they would eventually select, such as matching cards. However, they often took around 30 seconds to confirm all their choices by clicking, so this was not simply fast Type 1 responding. Using different methodology, Thompson, Evans, and Campbell (2013) later demonstrated that matching cards are strongly and rapidly cued as intuitive choices. The only plausible explanation for the delay in the inspection time experiments was that participants were engaging in Type 2 reasoning to convince themselves that their choices were correct – which they mostly did. However, we also showed in a later paper that sometimes a matching card was inspected but *not* selected, if it constituted a logical case (false antecedent) which was difficult to justify in the context of the instructions (Evans & Ball, 2010). This indicates that Type 2 reasoning does not always succeed in satisfying the reasoners that the intuitive answer is correct, which is theoretically important.

Shortly after the Wason and Evans paper was published, the social psychologists Nisbett and Wilson (1977) published a famous critique of introspective reports which has remained essentially unchallenged to this day. The argued that asking people to report on the mental processes underlying their actions was doomed to failure because people lack such introspective access. However, they do not appear to know what they do not know. Instead, they will always provide explanations in which they essentially theorise about their own behaviour, just as if they were providing explanations for someone else's actions. Applying this to the Wason and Evans study we see that the actual cause of behaviour – matching bias – never appears in people's reports. Rather the request for verbal justification is a new task that engages reasoning about their own actions in the context of the experiment and its instructions. Choosing the A card on the affirmative rule can only be justified in terms of making the rule true, and on the negative rule in terms of making it false.

In the same way, there are many studies in cognitive and social psychology showing that people (a) have no knowledge of the actual factors influencing their behaviour but (b) nevertheless provide rational sounding explanations, in which they *theorise* about their own actions. In effect they look at their behaviour and the context and find reasons to explain it. For many examples of such findings see Wilson (2002) and Mercier and Sperber (2017). The latter authors claim this as evidence for their *argumentative* *theory of reasoning*: they suggest that reasoning evolved not to solve problems but to provide arguments supporting social and communicative functions. Part of this theory is that people apply this "argumentation module" to justify and explain their own actions as well as those of others. Mercier and Sperber are effectively much greater fans of Proposition A than B: they suggest that people reason much better in argumentation than they do in logical deduction. More specifically, they claim that "The main role of reasons it not to motivate or guide us in reaching conclusions but to explain and justify after the fact conclusions we have reached." (Mercier & Sperber, 2017, p. 112).

So where does Proposition A stand? The evidence that people do in fact rationalise their intuitions is very strong. The evidence also supports the view that such actions are often ultimately intuitive, prompted by cues or cognitive biases of which the individual seems completely unaware, finding other reasons to confirm them. Why should this be? Wason, as those who knew him will attest, was strongly influenced by Freudian theory, rare among cognitive psychologists. However, in Freudian theory, rationalisation, like projection and repression, is a defence mechanism and requires the presence of strong emotion to operate. What is emotional about matching bias that we should need to conceal it from ourselves? More plausible, perhaps, is the theory of Mercier and Sperber (2017, p. 115) that reasoning evolved originally for social reasons but also became applied to the self. They argue that "To explain the behaviour of others, we take into account what we know of them and the situation, and we look for probable causes … To know our own mind and explain our own behaviour, do the same." We also note that psychological experiment is a social situation, and there is always at least one other person involved (the experimenter) in the request for reasons.

Propositions A and B are not mutually exclusive, however, so I now turn separately to the evidence that supports B.

Proposition B: Type 2 processes engage reasoning to draw conclusions or make decisions

The crux of Proposition B is that Type 2 processing is not only qualitatively different from Type 1 processing but that it does something *useful*. So useful, in fact, that psychologists have claimed that it gives human beings a higher form of rationality than that found in other animal species (Evans, 2010b, 2013; Stanovich, 2004, 2011). Two key defining features in this approach are (a) the engagement of working memory, so extensively researched in a separate tradition (Baddeley, 2007) and (b) the facility for *hypothetical thinking* (also known as cognitive decoupling) in which we can conduct thought experiments which alter or extend our actual beliefs about the world. This allows us to suppose how things might be different in future, or might have been different in the past (Evans & Stanovich, 2013a).

The engagement of working memory does not in itself speak to function and must be necessary for Proposition A (rationalisation) as well as Proposition B (decision making). However, it does feature strongly in empirical claims for function B, as we shall see. The ability to think hypothetically, however, provides human beings with a facility for consequential decision making, in which actions may be chosen by modelling the future, not simply relying on what worked in the past. Proposition B is broadly supported by other dual-process theorists even if they disagree about whether the two systems combine in a parallel (Sloman, 1996) or serial (Kahneman, 2011) manner. Stanovich has argued that the override of Type 1 thinking with high effort Type 2 thinking is essential to achieve rational actions in a modern technological world (Stanovich, 2009b; Stanovich, West, & Toplak, 2016).

In my own work, Proposition B derived from the two-factor theory of Evans (1982) and a critical development, as mentioned earlier, was the belief bias study of Evans et al. (1983). The conflict between apparent logical reasoning and belief bias was stark in the syllogistic reasoning data and has been replicated many times since (see Klauer, Musch, & Naumer, 2000). By examining verbal protocols and other evidence, Evans et al. (1983) concluded that it was not a matter of there being either logic or belief-based reasoners, but rather that the two factors conflicted *within* participants who would sometimes go with logic and other times with belief. In assessing the general evidence for Proposition B, however, a difficult issue is the normative fallacy mentioned earlier. Although we cannot say in general that Type 2 processing will be accurate and Type 1 biased, this does seem to be the case in many of the experimental paradigms studied. Due to the artificial and novel nature of the problems, Type 2 reasoning is typically required for normative solutions and Type 1 processes appear to be responsible for biases.

The artificiality of the experimentation on dual processes is clearly one of the main factors responsible for the normative fallacy. At the same time, it has been critical in providing empirical tests of dual processing in reasoning. By constructing tasks that *require* Type 2 reasoning for their solution, and which invite biases based on Type 1 processing, a mass of evidence has been presented which appears to support the qualitative distinction between the two processes (for detailed reviews see Evans, 2007a; Evans & Stanovich, 2013a; Stanovich, 2011). For example, people show "better" reasoning in such experiments when they are allowed longer time limits or given strong experimental instructions to reason logically, and more bias when asked to reason quickly or given a concurrent working memory load (e.g. De Neys, 2006; Evans & Curtis-Holmes, 2005). Some apparently conflicting evidence in the recent literature (Newman, Gibb, & Thompson, 2017) is discussed later in this article. Psychometrically, there are strong correlations between IQ and working memory capacity – or other highly correlated measures of cognitive ability – and the ability to find the correct solutions to most laboratory reasoning and decision tasks. Analysis of residual variance shows that an important predictor is also *rational thinking style* – a self-reported disposition to engage reasoning rather than rely on intuition (Stanovich, 1999, 2011).

The evidence suggests that many tasks which require conclusions to be drawn or decisions to be made seem to reflect two types of processing, with the case that they are different being essentially that Type 2 but not Type 1 processes engage resources which are associated with general intelligence and working memory. Both of these topics have long histories of research which attest to a *general* factor of human intelligence. That Type 2 processes are – or can be – instrumental in reaching conclusions and decisions (Proposition B), I must concede, rests primarily upon normativity. In many of the laboratory tasks used, decisions which are made quickly and intuitively, under working memory load or time constraints, or by people of lower cognitive capacity are more often prone to cognitive biases. Under the contrary conditions, normatively correct solutions are more often found. This is a fact established by large number of published studies. Yes, the experiments are unrepresentative of many real-world decisions where prior experience is helpful and Type 1 intuitions may serve use well. However, the case that Type 2 processing provides a higher form of rationality in human beings rests upon the evidence that we *can* use it to solve novel and difficult problems, where intuition lets us down.

We should note that there is also evidence to suggest that Type 2 processing is required to understand and comply with instructional sets given in reasoning experiments. We have known for some years that strict logical instructions can lead to significant inhibition of belief biases in deductive reasoning (Evans, Allen, Newstead, & Pollard, 1994). More recently, it has been shown that those of higher cognitive ability are better able to resist the influence of beliefs in conditional reasoning tasks but only when strict deductive reasoning instructions are given; under pragmatic reasoning instructions there are no differences between high and low ability reasoners (Evans, Handley, Neilens, Bacon, & Over, 2010). This finding is compatible with Stanovich's argument that higher ability people show advantage in finding correct solutions only when they perceive the need for high effort reasoning (Stanovich, 2011, 2018). However, there is no necessary linkage to normativity in the sense of logicality. On belief-logic problems, similar conflict effects are observed whether people are instructed to answer on the basis of logic or believability (Handley, Newstead, & Trippas, 2011) and there is now evidence that complying with the belief instructions also puts a load on working memory (Howarth, Handley, & Walsh, 2016). Of course, complying with the instructions – whatever they are – is required for the correct answer as defined by the experimenter so we can still see this as evidence for Proposition B – the use of Type 2 processing to draw conclusions or make decisions.

This now leaves us with the question of how Propositions A and B can both be true. If reasoning evolved for argumentation and rationalisation, as Mercier and Sperber (2011, Mercier & Sperber, 2017) propose then why can it also be applied in reasoning to conclusions? It is not enough to argue, as they do, that experts can acquire specialised modules for reasoning through training and study. The point is that the evidence for B depends on the administration of *novel* problems as do tasks designed to measure general intelligence, such as IQ tests. One possibility is that reasoning originally evolved for function A but became exapted for function B. This would explain why reasoning is more effective in its primary than secondary function, but still usable for solving problems under the right conditions. This idea is supported by the evolutionary theorising of a number of scholars. For example, the cognitive archaeologist Mithen (1996) claims that what marks modern humans out from all others is a form of general intelligence in which the outputs of specialised intelligences, also present in other hominids, became able to flow freely through the mind and interact with each other. A related idea is advanced by the philosopher of mind Carruthers (2006, Chapter 4) who proposes that System 2 is conscious in the sense that the outputs of various modules are broadcast globally – also attributing great importance to inner speech deriving from the language module. For a detailed review of arguments on the evolution of Type 2 thinking see Stanovich (2011, Chapter 5). So while the massive modularity theory of the mind advanced by some evolutionary psychologists appears to argue against dual-process theory, allowing no place for a general reasoning system (e.g. Cosmides, 1989), there are also powerful evolutionary arguments to be found across the literature that support the evolution of the general ability to reason out solutions to problems, that I am calling function B in this article. In addition, the progressive accumulation of culturally transmitted mindware, such as scientific knowledge, greatly advances the power of Type 2 thinking in modern societies (Stanovich, 2018).

Incorporating both propositions A and B: a default-interventionist model

I showed in an earlier paper that one could not distinguish serial or parallel dual-process theories merely by demonstrating conflict between responses attributed to one or the other (Evans, 2007b). In order to favour the serial form, default-interventionism, one needs either *a priori* arguments or other kinds of empirical evidence. The main reason for the popularity of the default-interventionist approach, I believe, is the assumption that intuitive Type 1 processes operate a lot quicker than reflective Type 2 processes (e.g. Kahneman, 2011). It makes theoretical sense that the intuitive answer would become available much quicker. However, one cannot then account for the often-perceived conflict between the two forms of processing unless it is also assumed that Type 2 processing is always engaged on these tasks, at least to some degree. It may be minimal, depending on a variety of factors, but there must always be the potential for Type 2 processing to intervene and substitute a different answer to the one suggested by intuition.

In this section, I will outline a specific default-interventionist account which incorporates several forms of evidence that have led people to favour this general approach. I should note that Pennycook et al. (2015) have recently presented a three stage dual-process theory which explicitly distinguishes the two functions of Type 2 processing which they term rationalisation (A) and cognitive decoupling (B) using Stanovich's terminology for the kind of processing required to reason out an alternative solution to the default intuition. I will say more about this model in a later section. My own first attempt to provide a model which incorporated Propositions A and B, that is both rationalisation and decision-making functions of Type 2 processing was published earlier (Evans, 2011). Here, I present a somewhat modified and updated version which I believe is a little more accurate in how it portrays the factors which affect this process, now differentiated as motivational, situational and cognitive (Figure 1). At the start we assume that a default intuition is generated which – if not intervened upon – will produce an answer A1 but has the potential to be changed to a different answer, A2, by Type 2 reasoning. Two major determinants of whether intervention will occur are the degree of critical effort expended and the cognitive resources available.

The model assumes, as in Proposition A, that the first thing that Type 2 processing does is to evaluate the intuition and see whether it is fit for purpose. So, there is built-in bias towards the default intuition which is "right" until or unless proved wrong. This testing of the intuition is influenced by both motivational and situational factors. More effort is likely to be expended on reasoning at this stage if the decision is important or if the individual is inclined by personality to check out intuitions with reasoning (rational thinking style). Less effort will be made if the intuition comes with a high FOR (Ackerman & Thompson, 2017; Thompson & Johnson, 2014; Thompson et al., 2011). However, situation and context also determine the

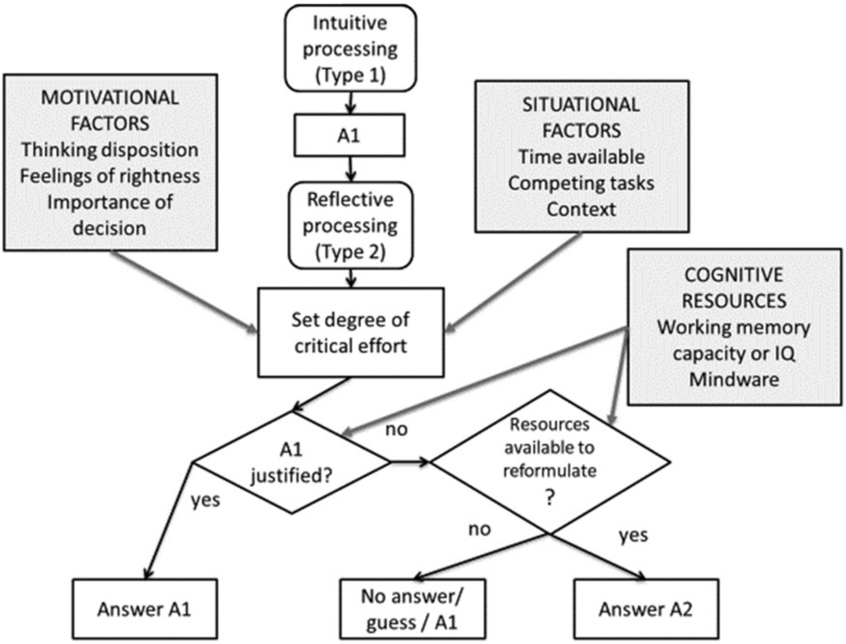

Figure 1. Default-interventionist model, revised and extended from that presented by Evans (2011).

amount of processing effort that *can* be made. This will be reduced, for example, if time is limited or there are competing tasks to perform, as in experimental tasks where working memory loads are introduced.

The next stage results in a decision as to whether A1 is justified. In addition to the degree of effort, this decision will also be influenced by cognitive resources. Particularly important is *mindware*, the possession of explicit rules for reasoning supplied by education and study. We have known for some years that people with statistical training perform better on laboratory tasks requiring probability judgements, for example, and are less susceptible to biases on these tasks (Nisbett, Krantz, Jepson, & Kunda, 1983; for a recent example, see Thompson, Pennycook, Trippas, & Evans, 2018). This is one of the main ways we would hope to debias reasoners. In fact, there is evidence that an effective form of cognitive therapy for problem gamblers is provided by giving them instruction in probability theory (Raylu & Oei, 2002). If the outcome of the reflective reasoning at this stage is to accept the default intuition, then A1 is made. However, it is a mistake to describe this as an intuitive or Type 1 response as though no reasoning ever happened. As we saw earlier, with the Wason selection task in the standard four card format, matching responses can be made quite slowly due to Type 2 processing which does *not* (usually) alter the default.

If A1 is considered unsatisfactory then an attempt may be made to substitute another answer, A2, by reasoning – Proposition B. Whether this succeeds depends also on cognitive resources, both mindware and the capacity (IQ, working memory) to apply them successfully. Sometimes this is much easier than others. The items of the Cognitive Reflection Test (Frederick, 2005), for example, all have relatively simple arithmetical solutions once the powerful default intuition, leading to a wrong answer, is avoided. Finding the correct answer on a base-rate fallacy problem, however, might be difficult if it requires knowledge of Bayes' theorem (mindware) and the cognitive capacity to apply its equations. Bayesian inferences are more often made when nested sets cue the correct answer in much simpler fashion (Barbey & Sloman, 2007; Hoffrage, Gigerenzer, Krauss, & Martigon, 2002).

The model shown in Figure 1 is broadly compatible with those proposed by Stanovich (e.g. 2011, 2018) while differing in some details and lacking the emphasis that he makes on normative responding. While in many experimental paradigms A1 might be a biased answer and A2 a normative one that plays no part in the psychological account. In fact, we know that reflection may often lead people to change a right answer to a wrong one (Thompson et al., 2011). How does the current model compare with that of Pennycook et al. (2015)? Their focus is on problems where conflict between competing cues may be detected in Type 1 processing, such as the extreme base rate task of Wim De Neys (2012) which I discuss in a later section of this article. In contrast with the current model, they propose that people *either* use Type 2 processing to rationalise an intuition (A) *or* substitute an alternative answer (B), although it is unclear why one or the other function is preferred. The current model (Figure 1) quite clearly proposes that attempting to justify the default intuition happens first. Pennycook et al. try to operationalise engagement of Type 2 reasoning by increases in processing time, a methodology which I believe is difficult to interpret, and also link this form of processing to normative responses. As I have shown in this article, Type 1 cued biased responses can be slow because of Type 2 reasoning for justification which does not change the answer given; also correct answers can be quick due to automation (Stanovich, 2018). My own model (Figure 1) does not explicitly refer to early conflict detection as a factor triggering Type 2 processing and I will revisit this issue when discussing work on similar tasks in a later section.

Multiple type 2 systems

I stated earlier that the main reason that I have stopped using the terms Systems 1 and 2 is because there is clearly a multiplicity of systems underlying autonomous Type 1 processes. This is still true if one applies the more restrictive definition of Type 1 processing that it results in intuitions and feelings of rightness. Matching bias, for example, appears to be related to linguistic processing and implicit negation (Evans, 1998) whereas belief biases clearly implicate at least one belief or memory system which is something quite different. But both are treated as resulting from Type 1 processes in dual-process theories. The case for a singular System 2 seems stronger than the case for System 1 as people often talk of working memory as a system. But the problem here is the vast range of cognitive tasks that have been shown to correlate with general intelligence and engage working memory. To attribute all of this to a single system has little explanatory power. We might as well talk about the conscious mind performing all these functions.

If Type 1 is a category of processes, then why should Type 2 not be as well? The philosopher Samuels (2009) suggested some time ago that we should talk of Type 1 and 2 systems but the idea has received relatively little attention in the psychological literature. A similar idea was put forward by Mercier and Sperber (2011, p. 95) in defence of their (modular) argumentative theory of reasoning:

> While system 1 is commonly seen as a set of difference mechanisms, system 2 is often considered to be more unitary. It is also possible however to view system 2 as comprising several different mechanisms, such as reasoning, planning, imagination, and strategic thinking, each with a specific function. What might justify seeing these different mechanisms as part of a single system is, for instance, their heavy use of working memory or of metarepresentational machinery. If different system 2 mechanisms shared such common resources, this might help explain the covariation of traits measured by various measures of cognitive ability stressed by Evans.

I am quite attracted to this idea, especially as these authors propose that modules can be acquired as well as innate. I have myself argued (Evans, 2010b) that unique human powers of Type 2 thinking draw upon multiple resources which developed uniquely in human beings, such as language, meta-representation and large frontal lobes (related to working memory and executive processing). I have also previously made some specific proposals about how Type 2 systems might operate:

> Each Type 2 system can be thought of as an *ad hoc* committee whose membership is chosen to have just the expertise required for the task at hand and which is disbanded on its completion. Each such system will be temporarily formed and will have access to whatever modular support systems are required. For example, someone engaged in a reasoning task will require use of vision, language and pragmatic systems to create relevant explicit representations. But the proposal that working memory must also be engaged is sufficient to give Type 2 systems their defining characteristics: only one can function at a time, and each is limited in speed and processing capacity and correlated in its efficacy with individual differences in cognitive capacity (Evans, 2010a, p. 316).

The essence of the argument is that the fact that Type 2 processing engages a common resource like working memory does not mean that it reflects a singular system: there could be a set of Type 2 systems (or modules) that require working memory and another set of Type 1 systems that do not. In consequence, we should not think of dual-process theory as a two-process theory, but nor should be think of it as a two-system theory. Rather, it is *dual type* theory. Multiple systems or modules could be involved with both types of processing.

A key concept in Type 2 systems is motivation. In the real world, *ad hoc* committees are formed for a purpose and abandoned when that purpose is achieved, or becomes irrelevant for some reason. Also, the particular membership of the committee – or the particular brain resources of a temporary Type 2 system – are chosen according to the task at hand. At the very least, different mindware will be recruited for solving a Bayesian decision problem or carrying out syllogistic reasoning in the laboratory, and different again for a real-world decision, such as deciding whether fulfil an obligation to attend an evening meeting while missing a live broadcast of your favourite football team. But also, we know that different brain systems will be recruited for different reasoning tasks. For example, when problems are pragmatically rich, involving beliefs, neural imaging studies show that quite different brain regions are activated than during abstract reasoning (Goel & Dolan, 2003). We know, of course, from many experimental studies that the nature of the reasoning observed is dramatically affected by the same manipulation (Evans, 2007a). When belief systems are recruited to the committee it makes quite different decisions. A Type 2 system might also have a strong or weak input from emotional systems, for example. The only thing that makes it Type 2 is the common resource of working memory.

With this multifunctional model of Type 2 processing in mind, it is clearer why Propositions A and B can both appear be true. Whether for reasons of cognitive miserliness or built-in argumentation, Type 2 systems are often used to rationalise or justify intuitions, especially when these come with strong feelings of rightness (Thompson et al., 2011). But there are reasons why such a system might fail or be abandoned and replaced by another formed for a different purpose, namely to reason to a conclusion or decision, based on evidence rather than intuition. Strong intuitions are only one factor which affect the likelihood of the B function being served. People are more likely to reason in the B sense if strongly instructed to do so, have more time, more capacity for reasoning or are more inclined to analytic thinking by the way of personality. Motivation is, again, a key factor. A chess player who plays only intuitively, with little effort at calculation and little study of theory will make many errors and play to a lower standard. Some people are happy to play this way and others seek always to improve their play, putting in the requisite effort. One cannot say that the serious player is more rational than the causal player – they simply have different goals.

The cognitive control problem and type 3 processing

Does Type 2 thinking, or "System 2" as some still prefer to call it, do more than reason? Does it also decide whether reasoning should be engaged? If you have the potential to respond using one of two processes (or types of processes) then something in the mind-brain must determine which of these two processes is used. Can that be one of the two processes itself? Is there a System 2 which acts a referee as well as one of two candidates for control of processing? This position seems to be taken by Kahneman (2011; Kahneman & Frederick, 2002) who suggests that System 1 proposes intuitions, belief and judgements to System 2 which decides whether to endorse them (which it usually does) or to engage its own resources of reasoning. So, in this theory, System 2 is indeed both a referee (or police officer) deciding whether to allow System 1 to win, and also a participant, able to provide an alternative basis for responding. I admit that I have never been comfortable with this dual role.

The model presented in Figure 1 does appear to have a similar feature in that cognitive resources and Type 2 processing impact both on the evaluation of the default response *and* in the generation of an alternative answer if that default is found unsatisfactory. However, this does not mean that Type 2 processing is itself responsible, for example, for setting the degree of critical effort, or deciding whether to engage new reasoning when the default intuition is unsatisfactory. Now that we have restricted the definition of Type 1 processes to a subset of autonomous processes, we can assign these kinds of preconscious monitoring and control processes to separate category which I have previously called Type 3 processes (Evans, 2009), a term which I shall revive here. Unlike, Type 1 processes, Type 3 processes are wholly unconscious. They post no product in working memory and come with no feelings of rightness. Instead they switch attention or increase effort, so that we become conscious only of a new task with which we are engaging. But they do more than this, also convening the *ad hoc* committee that function as a Type 2 system for a particular task.

It has recently been proposed by Houde (2019) that there is an inhibitory-control system located in the prefrontal cortex which he calls System 3 which seems broadly compatible with my terminology here. Although the term Type 3 processing is not in general use, the concept is implicit in many discussions by dual-processing theorists. Stanovich (2011, 2018) for example, writes at length about the "cognitive miser" hypothesis, suggesting that high level cognitive resources are applied sparingly. He is particularly interested in rational thinking style as a determinant of whether sufficient Type 2 processing effort is made, proposing that IQ tests are inadequate measures of rational thinking because they currently omit to measure individual differences in thinking style (Stanovich, 2009a; Stanovich et al., 2016). This is clearly a discussion of Type 3 processing, as I am defining it. Thompson and colleagues have emphasised instead the role of metacognitive feelings, proposing that feelings of rightness (FOR) in initial intuitions are part of a monitoring and control system for allocation of cognitive resources, clearly also a proposal of Type 3 processing. Initially, this approach was developed within a dual-process framework, with FOR being seen a key determinant of whether Type 2 reasoning is engaged to check out Type 1 intuitions, in a default-interventionist approach. For example, Thompson and Morsanyi (2012, p. 101) state that "the initial answers suggested by Type 1 processes lie along a continuum of compellingness … The more compelling the answer the lower the probability of subsequent analysis. In this way FOR is akin to other metacognitive measures which are causally relevant in the decision … ." More recently, Thompson has argued that the approach can still stand when taken outside of a dual-process framework (e.g. Ackerman & Thompson, 2017).

Just as there are multiple Type 1 and 2 systems, the same might apply to Type 3 processes. The amount of time and effort expended to check intuitions by reasoning is certainly multi-factorial. Rational thinking style and feelings of rightness in intuitions are both correlated with processing effort, although evidence of direct causal role is currently lacking. But we also know that other factors can motivate, such as strong experimental instructions to reason logically or suspend prior beliefs (see Evans, 2007a for review of relevant studies). It also seems likely that the importance of a decision to the individual's personal goals will influence reasoning effort. However, motivation may increase effort to no useful effect. Early studies of Wason's 2 4 6 problem, for example, showed that when a financial incentive is offered, people test a lot more instances before announcing their (wrong) hypothesis (Wason, 1968). The effort was made but to no benefit. In the same way, I showed earlier that matching cards may be mistakenly chosen on the four-card selection task, despite quite lengthy Type 2 processing to try to determine whether these intuitive choices were actually justified. Cognitive biases, especially those supported by strong feelings of rightness, and for individuals of low rational thinking disposition, will be difficult to avoid.

"Logical intuitions": an alternative to type 2 processing?

In recent years a number of experimental studies have produced findings that were initially puzzling for researchers in this field. On several laboratory tasks, correct answers which are in conflict with a well-known bias appear to be themselves intuitive. Wim de Neys who did pioneering studies on this phenomenon has dubbed these "logical intuitions" (De Neys, 2012). While I dislike this term, with its normativism associations, I will take it as a short hand for the fact that formally correct answers may be cued by Type 1 processes, as well as biases. This is certainly correct.

Evidence for "logical intuitions"

The task that De Neys has most studied himself has become known as the *extreme base rate* task. Here is an example:

> A psychologist wrote thumbnail descriptions of a sample of 1000 participants consisting of 995 females and 5 males. The description below was chosen at random from the 1,000 available descriptions.
>
> Jo is 23 years old and is finishing a degree in engineering. On Friday nights, Jo likes to go out cruising with friends while listening to loud music and drinking beer.
>
> Which one of the following two statements is most likely? Which one of the following two statements is most likely?

a. Jo is a man
b. Jo is a woman

The base rate heavily loads the odds in terms of Jo being a woman but in this conflict version of the problem, the description is stereotypical of a man. Using a variety of techniques in several studies, including neural imaging, De Neys was able to show that such conflict is detected rapidly and preconsciously by participants, even if they give the stereotypical response (for review or relevant studies and theoretical discussion see De Neys, 2012, 2014). The finding does not reliably extend to versions with less extreme base rates (Pennycook, Fugelsang, & Koehler, 2012). It is not strictly clear that the base rate intuition here is "logical" or normative, since Bayes' theorem requires it to be balanced against diagnostic information. I believe that De Neys chose extreme base rates in order to reasonably assume that they would be formally correct but really, why does that matter? The result would only be paradoxical if we committed the normative fallacy and assigned responsibility for any correct answer to Type 2 processing.

A second example is given by Handley et al. (2011) who adapted the standard methodology for studying belief biases in reasoning. The normal method is to instruct people to make assessments of logical validity and demonstrate that their prior belief in the conclusion interferes with the process. They added the opposite task – asking people to judge the believability of conclusions which might or might not follow logically. Here is an example of a conflict problem with the reverse method:

If a child is crying then it is happy

Suppose a child is crying

Does it follow that the child is happy?

On the believability judgement task, people should say the child is not happy (because it is crying) but when the logic is conflict as here (the conclusion is valid by Modus Ponens) an interference effect was observed. Validity interferes with belief as well as the other way around. While the findings are interesting and important, I do take issue with the authors' claim that their findings' contradicts the standard default-interventionist theory of belief bias. Again, it only does so if one commits the normative fallacy. Just because an answer is logically correct, it does not follow that it resulted from a Type 2 process. The Modus Ponens inference is known to be very easy and arguably follows from our understanding of the word "if" by linguistic processing (Braine & O'Brien, 1991). In an attempt to try to counter this argument, Handley et al. in their final experiment, replaced Modus Ponens with a Disjunction Elimination task such as

Either the sky is blue or it is green

Suppose the sky is not blue

Does if follow that the sky is green?

The authors claim that his inference is more complex, although solutions rates are only slightly lower than Modus Ponens under Logic instructions. However, we can make the same argument here as well. Disjunction elimination is the equivalent of Modus Ponens for disjunctives and it similarly follows from a linguistic understanding of "or." Basically, people are likely to have drawn either inference by linguistic processing simply by reading the premises. As in De Neys' study we can say that the correct answer asserts itself intuitively, in spite of being in conflict with belief bias.

It is true to say that these studies show how reasoning problems may be solved in other ways than those traditionally attributed to dual-process theorists, namely that Type 2 reasoning overrides intuitions provided by Type 1 processing. But this is not an accurate representation of contemporary dual-process theory in which role of automated rule-based processing (mindware) is actually emphasised (e.g. Stanovich, 2018). We do not even need to posit automation to account for the findings of Handley et al. as we need look no further than the language module. But is it not a problem for the theory that belief-based reasoning can be slow and effortful and apparently require Type 2 reasoning? No again, because of the need to comply with explicit instructions as discussed earlier. Also, it is only a feature of *received* dual-process theory that belief-based reasoning is necessarily fast and intuitive (Type 1). The association of Type 2 processing with abstract reasoning and Type 1 processing with belief-based reasoning is another fallacy of the received theory (Evans, 2018).

In a recent paper using a combination of base rate and conditional inference tasks Newman et al. (2017) demonstrate that rule-based reasoning can be quick and belief-based reasoning can be slow which they claim to create problems for traditional default-interventionist accounts of reasoning, stating that such theories explain belief bias as a fast, default response. However, a wider reading of the dual-process literature reveals that belief-based reasoning is not always proposed to be Type 1 and not always fast. For example, a dual-process theory of belief-based reasoning was proposed by Verschueren, Schaeken, and d'Ydewalle (2005) in which fast associative effects (Type 1) are contrasted with slower reasoning processes involving searches for counterexamples (Type 2). And in case readers think I am constructing *post hoc* explanations of the recent findings let me draw your attention to the Selective Processing Model of belief bias which I published nearly 20 years ago (Evans, 2000). This is discussed in detail by Evans (2007a, pp. 90–93) along with similar proposals by Evans, Handley, and Harper (2001) and by Klauer et al. (2000). (A dual-process account of belief bias is also implicit in earlier paper of Oakhill, Johnson-Laird, & Garnham, 1989). The Selective Processing Model asserts that there are two sources of belief bias. The first a response bias based directly on conclusion believability which is indeed quick and intuitive (Type 1) but the other is a bias to search for models of the premises which support believable but refute unbelievable conclusions, which is clearly Type 2. As Evans (2007a, p. 91) puts it "If the analytic system intervenes … this process is also biased by the believability of conclusion, delivering the analytic component of belief bias." In reference to the finding that a speeded task increases belief bias in the study of Evans and Curtis-Holmes (2005), Evans (2007a, b) also noted that the Selective Processing Model proposes that the Type 2 component of belief bias causes the belief by logic interaction normally observed in syllogistic reasoning tasks. This interaction disappeared in the speeded task version, consistent with the view that Type 2 but not Type 1 reasoning was inhibited by the manipulation.

De Neys himself (e.g. De Neys 2018) has been careful in recent writings to avoid the normative fallacy. His view - the "hybrid model" – is that multiple Type 1 processes can provide intuitive cues, something which is not inconsistent with the writings of dual-process theorists, even if at odds with the received theory. I have no problem agreeing with De Neys on this. However, most of the studies showing these kinds of results to date have used relatively simple tasks, where it is plausible that Type 1 cues to their solution could be provided (Evans, 2018). In this respect, they differ from most of the tasks traditionally discussed by dual-process theorists. Those tasks, as mentioned earlier, were deliberately designed to be novel and taxing and hence demanding of Type 2 processing for this solution.

If at least simple reasoning tasks can be solved intuitively, are there also individual differences in the ability to do this? On the traditional interventionist account, the greater success of high ability individuals is normally attributed to either greater intervention (due to rational thinking style) or more effective Type 2 reasoning (due to higher cognitive ability or superior mindware). What has not been considered, until very recently, is that high ability reasoners might have more normatively accurate Type 1 intuitions. I collaborated in a recent study which examined this idea. Thompson et al. (in press) adapted the Handley et al. paradigm to put belief in conflict with either logical or statistical reasoning and asking people to make decisions based on either logical/statistical information or belief. By analysing interference effects, we were able to show that participants of higher cognitive ability were more influenced from the beginning by logical or statistical information. We should note again that these are relatively simple tasks of the kind studied by both Handley at al. and De Neys. Nevertheless, on these tasks, "logical intuitions" are much stronger for those of higher cognitive ability whose more accurate judgements seem to originate from Type 1 processing. One possible explanation is that high ability people are more practised in reasoning and have automated some of the skills such as processing numerical information. Stanovich (e.g. 2011, 2018) has proposed in a number of publications that Type 1 processing can reflect the automation of mindware that was previously explicitly applied by Type 2 processing. In order for such automation to occur, the individual must have possessed the mindware and the ability to apply it correctly in the past, both of which point to higher ability individuals in Stanovich's theory.

The Bago and De Neys studies: how often do people intervene on their intuitions?

I would like to discuss in some detail a couple of recent studies by Bago and De Neys (2017, Bago & De Neys, 2019) because they are critically relevant to the debate between Propositions A and B. They address the question of how often, giving time to reflect, people actually change their initial intuitive judgements. In order to study this question, Bago and De Neys adapted the two-response task of Thompson et al. (2011) and applied it to a range of tasks, including base rate neglect, simpler versions of syllogistic reasoning the bat-and-ball problem from the Cognitive Reflection Test (Frederick, 2005). The two-response task involves asking people to give a quick intuitive answer, rating their FOR and then to reflect as long as desired before offering a second answer which may or may not be the same. The findings of Thompson and colleagues were that, when FOR is high, people spend little time rethinking and rarely change their first answer. This appears to support default-interventionism as when FOR is low, people will spend time thinking and more often change an answer. However, there is no evidence that FOR is correlated with the actual accuracy of answers. Moreover, strong feelings of rightness appear to support major cognitive biases like matching bias (Thompson et al., 2013) and belief bias (Thompson & Morsanyi, 2012).

Bago and De Neys focussed on the question of how often people change from a right answer to a wrong one or vice versa. They strengthened the method to ensure that initial answers would be Type 1 by adding fast time controls and working memory loads. On all these tasks they coded the correct answer as 1 and the bias as 0 and then counted the number of 00, 01, 10, and 11 cases. Their main claim is that people infrequently change their answers. If they were right at time 2, they were generally right at time 1 also. On the Cognitive Reflection Test (Frederick, 2005), the general view in the literature is that the wrong answer is generated by a powerful intuition which could be overturned by reflection. On the bat-and-ball problem of the CRT they studied (Bago & De Neys, 2019) people are told that a bat and ball together cost $1.10. If the bat cost $1 more than the ball, then how much does the ball cost? The correct answer is 5 cents and the wrong but "intuitive" answer 10 cents. As the original study showed, the intuitive answer is often given even by students at Ivy League universities (Frederick, 2005) who we might reasonably expect to possess the mindware for some quite simple mathematical reasoning.

Before looking at their findings in more detail, refer to Figure 1. This model stacks the odds in favour of the initial intuition, be it correct or biased (11 or 00). Hence, intervention should be relatively infrequent. However, since the correct solution requires neither very specialist mindware nor unusual reasoning ability, those who fail to support their intuition and engage new reasoning should more often change from bias to correct (01) than vice versa (10). I have concerns about the methodology of the Bago and De Neys (2019) study as a number of the experiments required forced choice between two answers and there was also repetition of similar problems which could encourage automation. Looking only at free response tasks, the dominant response was 00 that is giving the biased answer and maintaining it. (As with matching and belief bias, the FOR in this bias is generally high.) After 00 came 11 (starting correct and staying correct) followed by 01 and then 10. None of this is inconsistent with Figure 1, although it does contrast with the received view of dual processing in which people will solve the task only by reflection.

In some of the studies, participants were asked to provide a verbal justification of their initial response before engaging in a period of reflection. Although intended as a measurement, this is also an intervention. In effect, the requirement to give an explicit justification forces a more thorough evaluation of initial intuition, which could not simply be maintained due to high FOR with little thought. The 01 case was more frequently observed, especially in the case where free rather than forced choice was used. In the latter case the numbers were 11 (15%), 00 (49%), 10 (2%) and 01 (34%). So, the study as a whole does not just show that those who get it right were right first time. When a manipulation is introduced which forces people to think about their initial intuition, 34% change from the bias to the correct answer with only 2% going the other way. This shows that Type 2 intervention can occur under the right circumstances.

Implications for conflict detection in dual processing

The literature on logical intuitions uses tasks that provide conflicting intuitive cues which, I call Type 1–Type 1 conflict. This should not be confused with discussions of conflict in the traditional dual processing literature, which deal with Type 1–Type 2 conflict. Much of the discussion in this literature is about how people can override a bias arising from Type 1 processing and solve the problem by reasoning with Type 2 processes according to the instructions (for review of many examples, see Evans, 2007a; Stanovich, 2011). Default-interventionist models, such as that shown in Figure 1, deal with this by supposing that evaluations of the default intuition may be deemed satisfactory so that it is endorsed, or unsatisfactory so that more effortful reasoning might be employed. This, of course, is where the A and B functions of Type 2 processing are distinguished. One reason that the bias may be overridden in favour of reasoning to a conclusion is the instructions given on the task. For example, in the belief bias-paradigm (Evans et al., 1983) participants are clearly instructed to draw only conclusions that are logically necessary. We can assume that this feeds into the initial attempt – function A – to justify the intuitive conclusion, which is hence sometimes found unproven. We know that stronger logical instructions reduce belief bias and increase logical answers (e.g. Evans et al., 1994; Evans & Ball, 2010) and other factors such as FOR, time availability, cognitive ability and thinking disposition may also influence the likelihood of function B reasoning overriding the default.

The studies reviewed in this section, however, are different as they concern conflict between rival intuitive cues, for example between extreme base rates and stereotypes, or between rapid Modus Ponens inferences and prior beliefs. Hence, the mere fact that conflict is detected in people giving one response or the other, tells us nothing directly about Type 1 or 2 processing. Pennycook et al. (2015) have presented a dual processing model specifically concerned with this kind of Type 1–Type 1 conflict resolution and employing the extreme base rate task for its experimental study. They assume in their model that Type 2 processing effort is stimulated by the detection of such conflict and they may well be right. It is plausible that the presence of conflicting Type 1 (intuitive) cues will decrease feelings of rightness and hence increase Type 2 processing effort to justify which answer is correct. However, these authors pay far too much attention, in my view, to the supposed normativity of the base rate answer and supposed bias of the stereotypical answer on the extreme base rate task. Why does one response indicate rationalisation or Function A and the other cognitive decoupling or Function B as they suggest? As I have argued often elsewhere (e.g. Elqayam & Evans, 2011; Evans & Stanovich, 2013b) we cannot take the normativity of an answer as a clear guide to the type of cognitive processing responsible for it.

It is also important to note that instructions in intuitive logic tasks do not provide cues as to the correct line of reasoning people should follow. As noted earlier, In the deduction paradigm people are specifically told to draw necessary conclusions and sometimes to disregard prior beliefs. So, it makes sense that Function A reasoning will sometimes fail to justify an intuition and be overridden by Function B reasoning. However, if we examine the instructions given for the extreme base rate task employed by Pennycook et al. (2015) there is nothing whatever to indicate that people should weight statistical information (base rates) more heavily than the personality description. They are simply told that both will be presented, and they should indicate the population group to which the individual belongs. Hence, I can see no basis for the claim that the stereotypical response is a rationalisation and base rate response is achieved by some superior kind of reasoning. More likely is that reasoning becomes a competition between two function A processes in such cases. That is, people look to justify one answer or the other but have no instructional cues to favour the statistical information.

Conclusions

In this article, I have discussed the nature and especially the function of Type 2 processing. The received view of dual processing incorporates what

I have called Proposition B, the idea that Type 2 processing serves to reason to conclusions and decisions, often adding that it responsible for correct answers, avoiding biases cued by Type 1 processing. However, this was not the original proposal about Type 2 processing at all. Proposition A, which historically preceded B, was the Type 2 thinking serves to rationalise or justify intuitions, often *supporting* cognitive biases in the process. It is, however, possible to assign both functions to Type 2 processing as in the default-interventionist model presented in Figure 1. This model implies that not only is there a default Type 1 intuition, but that the default Type 2 processing is to support and justify it. Only if this fails may there be an attempt to use reasoning to substitute a different answer to the problem. The received theory, with its normative fallacy, is exposed both by this role of Type 2 reasoning in supporting biased intuitions, and by recent evidence that on simpler tasks, correct answers are often those which were initially cued by Type 1 processing.

The original dual-process theory of reasoning (Wason & Evans, 1974) strongly emphasised Proposition A, as does the much more recent argumentative theory of reasoning (Mercier & Sperber, 2017). The evidence considered here suggests that the norm is indeed for people to consider a response which comes to mind quickly and intuitively, to reason about it for a significant amount of time and then to accept it. This does make a good case for the argumentative theory because, as its authors say, we are much better at using arguments to find reasons for our own behaviour and that of others, than using it to reason to logical conclusions. We also have to explain why people engage in so much reasoning to so little effect, which does not appear compatible with the cognitive miser hypothesis (Stanovich, 2011). It is true that both Stanovich and I have discussed miserly processing at the Type 2 level, something which he calls "serial associative cognition" which does not require expensive cognitive decoupling (Stanovich, 2011). I have argued that Type 2 processing can be a cause of cognitive biases as well as Type 1, in that people tend to focus on the first hypothesis that comes to mind without considering alternatives (Evans, 2007a). But my point here is that people may nevertheless expend much time and effort on justifying the focal hypothesis or judgement, which does not seem miserly.

In spite of the dominance of intuition and rationalisation, there is support for Proposition B as well, even if we have to look harder to find it. Most laboratory tasks are artificial and novel, not allowing participants to benefit from prior knowledge and practice. In such cases, it appears that Type 2 processing may solve problems where intuitions let us down. Even if our general reasoning facility is not all that good, we can learn to reason very well indeed in specialist fields like mathematics, engineering and chess. In addition, both in the real world and the laboratory, it definitely helps to have a higher IQ or working memory capacity. At the very least, we can say with some confidence that there exists a set of Type 2 systems or modules that rely on this general resource, as well as a set of Type 1 systems that do not.

Recent findings do suggest that Type 1 processing or intuition has a greater influence on our reasoning and decision making than has been generally assumed in the literatures on dual processing and decision making. When we acquire expertise, for example, it is more about developing efficient and accurate intuitions, often described as pattern recognition (Klein, 1998; Robertson, 2001) than applying explicit rules or mindware with high effort reasoning. However, the latter has an important part to play in training, as we have to practise the correct rules in order to automate them, an idea with a long history in cognitive psychology (Schneider & Shiffrin, 1977; Shiffrin & Schneider, 1977). Also, we should not get the idea that expert thinking relies *only* on Type 1 thinking. Chess is an area that has been highly studied (Gobet, 2019) and we know that achieving master level requires thousands of hours of practice which result in the development of highly specialised mental representations; for example, most players at this level can play blindfold chess. However, chess expertise also requires the acquisition and application of much explicit mindware, in the form of opening and endgame theory. Choice of a chess move requires calculation of continuations as well as specialised perception and pattern recognition and so involves substantial amounts of Type 2 thinking. There are at least modest correlations between chess ability and general measures of cognitive ability (Gobet, 2019). In other areas of expertise, for example, law and medicine, it is evident that novel and unusual cases may require explicit reasoning as well as access to databases and other external sources to support complex decisions.

It is now also becoming clearer that cognitive biases result largely from false feelings of confidence which perhaps allow the cognitive miser to stick with default intuitions. However, the cognitive miser hypothesis may not be a sufficient explanation, given the finding that extensive Type 2 reasoning often is engaged in such cases, but only to rationalise the initial intuition. It does appear that the primary function of Type 2 reasoning is to find reasons for decisions we have already taken. Whether it be matching bias, belief bias or the intuitive errors on the Cognitive Reflection Test, it seems that when the biased answer comes to mind, it often does so with high feelings of rightness and is infrequently changed. In the Bago and De Neys studies using several tasks, around 50% of responses started out biased and stayed that way after opportunity for reflection. And these tasks were relatively simple to solve by reasoning compared with a number of others studied by psychologists. So while Stanovich (2011; Stanovich et al., 2016) has placed great emphasis on Type 2 override as the basis for rational thinking, linked this with measures of rational thinking style, it is questionable whether this will provide the most effective approach to debiasing. More likely, we need to find ways of training people to have more accurate intuitions in the first place. It also suggests that training needs to be domain-specific rather than domain-general.

This discussion leads me to suggest several ways in which future research may seek to diverge from the dominant paradigms of the past 40 years or so. First, we need to recognise the importance of intuitive processing in reasoning and decision making, neither dismissing it as a mere cause of cognitive biases, nor allowing ourselves to be deceived by philosophical tradition into thinking that slow reflective reasoning is the main basis for rational thought. The fact is that we do not use this kind of thinking all that much, except for self-justification, and are not very good at it when we do. We should make less use of artificial and novel tasks, and place more emphasis on training, experience and expertise in thinking. We should also abandon the simplicity of the System 2 concept as well as System 1. Thinking of working memory as single system that does lots of different things will only get us so far. We need to start investigating and understanding the multiple Type 2 systems of thought that make use of this common resource.

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