BIAS AND CONFLICT: A CASE FOR LOGICAL INTUITIONS

Wim De Neys

Centre National de la Recherche Scientifique (CNRS)

University of Toulouse, France

(in press) Perspectives on Psychological Science

Mailing Address : Laboratoire CLLE (CNRS, Université de Toulouse)
Maison de la Recherche
5, allée A. Machado
31058 Toulouse Cedex 9
France

E-mail: Wim.Deneys@univ-tlse2.fr

ABSTRACT

Human reasoning has been characterized as often biased, heuristic, and illogical. Here I consider recent findings that establish that despite the widespread bias and logical errors, people at least implicitly detect that their heuristic response conflicts with traditional normative considerations. I propose that this conflict sensitivity calls for the postulation of logical and probabilistic knowledge that is intuitive – and that is activated automatically when people engage in a reasoning task. I sketch the basic characteristics of these intuitions and point to implications for ongoing debates in the field.

BIAS AND CONFLICT: A CASE FOR LOGICAL INTUITIONS

Half a century of reasoning and decision-making research has shown that human judgment is often biased (e.g., Kahneman & Frederick, 2005). People seem to over-rely on stereotypical intuitions and so-called heuristic thinking instead of on more demanding, deliberative reasoning when making decisions (e.g., Evans, 2003, 2008). The received view is that although intuitive heuristics can sometimes be useful, they often cue responses that conflict with traditional logical or probabilistic normative principles and bias our decisions (e.g. Evans, 2010).

This bias has been demonstrated with a number of classic tasks that can be considered the “fruit flies” of the reasoning and decision-making field. Table 1 presents some examples of the most famous of these classic tasks. Literally hundreds of studies have used these tasks and they have been the basis for most of the theorizing in the field (Bonnefon, 2011). Giving the correct response in the tasks requires only the application of some very basic logical or probabilistic principles. However, the tasks are constructed such that they intuitively cue a tempting stereotypical or belief-based heuristic response that conflicts with these principles. The striking finding has been that although the studies have been run with educated, university students, the vast majority of participants nevertheless fail to solve the problems correctly and pick the heuristic response. These findings have contributed to the widespread belief that traditional logical or probabilistic considerations play little role in our reasoning (e.g., Gigerenzer, 1996; Hertwig & Gigerenzer, 1999).

Consider again the classic tasks in Table 1 for a minute. Presumably, as most people, you were probably biased and picked the heuristic response the first time you encountered them. However, you might have picked the incorrect response, but were you actually fully convinced that your answer was right? That is, the problems might have tempted you to pick the heuristic response, but were you convinced that your answer was correct or did you feel that there was something tricky about the problem, that you were missing out on something? Recent studies on conflict sensitivity during biased reasoning suggest you probably did sense that something wasn’t right and questioned your response (e.g., Bonner & Newell, 2010; De Neys, Cromheeke,

& Osman, 2011; De Neys, Moyens, & Vansteenwegen, 2010). Using a range of methods these studies showed that people are especially sensitive to violations of the traditional logical and probabilistic principles in the classic tasks. For example, giving an unwarranted heuristic response in these tasks has been shown to affect reasoner's autonomic arousal (e.g., De Neys et al., 2010), response times (e.g., Bonner & Newell, 2010), and subjective response confidence (e.g., De Neys et al., 2011). In this paper I point to the fundamental implications of this conflict sensitivity. My basic idea is that despite their erroneous responses, people have implicit knowledge of the logical and probabilistic normative principles that are evoked in the classic problems and automatically activate this knowledge when faced with the reasoning problem. Bluntly put, contrary to conventional wisdom, I argue that people are actually intuitive logicians whose intuitive gut feelings are cueing the correct logical response.

I have organized the paper around three sections. I start with a brief overview of the conflict sensitivity studies that inspired my claim. In the second section I discuss the nature and characteristics of the logical intuitions that I propose. Lastly, in the third section I point to some intriguing implications of this proposal for dual process theories and the debate on human rationality.

For clarity, the reader should bear some general points in mind with respect to the nomenclature and labels that I use in this paper. When I refer to the "correct", "logical" or "normative" response I simply refer to the response that has traditionally been considered as correct or normative according to standard logic or probability theory. As I describe in the last section, the appropriateness of these traditional norms has been questioned by a number of authors. Under this interpretation, the heuristic response should not be labeled as "incorrect" or "biased". I will discuss implications of the present proposal for this debate but for the sake of simplicity I stick to the traditional labeling. In the same vein, I use the term "logical" as a general header to refer both to standard logic and probability theory. Hence, the term "logical intuition" refers to an intuitive grasping of the standard logical and probability theory principles (e.g., conjunction rule, proportionality principle, logical validity) that are evoked in the classic reasoning problems.

Looking for Conflict

My claims are based on recent work on conflict detection during thinking (e.g., Bonner & Newell, 2010; De Neys et al., 2010, 2011; Stupple & Ball, 2008). The question that this line of research tries to answer is whether people detect that they are biased. More specifically, the studies use a wide range of processing measures to examine whether people are sensitive to violations of the traditional logical and probabilistic normative principles. That is, when people give the heuristic answer to the classic problems, do they really totally disregard these principles or do they show some basic sensitivity to the fact that their answer is inconsistent with them? To address this question the conflict studies have contrasted people's processing of the classic problems with newly constructed control versions. Recall that the classic versions typically cue a strong heuristic response that conflicts with the traditional normative principles. In the control or no-conflict versions this conflict is removed and the heuristic response is consistent with the normative principles. Table 1 also presents examples of these control versions. In sum, heuristic thinking will cue the correct response on the control no-conflict problems and the incorrect response on the classic conflict versions. Accuracy rates on the control versions are typically very high whereas they are dramatically low on the conflict versions. However, the key contribution of the conflict detection studies is that they started to look under the accuracy surface and focused on more subtle measures that made it possible to test whether people processed the two types of problems any differently.

Response Latencies

For example, one basic procedure has been to simply look at people's response latencies: A number of studies reported that people need typically more time to solve the conflict than the control versions (e.g., Bonner & Newell, 2010; De Neys & Glumicic, 2008; Stupple & Ball, 2008; Thompson, Striemer, Reikoff, Gunter, & Campbell, 2003; Villejoubert, 2009). Now, clearly, the only difference between the two versions is whether the cued heuristic response is consistent with the traditional normative principles or not. If people were mere heuristic thinkers that did not take these normative considerations into account, they should not process the two types of problems any differently. Hence, the latency findings support the idea that people are sensitive to the traditional normative status of their judgment.

Gaze and Eye-tracking Studies

Further support for this claim has come from gaze and eye-tracking studies that showed that the longer latencies are specifically accompanied by a longer inspection of normatively critical problem information. For example, it has been observed that after participants read the conclusion of a conflict syllogism in which the conclusion believability conflicts with its logical validity (e.g., a valid but unbelievable conclusion) they make saccades to the major and minor premises and start re-inspecting this information (Ball, Philips, Wade, & Quayle, 2006). Such "reviewing" was found to be much less pronounced on the no-conflict problems.

A similar gaze trend has been observed with base-rate problems: When solving conflict versions, participants show an increased tendency to re-view the paragraph with the base-rate information after they have read the personality description (De Neys & Glumicic, 2008). A surprise recall test that followed showed that the increased base-rate inspection was accompanied by a better recall of the base-rate information for the conflict vs. no-conflict problems. Interestingly, a subsequent study showed that in contrast to the normative information, information that was associated with the heuristic response was less accessible in memory after solving conflict problems (De Neys & Franssens, 2009). Participants in this study were given a lexical decision task in which they had to decide whether a string of letters formed a word or not after each reasoning problem. Results showed that lexical decisions about words that were linked to the cued heuristic response took longer after solving conflict vs. control problems, suggesting that participants had attempted to block this information during reasoning.

Neuropsychology

The behavioral conflict findings have also been validated with a brain-based approach. For example, in one study (De Neys, Vartanian, & Goel, 2008) fMRI was used to monitor the activation of a specific brain area, the anterior cingulate cortex (ACC), which is believed to mediate conflict detection during thinking (e.g., Botvinick, Cohen, & Carter, 2004). Participants were given classic conflict base-rate problems and the no-conflict control versions. In line with the behavioral findings, results showed that the ACC was much more activated when people solved the conflict versions than when they solved the control versions. In a subsequent study, participants' skin-conductance was recorded to monitor autonomic nervous system activation while solving conflict and no-conflict syllogisms (De Neys et al., 2010). Results showed that solving the conflict problems resulted in a clear electrodermal activation spike. Hence, in addition to the ACC activation, solving conflict problems literally aroused participants. These neural conflict signals have also been shown to affect people's subjective response confidence: Participants typically indicate that they feel less confident about their answer after solving conflict problems than after solving the control problems (e.g., De Neys et al., 2011).

A Case for Logical Intuitions

The conflict detection studies established that despite the well-documented failure to give the correct answer on the classic problems, people do not simply disregard the traditional normative implication of their judgments; rather, they are sensitive to the fact that their heuristic answer conflicts with it. However, although the studies clarified that people might show some basic normative sensitivity, it is less clear how this sensitivity needs to be conceived. What is the exact nature of the normative knowledge that is needed to detect conflicts and where does it come from? In this section I clarify my basic point that this knowledge is intuitive in nature. I validate my claim by demonstrating that the established normative sensitivity has two key characteristic of intuitive processes: That is, the necessary knowledge is activated automatically and it is implicit in nature. In an attempt to demystify the idea of intuitive logical thinking[1] I also point to the developmental origin of the postulated intuitions.

[1] As I stated, I use the label "logical" in this paper as a general header to refer to both standard logic and probability theory.

Automatic activation

In theory, one could argue that the documented normative sensitivity in the conflict detection studies results from effortful probabilistic or logical thinking. That is, people would detect that the cued heuristic response conflicts with the traditional normative response because they actively compute this normative or logical response by engaging in demanding logical or probabilistic analysis (e.g., some sort of hypothetical thinking, mental model construction or Bayesian computations). A number of influential authors have indeed argued that people would always simultaneously engage in intuitive-heuristic and demanding-logical thinking and consequently be sensitive to conflicts (e.g., Epstein, 1994; Sloman, 1996). However, in contrast with this view, I propose that the crucial normative considerations are activated automatically. Indeed, the idea is that people master the normative principles and that this knowledge is brought in a heightened activation state when faced with the reasoning problem. In other words, I suggest that in addition to the well established heuristic response, the classic tasks also automatically evoke an intuitive logical response. The key point is that this activation is effortless and does not require any demanding or elaborate analytic thinking.

Cognitive load

Although the idea of an effortless logical sensitivity may sound somewhat counterintuitive, it is important to stress that there is direct empirical support for this assumption. For example, in one study, participants solved conflict and control base-rate problems while their cognitive resources were burdened with a secondary task (i.e., memorization of a dot pattern, see Franssens & De Neys, 2009). Solving conflict problems correctly is generally considered cognitively demanding because it requires, for example, the inhibition of the salient heuristic response, a process know to heavily tax our limited executive resources (e.g., Dempster & Corkhill, 1999; De Neys & Van Gelder, 2008; Handley et al., 2004; Houdé, 1997, 2007; Moutier, Plagne-Cayeux, Melot, & Houdé, 2006; Morris, 2000; Perret, Paour, & Blaye, 2003; Reyna, Lloyd, & Brainerd, 2003; Simoneau & Markovits, 2003; Stanovich & West, 2000). Since the heuristic response does not conflict with the normative considerations on the control problems, there is no need to engage in inhibitory processing and solving these problems is expected to be effortless (e.g., De Neys, 2006; Evans, 2009; Stanovich & West, 2000).

In line with these predictions, Franssens and De Neys indeed found that cognitive load did not affect accuracy on the control problems but decreased performance on the conflict problems. The crucial manipulation was that after the experiment was finished, participants took an unannounced, surprise memory test in which they were asked to recall the base-rates of the problems that they just solved. As noted above, this recall index had been previously introduced as a measure of conflict detection efficiency: The extended reviewing that is associated with successful conflict detection was shown to boost recall of the base-rates (see De Neys & Glumicic, 2008). In line with these findings, Franssens and De Neys indeed observed that in the no-load condition, base-rates of the conflict problems were better recalled than the base-rates of the no-conflict control problems. However, the critical finding was that although the reasoning accuracies on the conflict problems decreased under load, the load had no impact on the base-rate recall on these problems. Hence, the recall-conflict sensitivity index was not affected by cognitive load. This suggests that whatever the nature of the necessary knowledge that allows people to identify conflict problems as such might be, its activation is not cognitively demanding.

Cognitive capacity

Additional evidence for the automaticity of the normative sensitivity comes from the observation that the conflict detection findings did not depend on participants' cognitive capacities or response accuracy. Note that although most people are biased when solving the classic conflict problems, some participants do manage to solve the problems correctly. It has been shown that these participants are specifically those highest in executive resources (e.g., De Neys & Verschueren, 2006; Newstead, Handley, Harley, Wright, & Farrelly, 2004; Stanovich & West, 2000). One might argue that these cognitively gifted participants are driving the observed conflict sensitivity findings since they might have the potential to engage in demanding analytic computations. However, the detection studies clearly established that even the least gifted reasoners (i.e., the most biased reasoners with the lowest accuracy scores) showed the sensitivity effects (e.g., De Neys & Glumicic, 2008; De Neys et al., 2010, 2011). Hence, while solving conflict problems correctly might require abundant executive resources, detecting the conflict is successful even for the most biased reasoners. This lack of individual differences in conflict detection efficiency further suggests that the necessary normative knowledge activation is indeed effortless.

Repeated testing confound?

Finally, a critic of the automatic activation idea might argue that the automaticity results from a repeated testing or training confound in the conflict detection studies. Note that these studies typically presented participant with multiple conflict and no-conflict problems. For example, in the fMRI study of De Neys et al. (2008) participants solved about 100 base-rate neglect problems. One might argue that this repeated presentation primed the activation of the necessary normative principles through some kind of learning process. That is, at the start of the experiment, conflict detection would only occur after successful completion of a demanding logical reasoning process. After repeated problem presentation, however, this process might become automated. Nevertheless, such a confound can be discarded since item analyses showed that the conflict sensitivity effects are present from the first problem presentation (e.g., De Neys & Franssens, 2009; De Neys & Glumicic, 2008; De Neys et al., 2010, 2011).

Taken together, these findings indicate that consistent with the idea of a logical intuition, the conceptual knowledge that is needed to detect heuristic and logical conflict is activated automatically and does not draw on demanding computations.

Implicit knowledge

A second issue that points to the intuitive nature of people's normative sensitivity is its implicitness. For example, when participants were asked to think aloud while they were solving base-rate problems they hardly ever explicitly referred to the base-rate information when solving the classic conflict versions (see De Neys and Glumicic, 2008). Hence, although participants needed more time to solve these problems, made eye-movements to the base-rate information, showed increased ACC activation, increased autonomic arousal, and decreased response confidence when solving these very same problems, they did not verbally express that the base-rates mattered. In general, this fits with the long established observation that people's online verbalizations during thinking and their retrospective response justifications do typically not indicate that they are taking any normative logical or probabilistic considerations into account (e.g., Evans & Over, 1996; Wason & Evans, 1975). Indeed, it is the lack of such explicit reference to traditional normative principles that initially contributed to the popular belief that people do not take these principles into account (De Neys & Glumicic, 2008): If people do not give the correct logical response and do not refer to any traditional logical or probabilistic principles or information, it is not surprising that researchers became convinced that these principles play little role in reasoning. Note that it is only by introducing new and more subtle processing measures that the conflict detection studies managed to start cutting the ground under this view. However, the point is that the activated knowledge that allows people to detect the conflict is implicit knowledge. People will not manage to label the detected normative violations explicitly. Hence, the postulated logical intuition can be conceived as a "gut feeling" (e.g., Franssens and De Neys, 2009; Thompson, 2009): People will be aware *that* there is something fishy about their heuristic response, but they will not be able to put their finger on it and explain *why* their response is questionable. More precisely, the idea that I propose is that the conflict between implicitly activated normative knowledge and the cued heuristic response creates arousal. People experience this arousal, this makes them doubt their heuristic response, but they will not be able to justify why their response is questionable. Such explicit justification will require engaging in a proper, demanding logical or probabilistic analysis. However, the implicit knowledge suffices to signal that the heuristic response is not fully warranted.

Developmental basis

The automatic activation and implicitness of the demonstrated normative sensitivity in the conflict detection studies support the idea that the process is intuitive in nature and does not result from a demanding and explicit logical or probabilistic reasoning process. These characteristics help to validate the claim that people have indeed normative logical or probabilistic intuitions. Nevertheless, a critic might argue that the postulation of such intuitive logicality has a quite esoteric or mythical flavor. That is, the basis or origin of the hypothesized normative knowledge might be questioned: If the demonstrated normative sensitivity does not result from demanding computations, then where does it come from? More generally, one might wonder about independent evidence (i.e., independent from the conflict findings) that indicates that people do master the crucial normative principles. Therefore, I identify developmental findings that suggest that the core of the normative principles that are evoked in the classic problems are actually acquired quite early in life.

For example, with respect to the role of base-rates, by now, several studies have clearly shown that even very young infants seem to grasp the importance of proportionality in random drawing (e.g., Kushnir, Xu, & Wellman, 2010; Téglás, Girotto, Gonzalez, & Bonatti, 2007; Xu & Garcia, 2008). Following the pioneering work of Téglás et al. (2007), one study showed 8-month old infants a person taking four red balls and one white ball out of a box with her eyes closed (see Xu & Garcia, 2008). When the content of the box were revealed, infants looked longer at an unexpected population (a box full of mostly white balls with some red balls) than at an expected population (mostly red balls and some white balls). In a variation of this paradigm, 20-month old infants were shown a puppet that removed five toys of one and the same type (i.e., the target toy) from a box containing two types of toys (i.e., target toys and alternate toys). Next, they were presented with the two types of toys and were asked to give the puppet the one he liked most. The critical finding was that the infants' choices were affected by the base-rates of the target and alternate toys: The smaller the number of target toys in the container, the more likely that children selected it as the preferred toy of the puppet (Kushnir et al., 2010). Kushnir et al. reasoned that the infants inferred that the puppet had a preference for that type of toy when there was a mismatch between the sampled toys and the population of toys in the box. Hence, these findings clearly indicate that even infants are sensitive to the role of base-rates in probability judgments.

Similar observations, although with somewhat older children, have been made with respect to mastery of the conjunction rule and logical validity principles. Knowing the conjunction rule boils down to grasping the class inclusion principle that subsets will never be more numerous than superordinate sets (e.g., Reyna, 1991). Hence, there will always be more banktellers (i.e., the superordinate set) than banktellers that are also active in the feminist movement (i.e., the subset). However, ever since the seminal work of Piaget and Szeminska (1941) it is well established that children learn this principle between the age of 7 and 11. In a typical class inclusion task children will be shown a number of objects, for example, five cows and two dogs. Children are then asked whether there are more cows (i.e., the more numerous subset) or more animals (i.e., the superordinate set). Although children younger than five typically pick the subset, 10-year olds already show quasi-perfect performance (Brainerd & Reyna, 2001; Perret et al., 2003). It has been shown that in the same preadolescent age range, children also start to show good competence at discriminating classic valid (e.g., Modus Ponens) and invalid (e.g., Affirmation of the Consequent) logical arguments (Morris, 2000).

Possible misconception

The fact that even young children master the key normative principles to solve the classic problems underscores the point that there does not need to be anything esoteric about the claim that educated adults master these too. Indeed, given the developmental findings one might wonder why the reasoning field ever started questioning adults' knowledge of these principles in the first place. However, here it is important to stress an important theoretical point and misconception. Although some authors (e.g., Wason, 1968, 1983) have indeed claimed that people's failure to solve the classic tasks pointed to a genuine lack of normative knowledge (i.e., so-called "mindgaps", see Stanovich & West, 2008), others, such as the founding fathers of the Heuristic and Biases field, Kahneman and Tversky (e.g., 1973), have refrained from drawing this conclusion. Kahneman and Tversky's point was not that adults did not master the traditional normative principles, but rather that this knowledge was not used or activated when faced with salient heuristics. Indeed, in their classic studies, Kahneman and Tversky often included abstract versions of the classic problems. In contrast with the conflict (or no-conflict) versions, these abstract problems did not cue a heuristic response. For example, in an abstract base-rate problem people would be shown the base-rates without accompanying personality description. In line with the developmental findings, Kahneman and Tversky observed that adults did an almost perfect job in solving these abstract problems, indicating that people must have basic knowledge of the role of these principles. The same point is illustrated by studies that show how small changes in the problem cover story, aimed to evoke consideration of the normative principles, can dramatically decrease heuristic responding (e.g., Nisbett, Krantz, Jepson, & Kunda, 1983). However, the fact that people might know these principles does not imply that they also use them, of course. Hence, Kahneman and Tversky could still claim that when faced with salient heuristics in the standard tasks, people will not consider the normative insights and fail to detect the biased nature of their judgment. It is this critical issue that was tackled by the conflict detection studies. If these normative principles were not activated when people were biased by salient heuristics, if they were not taken into account, then reasoners should not process the conflict and no-conflict versions any differently.

In sum, the established normative sensitivity in the conflict detection studies invalidated the idea that people do not detect their bias. The point I am drawing in the present paper is that the necessary normative knowledge that enables the conflict detection is intuitive in nature (i.e., activated automatically and implicit). I pointed to the developmental findings and findings with abstract problem versions to clarify that there does not need to be anything mystical about the origin of these intuitions. In and by itself, there is ample evidence that even children master the basic principles. What is critical about the present claim is that these principles are taken into account even when people are biased and that this results from intuitive processing.

Potential Implications

In this final section I explore potential implications of the logical intuition proposal for ongoing debates in the reasoning and decision-making field. I focus on two critical issues concerning dual process theories and the role of traditional norms for thinking. I also discuss the boundary conditions of the implications.

Logical intuitions and dual process theories

The influential dual process theories have characterized human thinking as an interplay of an intuitive-heuristic and deliberate-analytic system (e.g., Epstein, 1994; Evans, 2003; Evans

& Over, 1996; Sloman, 1996; Stanovich & West, 2000). The intuitive system is typically conceived as the system that cues the heuristic response on the classic problems by relying on prior knowledge and beliefs. The deliberate system on the other hand is conceived as the system that enables the type of effortful hypothetical thinking that allows people to reason logically and probabilistically. Hence, it is assumed that the heuristic response to the classic problems is cued by the intuitive system, whereas the logical response (i.e., the response that is considered correct according to standard logic or probability theory) is computed by the deliberate system.

Note that this does not entail that deliberate processing always results in a correct, logical answer and intuitive processing in a biased answer. Dual process theorist have clarified that in some cases, people might be biased precisely because their cognitive resources are overburdened by too much deliberation (e.g., Evans, 2011; Stanovich, 2010). Likewise, a person who is guessing might end up giving a logically correct response without engaging in any deliberate processing. However, the point is that in the prototypical case, the dual process framework assumes that the logical response on the classic reasoning problems will be computed by the deliberate system. The concept of a logical intuition forces one to revise this idea. In dual process terms, the present claims imply that the intuitive system also cues a logical response. This proposal is puzzling from a standard dual process perspective (Evans, 2010; Handley, Newstead, & Trippas, 2011) but I believe it actually may help to understand how the intuitive and deliberate system can interact.

It has been noted previously that the nature of the relation between the two systems is not clear (e.g., Evans, 2007, 2009). In a nutshell, a serial and a parallel activation view can be distinguished (see Figure 1). According to the parallel view (e.g., Epstein, 1994; Sloman, 1996), both systems are supposed to be simultaneously computing a problem solution from the start. According to the serial view (e.g., Kahneman & Frederick, 2005; Stanovich & West, 2000) a reasoner initially relies on the intuitive system and the deliberate system will only be recruited in case the intuitively cued response conflicts with the output of the deliberate system. However, a fundamental conceptual problem for the serial view is how the reasoner can ever detect a conflict between the output of the intuitive and deliberate system, if the deliberate system is not yet engaged. The assumed simultaneous activation of the two systems in the parallel view sidesteps this problem. However, the parallel view faces its own problems. In the parallel model the deliberate route is blindly engaged from the start. People always start the time-consuming and demanding deliberate computations. Thereby, the parallel model basically throws away the benefits of the intuitive route. Clearly, intuitive and deliberate thinking do not always conflict. When there is no conflict it is perfectly fine to rely on the intuitive route. Engaging in demanding deliberate operations is redundant in this case and would be a waste of scarce cognitive resources (De Neys & Glumicic, 2008). Hence, what dual process models need is a way to detect whether deliberate thinking is required without having to engage in deliberate thinking (e.g., Evans, 2009; Thompson, Turner, & Pennycook, 2011).

The cueing of an intuitive logical response can help to solve this conceptual puzzle. If the intuitive system cues both a logical and heuristic response, potential conflict can be detected without prior engagement of the deliberate system. Hence, the idea is that rather than parallel activation of the two systems there would be parallel activation of two different types of intuitive responses: A heuristic intuitive response based on mere semantic and stereotypical associations, and a logical intuitive response based on the activation of traditional logical and probabilistic normative principles. If the two intuitive responses are consistent, people will select the cued response, and the reasoning process ends without further deliberate reflection. Any conflict between the two responses would signal the need to engage the deliberate system. Clearly, the fact that deliberate operations are called upon does not imply that they will be successfully recruited or completed. However, it does present the human reasoning engine with a clear switch rule to determine whether deliberate reflection is required without a need to postulate an inefficient, permanent activation of the deliberate system.

Further dual process considerations

As one reviewer suggested, it might be interesting to note that the idea of a logical intuition is not entirely in opposition to standard dual process theories. Dual process theories do allow for the possibility that a deliberate process becomes automated and intuitive in nature through repeated practice (Evans, 2003; Sloman, 1996; Stanovich & West, 2000). This point has been typically used to explain expert performance. For example, few scholars would contest that after years of extensive training, a professional logician might be able to solve logical reasoning problems in an entirely intuitive manner. One could argue that the logical intuition proposal shares some common conceptual ground with the basic automatization idea. Given the developmental origin of the logical intuitions that I sketched, one might want to conceive the critical mastering of the logical and probabilistic principles throughout a child's development as a kind of automatization process, for example. Although I would not necessarily object to such an analogy, it should be clear that a key aspect of the logical intuitions proposal is precisely that these are maintained by all reasoners and not just by a small subgroup of highly trained experts. Note that another aspect in which the analogy works less well is that even after automatization, we would still expect an expert to be able to justify her response, for example.

A final issue with respect to the dual process implications of the logical intuition proposal concerns the status of the two intuitive responses. That is, if I am right and the intuitive system cues both a heuristic and logical response, one might wonder why the heuristic response nevertheless typically dominates in case of conflict. One straightforward explanation is that the activation levels of the two types of intuitive responses differ. That is, the heuristic response might be more strongly activated, salient, or appealing than the logical response. Hence, there is no need to assume that the two intuitive responses have the exact same strength or status. I do claim that conflict between a heuristic and logical intuition will result in doubt and a questioning of the heuristic response but this does not imply that reasoners consider the logical response to be fully warranted, for example. All that is needed is that conflict lowers the default activation or confidence level of the heuristic response. In absolute terms, the intuitive heuristic response might still be stronger than the intuitive logical response. Note that such differential activation level would also explain why a final selection of the logical response will still require a demanding inhibition of the heuristic response (e.g., Evans, 2003; Handley et al., 2004; Houdé, 1997, 2007; Stanovich & West, 2000).

Logical intuitions and normative debate

Over the decades, the apparent omnipresent failure of educated adults to select the response that is consistent with the traditional logical and probabilistic norms on the classic problems has led some researchers to question the validity of these norms (e.g., Gigerenzer, 1996; Hertwig & Gigerenzer, 1999; Mercier & Sperber, 2011; Oaksford & Chater, 2007). These scholars argued that humans are adhering to other norms than the traditional logical or probabilistic standards when solving classic reasoning tasks (Bonnefon, 2009). People would interpret tasks such as the base-rate or conjunction fallacy task as a type of social classification problem in which they try to determine to which social group a character belongs. Given this alternative task interpretation people would consider the heuristic response perfectly valid and additional standard logical or probabilistic normative considerations would play no role in their reasoning. These claims resulted in the view that, except for some highly trained logicians, standard logic or probability theory principles would be irrelevant for human reasoning.

The present proposal argues against this view. Although people rarely give the traditional normative answer or explicitly refer to the traditional principles, the reviewed evidence suggests that they do activate these normative principles implicitly. The fact that a logical response is intuitively cued and affects a reasoners' task processing makes it very hard to argue that the traditional norms play no role in reasoning. At the very least one needs to acknowledge that the intuitive activation questions the claim that reasoners interpret the classic tasks as mere social classification tasks. If this were the case, and normative considerations such as the conjunction rule, sample sizes, or logical validity were considered irrelevant, then it becomes hard to explain why the presence of a conflict between cued social intuitions and the very same normative principles decreases people's response confidence or makes them review the normative problem information, for example.

Clearly, the normative debate in the cognitive sciences is a complex and multilayered debate. To avoid confusion, it is probably worthwhile to stress explicitly that my claim with respect to the role of the traditional norms is situated at the psychological processing level. Obviously, the fact that people show sensitivity to violations of a certain norm does not entail that the norm is valid. From an epistemological point of view, it might still be that other norms are more appropriate. In other words, my claim is not that the traditional norms are ultimately correct, but rather that human reasoners at least seem to consider them to be correct (i.e., relevant for their inference-making). Note that this does not imply that people need to be fully confident about their logical intuitions or consider them to be fully appropriate, either. As I argued with respect to the possible differential status of the intuitive heuristic and intuitive logical response, people might still find the heuristic response more appealing than their logical intuition when solving the conflict problems. The point is that the logical intuition proposal implies that people are giving some weight to the traditional logical and probabilistic principles during their decision-making process. This argues against the view that reasoners consider these principles irrelevant and should give pause for thought before rejecting the role of traditional logic and probability theory principles in human reasoning.

Boundary condition

In closing, when considering the present proposal and its implications it is important to keep an obvious but critical boundary condition in mind. As I clarified in the introduction, I use the logical intuition label to refer to the idea that people intuitively take the traditional logical and probabilistic normative principles that are evoked in the classic reasoning problems into account. Hence, my claims specifically apply to the classic tasks that have been the basis for most of the theorizing in the reasoning and decision-making field. To be clear, I do not argue that people have logical intuitions about each and every problem they may encounter in life. One of the main reasons for postulating that people intuitively consider the logical and probabilistic principles in the classic problems is precisely the fact that these principles are so elementary and acquired early in life. Note that it was the same elementary nature of these principles that gave the original bias studies such a wide impact. Indeed, few people would have been surprised if Tversky and Kahneman had shown that reasoners were biased when solving nuclear physics equations, for example. Clearly, one important part of the impact of the studies came from the suggestion that people are not even taking the most basic logical and probabilistic principles into account. It is this point that the conflict detection studies and logical intuition proposal argue against. However, the elementary nature of the principles involved presents an intrinsic boundary condition for the logical intuition claim. Logical intuitions are bound to arise in situations where the logical solution or principle is “simple” and easily (i.e., automatically) activated. Indeed, in as sense, one might state that what I tried to clarify in the present paper is precisely that the traditional standard logic and probability theory principles in the classic reasoning problems fit this criterion.

Summary and Conclusion

Recent studies on conflict detection during biased reasoning indicate that people are especially sensitive to violations of traditional normative principles in the classic “fruit flies” tasks. I argued that these findings call for the postulation of logical intuitions. That is, I claim that despite the erroneous answer, people have implicit knowledge of the logical and probabilistic normative principles that are evoked in the classic problems and automatically activate this knowledge when faced with the reasoning problem. I presented evidence for the automatic activation and implicit nature of the postulated intuitions, pointed to their developmental origin, and sketched potential implications for dual process theories and the debate on the validity of the traditional norms.

As I stated in the introduction, the goal of this paper was to sketch a new conceptual idea. Clearly, at this stage the present claims do not amount to a fully developed theoretical framework yet. Hence, I fully acknowledge that the present suggestions will need to be tested further. However, I hope to have clarified that the proposal is supported by recent data, generates testable predictions, and may help to shine a fresh light on long lasting controversies in the field. I believe that this should convince the reasoning and decision-making community that the idea that people have logical intuitions is valuable and should become a primary area of future empirical and theoretical scrutinizing.

Acknowledgements

I would like to thank Jean-Francois Bonnefon, Barbara Spellman, and three anonymous reviewers for valuable comments and suggestions.

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Table 1

Illustrations of some of the most popular "fruit flies" tasks in the reasoning and decision-making field. The left panel (A) shows the classic versions and the right panel (B) newly constructed control versions. The classic versions cue a heuristic response that conflicts with the correct logical response (i.e., the response considered correct according to standard logic or probability theory principles). In the control versions small content transformations guarantee that the cued heuristic response is consistent with the logical response.

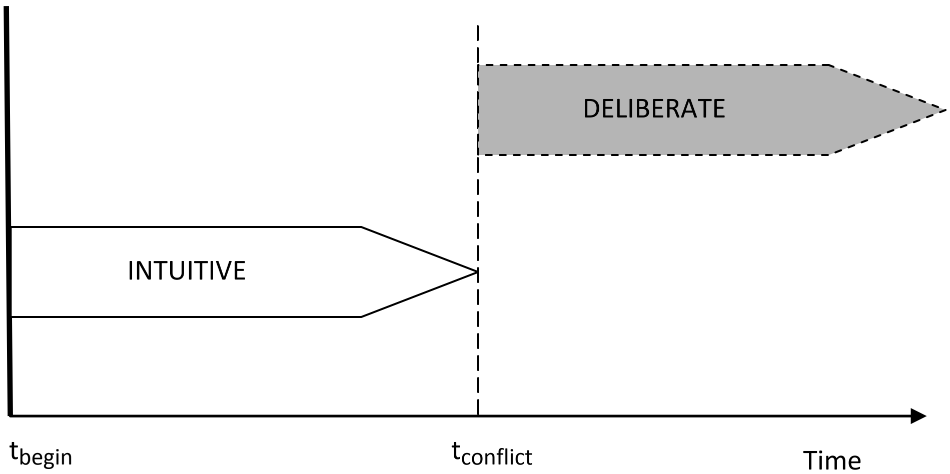
A. Classic "Conflict" versions	**B. Control "No conflict" versions**
Conjunction fallacy task:	**Conjunction fallacy task:**
Bill is 34. He is intelligent, punctual but unimaginative and somewhat lifeless. In school, he was strong in mathematics but weak in social studies and humanities.	Bill is 34. He is intelligent, punctual but unimaginative and somewhat lifeless. In school, he was strong in mathematics but weak in social studies and humanities.
Which one of the following statements is most likely?	Which one of the following statements is most likely?
a. Bill plays in a rock band for a hobby* b. Bill is an accountant and plays in a rock band for a hobby+	a. Bill is an accountant*+ b. Bill is an accountant and plays in a rock band for a hobby
Base-rate neglect task:	**Base-rate neglect task:**
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 1000 available descriptions.	A psychologist wrote thumbnail descriptions of a sample of 1000 participants consisting of 995 males and 5 females. The description below was chosen at random from the 1000 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.	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? a. Jo is a man* b. Jo is a woman+	Which one of the following two statements is most likely? a. Jo is a man*+ b. Jo is a woman
Syllogistic reasoning task:	**Syllogistic reasoning task:**
Premises: All vehicles have wheels Boats are vehicles Conclusion: Boats have wheels	Premises: All vehicles have wheels Bikes are vehicles Conclusion: Bikes have wheels
a. The conclusions follows logically* b. The conclusion does not follow logically+	a. The conclusions follows logically*+ b. The conclusion does not follow logically

** = logical response, + = heuristic response*

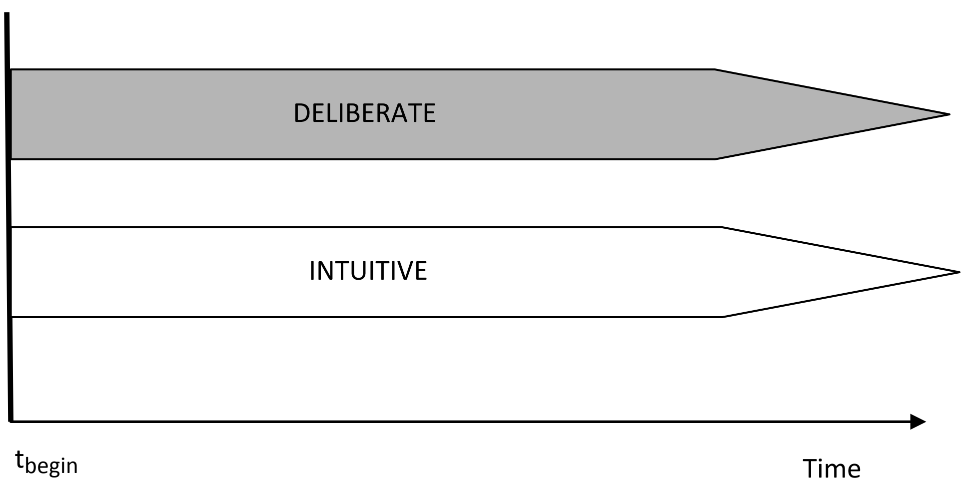
Figure Caption

Figure 1. Three different theoretical models of the relation between the intuitive and deliberate system. Deliberate processing is represented by gray bars and intuitive processing by white bars. The horizontal axis represent the time flow. In the serial model (A.) the deliberate system is only activated after a conflict ($t_{conflict}$)with the intuitive system. In the parallel model (B.) the intuitive and deliberate system are both activated from the start. In the logical intuition model (C.) deliberate processing is triggered by conflict ($t_{conflict}$)between intuitive heuristic and intuitive logical processing. The dashed lines represent the optional nature of the triggered deliberate processing in the serial and logical intuition model.

A. Serial model



B. Parallel model



C. Logical intuition model