**HEURISTIC BIAS AND CONFLICT DETECTION DURING THINKING**

Wim De Neys1, 2, 3

1 ‐ CNRS, Unité 8240 LaPsyDÉ, France

2 ‐ Université Paris Descartes, Sorbonne Paris Cité, Unité 8240 LaPsyDÉ, France

3 ‐ Université de Caen Basse‐Normandie, Unité 8240 LaPsyDÉ, France

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Mailing address: Wim De Neys

LaPsyDÉ (Unité CNRS 8240, Université Paris Descartes)

Sorbonne - Labo A. Binet

46, rue Saint Jacques

75005 Paris

France

wim.de-neys@parisdescartes.fr

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Decades of reasoning and decision-making research have established that human judgment is often biased by intuitive heuristics. Although this heuristic bias is well documented and widely featured in psychology textbooks, its precise nature is less clear. A key question is whether reasoners detect the biased nature of their judgments. My research is focusing on this detection process. In a nutshell, results indicate that despite their illogical response, people demonstrate a remarkable sensitivity to possible conflict between their heuristic judgment and elementary logical or probabilistic principles. In this chapter I present a detailed overview of the empirical studies that I have run and discuss theoretical implications. I will clarify why the empirical detection findings have led me to hypothesize that people not only have *heuristic* intuitions but also *logical* intuitions. I also explore implications for ongoing debates concerning our view of human rationality (“Are humans blind and ignorant heuristic thinkers?”), dual process theories of reasoning (“How do intuitive and deliberate thinking interact?”), and the nature of individual differences in bias susceptibility (“when and why do biased and unbiased reasoners start to diverge?”).

**1. INTRODUCTION**

One of my all-time favorite movie scenes comes from the iconic parody “This Is Spinal Tap”. The faux documentary covers a tour by the fictional British band “Spinal Tap”. In my favorite scene, Nigel, the band’s dimwitted lead guitarist, is giving the documentary director, Marty, a tour of his stage equipment[[1]](#footnote-1). When Nigel shows off his Marshall amplifiers, he points out that his volume knobs all have the highest setting of eleven, unlike standard amplifiers, whose volume settings are typically numbered from 0 to 10. Nigel proudly boasts that this is making his amplifiers sound “one louder” than the other amps. When Marty asks him why the ten setting is not simply set to be louder, Nigel pauses, clearly confused, and meekly responds “But these go to eleven!” (Up to Eleven, 2014).

 I like the “Going to eleven” scene so much because it is presenting us with a hilarious but quite illustrative example of the biased nature of human judgment. Nigel demonstrates here what is known as ratio bias or denominator neglect. He is merely focusing on the absolute difference (11 is more than 10) but fails to think things through and take the denominator or relative difference (10/10 = 11/11) into account. The striking thing is that although it is great to laugh at Nigel in the movie scene, numerous studies have shown that even well-educated university students are not immune to this bias (e.g., Epstein, 1994). To illustrate, consider the following problem:

You are faced with two trays each filled with white and red jelly beans. You can draw one jelly bean without looking from one of the trays. The small tray contains a total of 10 jelly beans of which 1 is red. The large tray contains a total of 100 jelly beans of which 9 are red.

From which tray should you draw to maximize your chance of drawing a red jelly bean?

1. The small tray

2. The large tray

When presented with this problem many participants have a strong intuitive preference for the large tray. From a logical point of view, this is not correct of course. Although the large tray contains more red beans than the small tray (9 vs. 1), there are also a lot more white beans in the large tray. If you take the ratio of red and white beans in both trays into account it is clear that the small tray is giving you a 10% chance of picking a red bean (i.e., 1/10) while the large tray only offers a 9% chance (i.e., 9/100*).* However, just like Spinal Tap’s Nigel, many educated reasoners are tricked by the absolute difference and fail to solve this basic “ratio” problem (e.g., Epstein, 1994). The fact that the absolute number of red beans is higher in the large tray has such a strong intuitive pull on people’s thinking that they seem to neglect the ratio principle and end up being biased.

Decades of reasoning and decision-making research have shown that similar intuitive judgments are biasing people’s reasoning in a wide range of situations and tasks (Evans, 2008; Evans & Over, 1996; Kahneman & Frederick, 2002; Kahneman & Tversky, 1973). In general, this literature indicates that human reasoners have a strong tendency to base their inferences on fast intuitive impressions rather than on more demanding, deliberative reasoning. In and by itself, this intuitive or so-called “heuristic” thinking can be useful because it is fast and effortless and can often provide valid problem solutions. For example, in some situations there is no need to take ratios into account. If you are playing around with your radio, you intuitively and rightly grasp that setting the volume knob to ‘10’ will make it sound louder than setting it to ‘1’. For educated adults (in contrast to, say, my two-year old son), there is no need to engage in much deliberation to arrive at this conclusion. However, the problem is that our intuitions can also cue responses that conflict with more logical or probabilistic principles. As the denominator neglect example illustrates, relying on mere intuitive thinking will bias our reasoning in that case (Evans, 2003, 2010; Kahneman, 2011; Stanovich & West, 2000).

 Although it is well established that our thinking can be biased by intuitive heuristics, the precise nature of this bias is less clear. A wide range of views and potential key factors have been identified (e.g., Brainerd & Reyna, 2001; De Neys & Bonnefon, 2013; Evans, 2007; Reyna & Brainerd, 2011; Stanovich, 2010; Stein, 1996). In my work I have focused on the role of the conflict monitoring or detection process. The importance of this process follows from the simple fact that, as clarified above, relying on heuristic thinking can sometimes be useful but also runs the risk of arriving at logically biased answers[[2]](#footnote-2). Hence, for sound reasoning it is important to monitor our heuristic intuitions for possible conflict with logical or probabilistic considerations. In the absence of any conflict it is perfectly fine to rely on mere heuristic intuitions but in case conflict is detected, one should refrain from it. Unfortunately, although there is wide agreement concerning the importance of the conflict monitoring and detection process (Evans, 2007; Evans & Stanovich, 2013; Kahneman, 2011), there have been some quite different views on its efficiency. For example, in the influential work of Kahneman (e.g., Kaheman & Frederick, 2002; Kahneman, 2011) heuristic bias is primarily attributed to lax monitoring. In Kahnemans’ view, one of the main reasons for why people end up being biased is simply that they tend to over-rely on heuristic thinking and will not detect conflict with logical considerations. In other words, under this interpretation people are biased because they do not realize that their heuristic answer is logically questionable. However, other scholars suggested that conflict detection will typically be successful and argued that the difficulty lies in the resolution of this conflict (e.g., Epstein, 1994; Houdé, 1997; Sloman, 1996). That is, people would have little trouble detecting that a cued heuristic is not logically warranted but subsequently face difficulties when they try to block or inhibit the salient and tempting heuristic response, for example*.*

 The answer to the bias or conflict detection efficiency question (“do we detect that we are biased or not?”) has far-stretching implications for our view of human rationality and related core debates in the reasoning and decision-making field. My research over the last couple of years has dealt with these issues. Together with my colleagues I have run an extensive set of empirical studies to test the efficiency of the conflict detection process. I have also spent quite some time reflecting on the theoretical implications. My goal in this chapter is to present a comprehensive and accessible overview of this work. In a first section I will present a detailed review of our empirical conflict detection studies. The following sections focus on the theoretical implications. I will clarify why the conflict detection findings have led me to hypothesize that people not only have *heuristic* intuitions but also *logical* intuitions. Next, I discuss implications for our view of human rationality (“Are humans blind and ignorant heuristic thinkers?”), dual process theories of reasoning (“How do intuitive and deliberate thinking interact?”), and the nature of individual differences in bias susceptibility (“when and why do biased and unbiased reasoners start to diverge?”).

 I should stress that I have written this chapter with the non-expert educated reader in mind. I have tried to present a comprehensive and accessible sketch of the key points and why I personally belief that they matter. The interested expert reader can always refer to a number of recent publications (e.g., De Neys, 2012, 2014; De Neys & Bonnefon, 2013) for a more specialized discussion.

**2. REVIEW OF CONFLICT DETECTION STUDIES**

 My research on conflict detection during thinking has focused on people’s processing of the (in)famous classic tasks that have been studied for decades in the reasoning and decision making field (e.g., ratio-bias task, base-rate neglect tasks, conjunction fallacy, belief bias syllogisms, bat-and-ball problem, etc. – illustration of these tasks can be found in Table 1). Giving the correct response in these tasks requires only the application of some very basic logical or probabilistic principles. However, as the introductory ratio-bias example illustrated, the tasks are constructed such that they intuitively cue a tempting heuristic response that conflicts with these principles. The basic question that the detection studies have been trying to answer is whether people are sensitive to this conflict and notice that their heuristic response is questionable. As I will illustrate, to do this the studies typically contrast people’s processing of the classic problems with newly constructed control versions. In the control or no-conflict versions the conflict is removed and the cued heuristic response is consistent with the logical response. For example, a no-conflict control version of the introductory ratio bias problem could simply state that the large tray contains 11 (instead of 9) red beans. Everything else stays the same. In this case both the absolute number of red beans (i.e., 1 vs. 11) and the ratio of red beans (i.e., 1/10 vs. 11/100) would be higher in the large tray. Hence, both heuristic considerations based on the absolute number and logical ratio considerations cue the exact same response.

 In a nutshell, the conflict detection studies have introduced a range of measures to examine whether people process the conflict and no-conflict versions differently. Since the only difference between the two versions is the presence of conflict between a cued heuristic and some basic logical or probabilistic principle, a differential cognitive treatment of both versions (e.g., longer response latencies for conflict vs. no-conflict versions) can help us to determine whether people are sensitive to this conflict or not. In this section I will present a chronological overview of our research efforts. This is an extended and updated version of an earlier review chapter (see De Neys, 2010).

**2.1 In the beginning …**

In a first study that we ran to start exploring the efficiency of the conflict detection process (see De Neys & Glumicic, 2008), Tamara Glumicic and I clarified that classic claims about the detection process were typically anecdotal in nature. Epstein (1994, 2010; Epstein & Pacini, 1999), for example, repeatedly noted that when picking an erroneous answer his participants spontaneously commented that they did “*know*” that the response was wrong but stated they picked it because it “*felt*” right. Such comments do seem to suggest that people detect that their intuition conflicts with normative considerations. The problem, however, is that spontaneous self-reports and anecdotes are no hard empirical data. This is perhaps best illustrated by the fact that Kahneman (2002, p. 483) also refers to “casual observation” of his participants to suggest that only in “some fraction of cases, a need to correct the intuitive judgements and preferences will be acknowledged”. Therefore, in a first experiment De Neys and Glumicic decided to adopt a thinking aloud procedure (e.g., Ericsson & Simon, 1993). The thinking aloud procedure has been designed to gain reliable information about the course of cognitive processes. Participants are simply instructed to continually speak aloud the thoughts that are in their head as they are solving a task. Thinking aloud protocols have been shown to have a superior validity compared to interpretations that are based on retrospective questioning or people’s spontaneous remarks (Payne, 1994).

De Neys and Glumicic (2008) asked their participants to solve problems that were modelled after Kahneman and Tversky’s classic (1973) base-rate neglect problems. In these problems a stereotypical personality description cues a heuristic response that conflicts with logically critical base-rate information. Consider the following 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 1000 available descriptions.

Jo is 23 years old and is finishing a degree in engineering. Jo likes to listen to loud music and to drink beer.

Which one of the following two statements is most likely?

1. Jo is a man
2. Jo is a woman

Intuitively, many people will be tempted to conclude that Jo is a man based on stereotypical beliefs cued by the description (“Jo is an engineer and drinks beer”)*.* However, given that there are far more women than men in the sample (i.e., 995 out of 1000) the statistical base-rates favor the conclusion that a randomly drawn individual will most likely be a women. Hence, logically speaking, taking the base-rates into account should push the scale to the “woman” side.

The crucial question for De Neys and Glumicic was whether verbal protocols would indicate that when people selected the heuristic response option (“a. Jo is a man”) they at least referred to the group size information during the reasoning process (e.g., “ … because Jo’s drinking beer and loud I guess Jo’ll be a guy, *although there* *were more women* …”). In this task such basic sample size reference during the reasoning process can be considered a minimal indication of successful conflict detection. It indicates that this information is not simply neglected.

Results were pretty straightforward. People who gave the correct response typically also referred to the base-rate information and reported they were experiencing a conflict (e.g., “… it sounds like he’s a guy, *but because they were more women*, Jo must be female so I’ll pick option b …”). However, people who gave the heuristic response hardly ever (less than 6% of the cases) mentioned the base-rate information (e.g., a typical protocol would read something like “ … This person is a guy … drinks, listens to loud music … yeah, must be a guy … so I’ll pick a … “). Hence, consistent with Kahneman’s (2011) seminal view, the verbal protocols seemed to indicate that people are indeed mere heuristic reasoners who do not detect that they are biased.

De Neys and Glumicic (2008) noted, however, that it could not be excluded that conflict detection was successful at a more implicit level. It might be that the conflict detection experience is not easily verbalized. People might notice that there is something wrong with their intuitive response but they might not always manage to put their finger on it. Such more implicit conflict detection would still indicate that people detect that their response is not fully warranted, of course. To capture potential implicit detection De Neys and Glumicic also presented participants with a surprise recall test. After a short break following the thinking-aloud phase participants were asked to answer questions about the group sizes in the previous reasoning task. Participants were not told that recall would be tested while they were reasoning but De Neys and Glumicic reasoned that the detection of the conflict might result in some additional scrutinising of the base-rate information. This deeper processing of the base-rate information should subsequently benefit recall.

To validate the recall hypothesis participants were also presented with additional control problems. In the classic base-rate problems the description of the person is composed of common stereotypes of the smaller group so that the response cued by the base-rates and the heuristic response that is cued by the description conflict. In addition to these classic conflict problems De Neys and Glumicic (2008) also presented problems in which the base-rates and description both cued the same response. In these *no-conflict* control problems the base-rates were simply switched around (e.g., a sample of 995 men and 5 women). Consider the following example:

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. Jo likes to listen to loud music and to drink beer.

Which one of the following two statements is most likely?

1. Jo is a man
2. Jo is a woman

Hence, contrary to the classic (i.e., conflict) problems the heuristic response did not conflict with logical ratio considerations and the response could be rightly based on mere heuristic processing. For a reasoner who neglects the base-rates and does not detect the conflict on the classic problems both types of problems will be completely similar and base-rate recall should not differ. However, if one does detect the conflict, the longer processing of the base-rates in case of a conflict should result in a better recall for the classic problems than for the no-conflict control problems.

Recall results showed that participants had indeed little trouble recalling the base-rates of the classic conflict problems. People easily remembered which one of the two groups in each problem was the largest. On the no-conflict control problems, however, recall performance was merely at chance level. Interestingly, the superior recall was obvious even for those people who never mentioned the base-rates while thinking-aloud and failed to solve any of the presented classic conflict problems correctly. Since the only difference between the classic and control problems was the conflicting nature of the base-rates and description, De Neys and Glumicic (2008) concluded that people had little difficulty detecting the conflict per se.

In an additional experiment, De Neys and Glumicic (2008) examined the conflict detection issue further by introducing a “gaze-tracking” procedure (e.g., Just, Carpenter, & Wooley, 1982) and measuring reasoning response times. In the experiment the base-rates and the description were presented separately. First, participants saw the base-rate information on a computer screen. Next, the description and question were presented and the base-rates disappeared. Participants had the option of visualizing the base-rates afterwards by holding a specific button down. Such base-rate reviewing can be used as an additional conflict detection index. De Neys and Glumicic explained their recall findings by assuming that when people detect that the description conflicts with the previously presented base-rates, they will spend extra time scrutinizing or “double checking” the base-rates. With the “gaze-tracking” procedure the time spent visualizing the base-rates can be used as a measure of this reviewing tendency. If conflict detection is indeed successful, people should show longer response latencies and a stronger tendency to visualize the base-rates when solving classic conflict vs. no-conflict control problems. This is exactly what De Neys and Glumicic observed. Once again the stronger base-rate reviewing and longer inference times were present for the most biased reasoners in the study who consistently gave the heuristic response on all presented conflict problems.

**2.2 The brain in conflict**

In a second study I decided to focus on the neural basis of conflict detection and response inhibition during thinking (see De Neys, Vartanian, & Goel, 2008). Together with Oshin Vartanian and Vinod Goel, I noted that numerous imaging studies established that conflict detection and actual response inhibition are mediated by two distinct regions in the brain. Influential work in the cognitive control field (e.g., Botvinick, Cohen, & Carter, 2004; Ridderinkhof, Ullsperger, Crone, & Nieuwenhuis, 2004; see also Brown, 2013, or Ullsperger, Fischer Nigbur, & Endrass, 2014 for recent discussion), for example, showed that detection of an elementary conflict between competing responses is among the functions of the medial part of the frontal lobes, more specifically the Anterior Cingulate Cortex (ACC). While the ACC signals the detection, correct responding and actually overriding the erroneous, prepotent response has been shown to depend on the recruitment of the more lateral part of the frontal lobes (more specifically the right lateral prefrontal cortex or RLPFC, e.g., see Aron, Robbins, & Poldrack, 2013, for recent discussion).

De Neys et al. (2008) therefore suggested that turning to the brain might help to address the dispute about the nature of heuristic bias. Solving classic reasoning and decision-making problems that cue a salient but inappropriate heuristic response requires that reasoners detect that the heuristic response conflicts with more logical considerations, first. In addition, the heuristic response will need to be successfully inhibited. If the ACC and RLPFC mediate this conflict detection and inhibition process, respectively, correct reasoning should be associated with increased activation in both areas. De Neys et al. reasoned that the crucial nature of the heuristic bias could be clarified by contrasting ACC and RLPFC activation for heuristic and correct responses. Different views on the efficiency of the detection process make different predictions with respect to the activation of the conflict detection region. If De Neys and Glumicic’s (2008) initial behavioural findings were right and people at least detect that the cued heuristic response conflicts with logical base-rate considerations, the ACC should be activated whether or not people are biased. However, if biased decisions arise because people fail to detect that the heuristic response is inappropriate, people will not detect a conflict when they select the heuristic response and consequently the ACC should not be activated.

 De Neys et al. (2008) tested these predictions in an fMRI study in which participants were asked to solve base-rate problems while the activation of the ACC and RLPFC was monitored. As expected, results showed that for trials in which people selected the correct base-rate response on the classic, conflict problems both the conflict detection (ACC) and inhibition region (RLPFC) showed increased activation. When people were biased and selected the heuristic response on these problems, the RLPFC inhibition region was not recruited. The conflict detection ACC region, however, did show clear activation when the heuristic response was selected. On no-conflict control trials in which the cued heuristic and correct response did not conflict, the ACC was not significantly activated.

In sum, De Neys et al.’s (2008) crucial finding was that biased and correct responses on the classic base-rate problems only differed in RLPFC recruitment. Solving conflict problems did engage the ACC region but the activation did not differ for heuristic or correct base-rate responses. Consistent with De Neys and Glumicic’s (2008) behavioural findings this suggested that the heuristic bias should not be attributed to a detection failure.

**2.3 More memory effects**

Our initial findings with respect to the successful nature of the conflict detection process lent credence to the view that heuristic bias does not result from a detection failure but more likely results from a failure to override the inappropriate but salient heuristic response. An interesting question is whether this override or inhibition failure needs to be conceived as a failure to engage in inhibitory processing or as a failure to complete the process. That is, do people after they detect the initial conflict at least try to inhibit the heuristic response too? To answer this question De Neys and Franssens (2009) presented participants with a lexical decision task after they solved reasoning problems. In the lexical decision task participants have to say whether a string of presented letters (e.g., “DETXXC” or “BALL”) forms an existing word or not. Classic memory studies have shown that when people try to inhibit certain information, memory access to this information is temporary impaired afterwards (e.g., MacLeod et al., 2003; Neill, 1997; Tipper, 1985). Lexical decision tasks are used to test this memory accessibility. For example, if you inhibit the word “BALL” and are subsequently asked whether “BALL” is a word or not, you will need a couple ms longer to make your decision.

De Neys and Franssens (2009) used this procedure in a reasoning setting. Participants solved a range of conflict and no-conflict reasoning problems. After each problem they were presented with a lexical decision task. The critical manipulation was that half of the presented words (i.e., so-called target words) were strongly associated with the heuristic response that was cued in the reasoning task. For example, in the introductory base-rate problem with “Jo” - who was drawn from a sample with males and females - possible target words associated with the heuristic response (“male”) would be “TIE”, “FOOTBALL” or “TRUCK” etc. De Neys and Franssens reasoned that if people indeed tried to inhibit the heuristic response when it conflicted with the logical response, then lexical decision times for the target words should be longer after solving conflict vs. no-conflict problems. This was exactly what they observed. Even biased participants who failed to answer the conflict problem correctly showed a slightly impaired memory access, suggesting that although they did not succeed in inhibiting the heuristic response, they at least engaged in inhibitory processing and tried to do so. Obviously, this blocked memory access further suggests that people at least implicitly detect that the heuristic response is not warranted.

It is also interesting to consider these findings together with the recall findings of De Neys and Glumicic (2008). As discussed before, De Neys and Glumicic observed that logically critical problem information (i.e., the base-rates) was better recalled for conflict vs. no-conflict problems. In contrast, De Neys and Franssens’ (2009) lexical decision findings established that information that was associated with the heuristic response was less accessible in memory after solving conflict problems. In other words, information associated with the correct logical response and information associated with the heuristic response show opposite memory effects after reasoning: whereas access to logical information is facilitated, access to heuristic information is impaired. Taken together these findings suggest that although reasoners might often be biased and rarely explicitly verbalize conflict, they are not completely oblivious to the different status of the heuristic and logical information.

**2.4 Gut conflict feelings**

A further characterization of the conflict detection process came from a study that I ran together with Elke Moyens and Deb Vansteenwegen in which we decided to measure people’s autonomic nervous system[[3]](#footnote-3) activation during thinking (see De Neys, Moyens, & Vansteenwegen, 2010). The inspiration for this study came from basic cognitive control studies (e.g., Botvinick et al., 2004; Ridderinkhof et al., 2004). In these basic studies people are typically presented with very elementary conflict tasks in which they need to withhold an inappropriate but dominant response (e.g., the Stroop or Go/No-Go task). As I mentioned, previous work in this field showed that the anterior cingulate cortex (ACC) is especially sensitive to the presence of conflict between competing responses. The fMRI study of De Neys et al. (2008) that I presented above established that this same cortical conflict region was activated when people gave biased responses during high-level reasoning. Interestingly, it has been shown in the cognitive control field that besides ACC activation, the elementary conflicts also elicit global autonomic arousal (e.g., Kobayashi, Yoshino, Takahashi, & Nomura, 2007). In other words, at least in the elementary control tasks, the presence of conflict seems to be accompanied by visceral arousal as reflected, for example, in increased skin conductance (Hajcak, McDonald, & Simons, 2003). This suggests that basic measures of electrodermal activation can be used as a biological index of conflict detection in the reasoning field. Based on the cognitive control findings one can expect that if conflict detection during thinking is indeed successful, solving reasoning tasks in which heuristics conflict with logic will elicit increased skin conductance responses. Hence, measuring participants’ skin conductance during reasoning allowed us to validate the previous behavioural and fMRI findings. In addition, establishing a possible link between autonomic modulation and conflict detection could help to provide more solid ground for the conceptualization of conflict detection as an implicit process. That is, it would help to argue that people indeed literally “feel” the presence of conflict.

In the study we presented participants with classic conflict and control no-conflict reasoning problems and attached electrodes to the palm of their’ hands to measure skin conductance (SCR) fluctuations. Results were very straightforward. As expected, we observed a clear SCR boost when participants were solving the conflict problems. Consistent with the earlier fMRI and behavioural findings, this SCR boost was present even when participants failed to solve the conflict problem correctly.

**2.5 Biased but in doubt**

The conflict detection work that I presented so far indicated that although it is clear that people do not explicitly say out loud that they are erring, they do seem to be sensitive to the presence of conflict between cued heuristic and logical principles at a more implicit level. The lack of explicitness has been explained by arguing that the neural conflict detection signal should be conceived as an implicit “gut” feeling. The signal would inform people that their heuristic intuition is not fully warranted but people would not always manage to verbalize the experience and explicitly label the logical principles that are being violated. That is, people would know that the heuristic response is questionable, but they would not necessarily manage to justify “why” it is wrong. Although this hypothesis is not unreasonable, it faces a classic caveat. Without discarding the possible value of implicit processing (Bargh, Schwader, Hailey, Dyer, & Boothby, 2012; Newell & Shanks, 2010), the lack of explicit evidence does open the possibility that the implicit conflict signal is a mere epiphenomenon. That is, the studies reviewed above clearly established that some part of our brain is sensitive to the presence of conflict in classic reasoning tasks. However, this does not necessarily imply that this conflict signal is also being used in the reasoning process. In other words, showing that the presence of conflict is detected does not suffice to argue that reasoners also “know” that their intuition is not warranted. Indeed, a critic might utter that the fact that despite the clear presence of a conflict signal people do not report experiencing a conflict and keep selecting the erroneous response, questions the value of this signal. Hence, what is needed to settle the bias debate is some minimal (nonverbal) indication that this signal is no mere epiphenomenon but has a functional impact on the reasoning process. I have tried to pass this last hurdle in a set of experiments that I ran with different colleagues (e.g., De Neys, Cromheeke, & Osman, 2011; De Neys, Rossi, & Houdé, 2013; Johnson, Tubau, & De Neys, 2014; Mevel et al., 2014).

We reasoned that a straightforward way to assess the functional relevance of the implicit conflict signal is to examine people’s decision confidence after they solve a reasoning problem. If the detection signal is not merely epiphenomenal but actually informs people that their heuristic response is not fully warranted, people’s decision confidence should be affected. That is, if people detect that they are biased but simply fail to verbalize the experience, we should at the very least expect to see that they do not show full confidence in their judgments.

Of course, people might never show full confidence and there might be myriad reason for why individuals differ in their confidence ratings (e.g., Kruger & Dunning, 1999; Shynkaruk & Thompson, 2006). Note, however, that our main research question did not concern people’s absolute confidence level. As in the initial detection studies, we gave participants classic conflict problems and no-conflict control problems. To recap, the only difference between the two types of problems is that cued heuristic intuitions conflict with logical principles in the conflict versions while heuristics and logic cue the same response in the control or no-conflict versions. The aim of the confidence contrast for the two types of problems is to help decide the detection debate. If detection of the intrinsic conflict on the classic versions is functional for the reasoning process and informs people that their heuristic response is questionable, participants should show lower confidence ratings after solving conflict problems as compared to no-conflict problems. If people do not detect the presence of conflict or the signal has no impact on the reasoning process, confidence ratings for the two types of problems should not differ.

To test our predictions participants were given a set of conflict and control reasoning problems. After participants solved a problem we showed them a confidence rating scale that ranged from 100% (“Very confident that my answer is correct”) to 0% (“Very unconfident that my answer is correct”). Participants were asked to indicate how confident they were that the response they just gave was correct.

Results confirmed our predictions. For all the different problem types that we used, participants who failed to solve the conflict versions correctly and selected the heuristic response were significantly less confident in their answer after solving the conflict than after solving the control no-conflict problems (i.e., on average we observed about a 10%-15% drop in confidence). This directly establishes that reasoners detect that their heuristic response is literally questionable. Hence, the previously established neural and behavioural conflict signals are not merely epiphenomenal. Although people might not manage to explain why their answer conflicts with logical principles, they do know that their answer is not fully appropriate.

**2.6 Review conclusion**

I hope to have demonstrated in this section that by using a range of converging methods (memory probing, response latencies, gaze-tracking, fMRI, electrodermal recordings, and confidence ratings) my colleagues and I found quite consistent evidence for the successful nature of conflict detection during thinking. To avoid confusion, I would like to stress that in addition to different methods, our studies have also used different reasoning tasks, of course. For illustrative purposes I have primarily focused on the base-rate neglect problems here but findings have been validated with other classic “textbook” tasks such as syllogisms (De Neys et al., 2010; De Neys & Franssens, 2009), conjunction fallacy (De Neys et al., 2011), ratio-bias task (Mevel et al., 2014), and the bat-and-ball problem (De Neys et al., 2013; Johnson et al., 2014). We have been explicitly looking for such converging evidence to make sure that the findings were not driven by one or the other specific measurement or task confound (e.g., Pennycook, Fugelsang, & Koehler, 2012; Singmann, Klauer, & Kellen, 2014; see De Neys, 2014 for discussion). For completeness, I should also point out that my direct colleagues and I are not the only ones who have been demonstrating people’s conflict sensitivity. Similar findings have been reported by independent labs (e.g., Ball, Philips, Wade, & Quayle, 2006; Bonner & Newell 2010; Morsanyi & Handley, 2012; Villejoubert, 2009; Stupple & Ball, 2008; Thompson & Johnson, 2014).

 Taken together, I belief that the currently available data presents convincing evidence for the claim that people are sensitive to the conflict between cued heuristics and basic logical principles during reasoning. In the following sections I will point to the more theoretical implications of these findings.

**3. A CASE FOR LOGICAL INTUITIONS?**

Establishing that biased reasoners detect conflict and show some logical sensitivity is one thing. However, the next question is how this sensitivity needs to be conceived. To detect conflict between intuitively cued heuristic intuitions and logical considerations, this logical knowledge needs to be activated at some level. I have argued (De Neys, 2012) that that this knowledge is intuitive in nature and is activated automatically when people are faced with a reasoning task – hence, the idea of a logical intuition. In other words, I suggest that in addition to the well-established heuristic response, the classic reasoning tasks also automatically evoke an intuitive logical response. When these responses conflict, the conflict will create arousal. The reasoner will notice the arousal and this results in a questioning of the heuristic response. However, people will typically not manage to label the experience explicitly – hence, the idea of a logical “gut feeling”.

I discuss elementary evidence for this characterization below (see also De Neys, 2013). The basic argument is that the observed logical sensitivity in the conflict detection studies demonstrates two key characteristics of intuitive processing (e.g., Epstein, 2010; Moors & De Houwer, 2006): It is implicit and automatic.

**3.1 Implicit detection**

 As documented in the previous section, in one of our first conflict detection studies we decided to adopt a thinking-aloud procedure to examine people’s explicit conflict sensitivity (De Neys & Glumicic, 2008). We presented participants with base-rate neglect problems and reasoned that if participants explicitly detected the conflict between the cued heuristic response and the base-rate information, they would at the very least refer to the base-rate information. However, results of two independent experiments that we ran (one in Toronto, Canada, and a replication in Leuven, Belgium) were strikingly clear: biased reasoners hardly ever explicitly referred to the base-rate information when solving the classic conflict versions. Hence, although we later established that when solving these very same problems participants reasoned longer, made eye-movements to the base-rate information, recalled the base-rate information, had difficulties accessing information associated with the heuristic response, showed increased ACC activation, increased autonomic activation, and decreased response confidence, reasoners did not verbally express that the base-rates mattered. Hence, at the explicit, verbal level there seems to be little detection or logical sensitivity going on. 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 logical or probabilistic considerations into account (e.g., Evans & Over, 1996; Wason & Evans, 1975). In sum, it is quite clear that people will not manage to label explicitly the logical violations that they do seem to be detecting. This was one of the reasons for claiming that the logical conflict sensitivity we demonstrated was implicit and should be conceived as a “gut feeling”: 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, as indicated above, the idea that I propose is that the conflict between intuitively activated logical principles 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. However, the implicit knowledge suffices to signal that the heuristic response is not fully warranted.

**3.2 Automatic detection**

 Further evidence for the intuitive nature of people’s logical sensitivity comes from the apparent automaticity of the process. Detecting conflict has been shown to be quite effortless. First, individual differences in cognitive capacity seem to have little impact on people’s conflict sensitivity. The detection studies clearly established that even the cognitively least gifted reasoners (i.e., the most biased reasoners with the lowest accuracy scores - who typically have the lowest scores on cognitive capacity tests, e.g., see Stanovich & West, 2000 -) showed the reported conflict sensitivity effects (e.g., De Neys & Glumicic, 2008; De Neys et al., 2010, 2011). This suggests (but does not prove) that successful conflict detection does not require abundant cognitive resources. However, we have also tested this claim directly by examining the impact of cognitive load on the efficiency of the conflict detection process (e.g., Franssens & De Neys, 2009; Johnson et al., 2014). For example, in one study participants were asked to memorize spatial dot patterns while they were trying to solve base-rate problems (Franssens & De Neys, 2009). This dot memorization task had been previously shown to specifically burden executive cognitive resources (Miyake, Friedman, Rettinger, Shah, & Hegarty, 2001). Franssens and De Neys reasoned that if conflict detection during thinking was indeed intuitive, it should not be affected by the executive memorization load. The efficiency of the conflict detection process was measured by presenting participants with the surprise base-rate recall task that was introduced in the De Neys and Glumicic (2008) study. As expected, results showed that reasoning performance per se decreased under memorization load. Participants gave more heuristic responses when their executive resources were burdened. However, the critical finding was that recall performance was not affected. Even under load, base-rate recall was still better for classic conflict than for no-conflict control problems and the percentage correct recall for the conflict problems did not differ under load and no-load conditions. Johnson et al. (2014) observed the same effects with a confidence measure and the bat-and-ball problem. Even under high load they observed that biased reasoners showed a decreased response confidence after solving conflict problems, just as we observed previously under no-load conditions (e.g., De Neys et al., 2011, 2013). The amount of cognitive load had no impact on the confidence effect. Hence, these studies directly indicated that conflict detection does not require hard, cognitively demanding computations but is effortless and automatic.

**3.3 “Blink don’t think?” and other misconceptions**

 In this section I hope to have clarified that the Logical Intuition idea did not come out of the blue but was coined by the empirical findings that indicated that the established conflict sensitivity in our detection studies demonstrated key characteristics of intuitive processing (i.e., it is implicit and automatic). However, to avoid confusion and misinterpretation of my claims it is important to keep some clarifications and boundary conditions in mind. I have discussed these at length in previous publications (De Neys, 2012, 2014) and try to present a basic summary here.

3.3.1 Boundary conditions: elementary logical principles

 I am not claiming that people have correct logical intuitions about each problem or task they need to solve in life. The logical intuition idea applies to people’s inferencing in the classic reasoning and decision-making tasks that have been the basis for most of the theorizing in the field and were the focus of my conflict detection work. As the ratio-bias, base-rate, and other tasks in Table 1 illustrate, these problems involve some of the most elementary logical and probabilistic principles (e.g., proportionality principle, conjunction rule). In general it can be argued that these task have fairly low computational demands (e.g., Bringsjord & Yang, 2003) Indeed, one of the reasons why the pioneering research on heuristic bias in the 1970s with these tasks attracted so much interest and controversy was precisely that it suggested that educated reasoners did not take these most elementary principles into account. Bluntly put, nobody would have been surprised or would have bothered if psychologists had shown that university freshmen erred when trying to solve complex rocket science problems, for example.

 Hence, what the conflict detection studies rectify is the suggestion that people blindly neglect the most basic logical and probabilistic rules. Although people might fail to pick the correct response, the findings show that they do know these principles and use them while solving the tasks. The logical intuition proposal boils down to the claim that these principles are activated automatically. As I documented here, there is good empirical evidence for this hypothesis. However, at the same time it should be clear that the empirical findings do not warrant any claims about more advanced and complex types of logical thinking (see De Neys, 2014, for an extensive discussion). Indeed, I believe that it is quite unlikely that reasoners will have logical intuitions about more complex tasks or problem solutions. Note that the automatic activation that is required to postulate logical intuitions demands that people are highly familiar with these principles. As I outline below, available developmental evidence suggests that basic logical principles such as the proportionality principle are acquired very early in our cognitive development. In addition, over our education we also get a lot of practice (e.g., in elementary math courses) that helps us to further internalize these rules. More complex principles or logical analysis might be so rarely encountered that it is hard to see how – except maybe for highly trained logicians - the principles or processing required to apply them could have been practiced and routinized. In sum, although it makes sense to postulate logical intuitions one needs to bear in mind that – at least in my view - these will necessarily be intuitions about the most basic and common logical principles.

3.3.2 Can detection be hard?: Conflict and the parallel activation view

 In theory, one could suggest that successful conflict detection results from a demanding and deliberate logical analysis. Indeed, some of the first authors who originally argued for the successful nature of conflict detection have defended this idea (e.g., Epstein, 1994; Sloman, 1996). According to these authors’ so-called *parallel activation* view, reasoners would simultaneously engage in heuristic and deliberate-logical thinking. Consequently, people would have little difficulty detecting that these two types of reasoning cue conflicting responses. Because my empirical conflict detection work has supported the successful nature of conflict detection, some scholars inferred that it supported this parallel activation view. It should be stressed that this is not the case. There are some clear theoretical arguments against the parallel activation view (see next section) but it clearly doesn’t fit with the empirical evidence. If successful conflict detection would result from demanding logical deliberation, it should be hampered by cognitive load, for example. In sum, both the logical intuition and parallel activation view entail that conflict detection will be successful. However, the key difference is that whereas the parallel activation view entails that the process results from simultaneous demanding deliberate processing, the logical intuition view entails that the detection is intuitive in nature. The available empirical evidence that points to the implicit and automatic nature of the detection process supports the intuitive view.

3.3.3 Blink don’t think? Power to the unconscious?

 Some readers might readily associate the logical intuition claim with recent popular science claims that have celebrated the power of intuitive or unconscious thinking (Dijksterhuis, 2007; Gladwell, 2005; Gigerenzer, 2007). Clearly, both ideas share some common ground in the sense that they entail that intuitive thinking is less problematic or “smarter” than traditionally assumed. They help to sketch a more positive imagine of intuitive thinking than that which might have resulted from the received “textbook” view within the reasoning and decision-making community. However, care should be taken to differentiate the core claims. For example, the logical intuition claim does not entail that intuitive thinking trumps deliberate thinking. Rather, the idea is that in some cases, intuitive thinking might cue the exact same response as a more deliberate and demanding reasoning process. In this sense, intuitive thinking will not be more accurate than more deliberate thinking. In addition, the “Unconscious Thinking” movement has emphasized that the benefits of intuitive thinking especially arise in more complex tasks whose computational demands would outweigh people’s cognitive resources available for deliberate thinking (e.g., multiple cue probability learning task, e.g., Dijksterhuis, 2007). As I stressed, the operating field of logical intuitions are the classic Heuristics and Biases tasks that involve elementary logical principles with fairly low computational demands.

3.3.4 Where do logical intuitions come from? Does God put logical intuitions in our brains?

Nevertheless, the suggestion that even basic logic is intuitive is controversial. It does not fit well with traditional reasoning theories (Singmann et al., 2014) and can be conceived as a *contradictio in terminis*: we traditionally associate the word logic with something that is hard and demanding. In this respect one might feel that the logical intuition proposal has a somewhat mystical or esoteric flavor. If logical sensitivity does not result from active deliberation, then where does it come from? As one critic once remarked: Does God put the logical intuitions in our brains? Here too it is important to keep the basic nature of the postulated logical knowledge in mind. I have tried to counter this argument by pointing to ample developmental evidence that indicates that the logical principles in question are acquired very early in life (e.g., Kushnir, Xu, Wellman, 2010; Téglás, Girotto, Gonzalez, & Bonatti, 2007; Denison & Xu, 2014). For example, it has been shown that even young babies show sensitivity to violations of basic logical principles such as ratio or base-rate considerations (see Girotto, 2013, for an excellent review). In a nutshell, these “baby logic” studies (a term coined by Luca Bonatti) often adopt a looking time paradigm and measure how long babies look at a certain stimulus. In a typical design an eight to 12-month old baby might be presented with a box containing white and black balls, for example. The experimenter then draws one ball from the box and shows it to the baby. Imagine two conditions in which the experimenter draws a black ball. In condition A the box contained four black balls and one white ball. In condition B the base-rates were reversed and the box contained four white balls and one black ball. A typical observation is that babies will look longer at the black ball in condition B than in condition A. Hence, when the drawing of a black ball is logically speaking unexpected (i.e., unlikely), looking times will increase. This indicates that young infants are sensitive to the proportionality principle. Interestingly, similar experiments with apes suggest that even non-human primates master this principle (e.g., Rakoczy et al., 2014). Such developmental findings help to validate the logical intuition claim. If 8-month old babies (or non-human primates for that matter) can be shown to grasp elementary logical principles, it is not that striking that when an educated adult is confronted with a reasoning task that cues a strong biasing response some 18-years later, this logical knowledge gets activated and results in a questioning of the heuristic response. Indeed, in my opinion, it should have been the absence of such conflict detection that should have shocked the scientific community.

**4. FURTHER IMPLICATIONS**

 I have argued that the evidence for the successful nature of conflict and bias detection has further theoretical relevance for a number of key controversies in the field. In this section I will discuss implications for our view of human rationality, dual process theories of reasoning, and the nature of individual differences in bias susceptibility.

**4.1 Of blind heuristic thinkers and rational psychopaths**

 As I mentioned in the introduction, in the influential work of Kahneman (e.g., Kahneman & Frederick, 2002; Kahneman, 2011) heuristic bias is primarily attributed to lax monitoring. Under this view people are biased because they tend to rely on heuristic thinking and will not detect that their heuristic answer conflicts with logical considerations. This view can lead to a somewhat bleak and pessimistic view of human rationality where human thinkers are considered to blindly follow their heuristic intuitions. The empirical conflict detection findings argue against this popularized characterization. In case of conflict with basic logical principles, people will detect the questionable nature of their heuristic judgment. I have argued that this leads to a more optimistic picture of human rationality (De Neys, 2010; De Neys & Glumicic, 2008). We might not manage to refrain from heuristic responding but at least we realize that it is not fully warranted. Bluntly put, we are not as dumb or ignorant as our biased answer might suggest.

 Interestingly, while I have interpreted the finding that biased reasoners detect their bias as resulting in a more optimistic view of human rationality, it has been pointed out to me that one could easily arrive at the exact opposite conclusion. That is, under this “negative” interpretation giving a heuristic answer when you realize it is questionable is considered to be more irrational than giving that same response when you believe it is fully warranted. In other words, doing something bad when you do not realize it is bad, might be considered less problematic. Obviously, rationality is a complex and hard-to-define concept. In the sense that rational behavior is considered to be behavior that is consistent with one’s beliefs, bias in the light of detection may be considered as inconsistent and therefore irrational behavior. I do not want to end up in a deep philosophical or epistemic discussion on what constitutes rational behavior but I do believe that the optimistic view is warranted. This is perhaps best clarified by taking a pedagogical or educational point of view. A reasoner who detects conflict is clearly in a more advanced knowledge state than someone who does not detect conflict. Detecting conflict implies that you already acquired the knowledge and realized its relevance for your judgment. In terms of learning one might argue that in order to get it right there is less to do for a biased individual who already shows sensitivity to conflict. To illustrate this point one might think of a simple analogy. Imagine two murderers. Both have done something bad (killed someone) and violated a moral rule. However, murderer A is a sane person, tried to respect the moral rule, but failed to do so. Murderer B on the other hand is a psychopath and does not hold this moral rule or does not have any intention whatsoever to adhere to it. Although one might say that the psychopath’s behavior is more consistent with his beliefs, I am convinced that most of us will agree that murderer A’s case is less problematic and holds a brighter perspective in terms of rehabilitation, for example. Coming back to reasoning and decision making research, one might say that the conflict detection findings indicate that biased reasoners are no rational psychopaths.

 In sum, while it is undeniable the case that people have trouble discarding erroneous heuristics when they conflict with logical principles, the empirical evidence for conflict sensitivity entails that biased reasoners must know the principles and must give them some minimal weight when making their judgment. This argues against a characterization of biased reasoners as either blind heuristic thinkers or rational psychopaths. In my view, this is a good reason for some optimism.

**4.2 Switching from intuitive to deliberate thinking**

I have argued that the conflict detection work and logical intuition proposal have also interesting implications for popular dual process theories of thinking (De Neys, 2012; see De Neys, 2014, for additional discussion). In a nutshell, dual process theories characterize human thinking as an interplay of a fast and automatically operating intuitive system and a slower and effortful deliberate system (e.g., Epstein, 1994; Evans, 2003; Kahneman, 2011; Sloman, 1996; Evans & Stanovich, 2013). The intuitive system is typically conceived as the system that cues heuristic responses 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.

One problem for dual process theories is that the nature of the interaction between the two systems is not clear (e.g., Evans, 2007; Evans & Stanovich, 2013). Generally speaking, a serial and a parallel activation model can be distinguished. As I mentioned before (section 3.2.1), according to the parallel model both systems are supposed to be simultaneously computing a problem solution from the start (e.g., Epstein, 1994; Sloman, 1996). According to the serial model (e.g., Evans & Stanovich, 2013; Kahneman, 2011) 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, it is hard for a purely serial model to explain 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. At first glance, the assumed simultaneous activation of the two systems in the parallel model might seem to solve this problem. Unfortunately, a purely parallel model faces its own shortcomings. In such a 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. As I stressed in the introduction, 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 (given the demanding nature of deliberate reflection) would be a waste of our limited cognitive resources.

Summing up, one might say that the problem is that a realistic dual process model needs a way to detect whether deliberate thinking is required without having to engage in deliberate thinking first (De Neys, 2012). This intuitive/deliberate “switch” issue has puzzled dual process theorists for quite some time. A number of interesting suggestions have been proposed (e.g., Alter, Oppenheimer, Epley, & Eyre, 2007; Evans, 2009; Oppenheimer, 2008; Thompson, Turner, & Pennycook, 2011; Thompson & Morsanyi, 2012; Topolinski, 2011). In my view, the logical intuition proposal (i.e., more specifically the postulated cueing of an intuitive logical response) is also relevant to help us solve this conceptual puzzle. As De Neys (2012) clarified, 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 elementary logical and probabilistic 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 a clear switch rule to determine whether deliberate thinking is required without a need to postulate an inefficient, permanent activation of the deliberate system.

**4.3 Individual differences in bias susceptibility**

Although it is well established that most people are biased when solving classic reasoning problems, it is equally clear that some people do get them right. This raises the general question of why some people end up being biased while others don’t. This question concerning individual differences in bias susceptibilityhas attracted quite some interest and resulted in a rife debate in his own right (e.g., Stanovich & West, 2000, 2008)*.* Obviously, one’s view on the nature of individual differences in bias susceptibility is linked with one’s view on the nature of heuristic bias. That is, if one believes that bias results from lax monitoring, for example, this process will be assumed to be the key to explain individual differences in bias susceptibility: Good reasoners will be those who succeed in detecting conflict, whereas biased reasoners will be those who fail to detect conflict. Hence, empirical data on the efficiency of the conflict detection process is relevant for this debate too.

 I have argued together with Jean François Bonnefon (De Neys & Bonnefon, 2013) that in addition to considering why individuals differ, we should also consider when they start to differ in the reasoning process. Biased and unbiased reasoners clearly arrive at a different conclusion at the end of the reasoning process. But when in the process does this individual variance arise? Do biased and unbiased reasoners take a different cognitive route from the start or do they initially follow the same path and only diverge in the later stages of the reasoning process? It is especially interesting to consider the implications of the empirical conflict detection findings from this “when” perspective. One might note that theoretical bias views that entail that biased reasoners do not detect conflict - either because reasoners would not know the relevant logical principles or would not use these for monitoring conflict - give rise to an early divergence view in which biased and unbiased reasoners differ from the outset. Biased reasoners will be assumed to rely on a mere heuristic path, whereas unbiased reasoners will take logical considerations into account. If both biased and unbiased reasoners detect conflict, however, this implies that both sources of information are initially considered by both groups. Consequently, at least at the first stages of the reasoning process, biased and unbiased reasoners would not be all that different. Hence, for whatever reason biased and unbiased individuals might ultimately diverge, the point is that this divergence will occur in the later phases of the reasoning process downstream from the detection stage (e.g., biased reasoners might ultimately not manage to block the heuristic response and resolve the detected conflict). Consequently, De Neys and Bonnefon argued that the conflict detection findings give rise to a late(r) divergence view.

 The important implication is that in light of the detection findings and the divergence time perspective, individual differences might be perceived as being less profound than traditionally assumed. Biased and unbiased reasoners might have more in common than what has been implied by positions such as the lax monitoring view that intrinsically helped to popularize an early divergence view. In other words, biased and unbiased reasoners turn out to be less different than their different answers might seem to suggest. As a side note, I feel that here too one can find a reason for some rational optimism: at least in the early stages of the reasoning process we all seem to be thinking alike.

**5. CONCUSION AND TAKE HOME MESSAGE**

 I opened this chapter by illustrating the biased nature of human judgment with my favorite “This is Spinal Tap” scene. In the scene, Nigel’s legendary “Going to Eleven” inference is giving us a very nice example of the notorious ratio-bias. The scene undeniably makes for a great laugh. However, after reading about the conflict detection work in this chapter it can be interesting to have a closer second look. Upon a second viewing, one might note that when Nigel’s “These are one louder!” claim is being questioned by the director, Nigel is clearly confused and in doubt. Indeed, one is getting the impression that he does realize that his claim is not really making a lot of sense. In this light, his blunt “These go to eleven!” reply sounds more like an attempt to hide his initial doubt and save his face rather than as a fiercely held belief. Given the conflict detection findings that I reviewed here, this might not be an unrealistic suggestion. Hence, one lesson that might be learned from this chapter is that the dimwitted Nigel character might be less ignorant than he seems at first sight. Of course, there is no way to verify my interpretation of a fictional movie character’s inference process. However, I hope that I managed to show that at least in the case of real reasoners who solve classic reasoning problems, there is good evidence for the claim that people are detecting their biases and do more than blindly follow cued heuristic intuitions.

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***Table 1***. Illustrations of the classic reasoning tasks that have been used in the conflict detection studies. The left panel (A) shows the classic, standard versions and the right panel (B) the control versions. The standard 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. Standard “Conflict” versions** | **B. Control “No conflict” versions** |
| **Ratio bias task:**You are faced with two trays each filled with white and red jelly beans. You can draw one jelly bean without looking from one of the trays. Tray A contains a total of 10 jelly beans of which 2 are red. Tray B contains a total of 100 jelly beans of which 19 are red. From which tray should you draw to maximize your chance of drawing a red jelly bean?1. Tray A \* 2. Tray B +**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. 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?1. Jo is a woman \*2. Jo is a man +**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.Which one of the following statements is most likely?1. Bill plays in a rock band for a hobby \* 2. Bill is an accountant and plays in a rock band for a hobby **+****Syllogistic reasoning task:**Premises: All flowers need water Roses need waterConclusion: Roses are flowers 1. The conclusions follows logically +2. The conclusion does not follow logically \***Bat-and-ball problem:**A bat and a ball together cost $1.10. The bat costs $1 more than the ball. How much does the ball cost? \_\_\_\_\_\_\_\_\_\_\_(\* = 5 cents, + = 10 cents) | You are faced with two trays each filled with white and red jelly beans. You can draw one jelly bean without looking from one of the trays. Tray A contains a total of 10 jelly beans of which 2 are red. Tray B contains a total of 100 jelly beans of which 21 are red. From which tray should you draw to maximize your chance of drawing a red jelly bean?1. Tray A2. Tray B \*+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. Which one of the following two statements is most likely?1. Jo is a woman 2. Jo is a man \*+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?1. Bill is an accountant \*+2. Bill is an accountant and plays in a rock band for a hobby Premises: All flowers need water Roses are flowersConclusion: Roses need water 1. The conclusions follows logically \*+ 2. The conclusion does not follow logicallyA bat and a ball together cost $1.10. The bat costs $1. How much does the ball cost? \_\_\_\_\_\_\_\_\_(\* = 10 cents, + = 10 cents) |

*\* = logical response, + = heuristic response*

1. For those who haven’t seen the scene yet, check <https://www.youtube.com/watch?v=4xgx4k83zzc> [↑](#footnote-ref-1)
2. For completeness, the expert reader might want to note that I will be using the label “correct” or “logical” response as a handy shortcut to refer to “the response that has traditionally been considered as correct or normative according to standard logic or probability theory”. The appropriateness of these traditional norms has sometimes been questioned in the reasoning field (e.g., see Stanovich & West, 2000, for a review). Under this interpretation, the heuristic response should not be labeled as “incorrect” or “biased”. 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. [↑](#footnote-ref-2)
3. The autonomic nervous system regulates bodily functions such as heart rate, respiration, body temperature, and is known to be involved in emotional expression. [↑](#footnote-ref-3)