Studia Psychologica, Vol. 64, No. 3, 2022, 256-267
https://doi.org/10.31577/sp.2022.03.852

Predicting the Most Common Incorrect Response: Metacognitive Advantage of Deliberative over Intuitive Responders on Cognitive Reflection Test

Lamija Šćeta[1], Josip Sliško[2], Nikola Erceg[3]
[1]University of Sarajevo, School of Economics and Business
[2]Facultad de Ciencias Físico Matemáticas, Benemérita Universidad Autónoma de Puebla, Puebla, México
[3]University of Zagreb, Faculty of Humanities and Social Sciences

In this study, we investigated the hypothesis that correct responders are at a metacognitive advantage compared to intuitively incorrect responders because they are aware that there exists an appealing but incorrect response that many would fall for. A total of 169 participants solved three CRT tasks, followed by questions about the perceived difficulty of the tasks and the most probable incorrect response that others gave. Results mainly confirmed the hypothesis: the more correct responses (or the less intuitive responses) participants gave, the more they were correct about the most prevalent incorrect responses of others. Furthermore, the more correct responses (or the less intuitive responses) participants had, the more difficult they found the tasks to be, perhaps due to the awareness of the incorrect but appealing response that would trick many others into giving a wrong response. Interestingly, the number of non-sensical responses (those neither correct nor intuitive) was positively related both to awareness of appealing incorrect responses and to the perceived difficulty of the task. This indicates that even those participants who seemingly gave non-sensical responses to CRT tasks might have a metacognitive advantage over intuitively incorrect responders. We discuss how our results fit into contemporary dual-process theories.

Key words: cognitive reflection, metacognition, deliberation, intuition

Introduction

The Cognitive Reflection Test (Frederick, 2005) is a three-item test that pits an intuitive, but incorrect, response against a correct one. Probably the best-known problem from the test is the "bat-and-ball" problem:

A bat and ball together cost $1.10. The bat costs $1.00 more than the ball. How much does the ball cost?

Correspondence concerning this article should be addressed to Nikola Erceg, University of Zagreb, Faculty of Humanities and Social Sciences. E-mail: nerceg@ffzg.hr

Received Dcember 29, 2021

Here, the correct response is 5 cents. However, despite the relatively simple math knowledge needed for solving this task, participants often end up giving the wrong response of 10 cents. Each of the test's items works in a similar way by luring solvers into an intuitive wrong response that allegedly needs to be recognized as wrong and overturned before calculating the correct response. The test became widely used and popular because it perfectly illustrates the main points of the dual-process theories of reasoning.

Reasoning, as seen through the lens of the dual-process theory, is an interplay of fast, automatic, autonomous, and non-conscious System 1 and slower, rule-based, effortful deliberate System 2 (De Neys, 2012; 2015; Evans & Stanovich, 2013; Kahneman, 2011). A more recent expansion of the dual-process theories is the tripartite theory (Stanovich, 2009; Stanovich, West, & Toplak, 2016) that further differentiates between two aspects of System 2 processing, the reflective and the algorithmic mind. The interplay between System 1 and two aspects of System 2 is elegantly captured by the CRT items. In order to overcome the initial wrong response generated by the fast and automatic System 1 (10 cents) and arrive at the correct one (5 cents), one has to reflect on the answer and recognize the need to engage in more deliberate processing (the reflective mind), but also to possess adequate computational power, knowledge, and abilities to calculate the right answer (algorithmic mind).

The above example is an illustration of the so-called "default-interventionist" view, which is one view on the interplay between intuition and deliberation in the dual-process theory. Specifically, the default-interventionist view presumes that people solve reasoning problems sequentially: first, an intuitive but incorrect response comes to mind that needs to be overturned and corrected before calculating a correct response. In other words, System 1 generates the default, heuristic response, and System 2 must intervene by overturning it and calculating a correct response, hence the name "default-interventionist" view (Evans, 2006; Kahneman & Frederick, 2005; Travers, Rolison, & Feeney, 2016). The alternative view is the "parallel activation" view. According to this model, the two systems do not act serially one after the other but are both active at the same time, simultaneously computing a problem solution from the start and competing for control of response and behavior (Handley & Trippas, 2015; Sloman, 1996; 2014; Trippas & Handley, 2018).

However, recently a so-called "logical intuition" model became prominent and has been backed up by a plethora of evidence (Bago & De Neys, 2017, 2019; De Neys, 2012, 2014, 2015; Pennycook, Fugelsang, & Koehler, 2015). According to this model, a person does not arrive at a correct response to these kinds of questions through deliberation. Instead, he/she generates both incorrect and correct, "logical" intuition from the start, and these types of intuitions compete for a final response. In other words, even those subjects that give incorrect responses are sensitive to the conflict between intuitive and correct responses. Which one will "win", i.e., which response will be given by a person depends on various things including the experience with the task at hand, "mindware", cognitive abilities and dispositions, etc.

Whichever dual-process model best describes the interplay between intuition and deliberation on cognitive reflection and similar tasks, it seems that correct responders should be aware of both solutions, a correct one and an intuitive one. This follows directly from a default-interventionist view – if a person first needs to overturn an intuitive response in order to calculate the correct one, then he/she is definitely aware of both types of responses. Theoretically, from a "parallel activation" and "logical intuition" viewpoints, it is possible that correct responders remain unaware of intuitive responses if the correct response is much stronger than the intuitive one. For example, it is possible that a person's correct, logical intuition could be so strong and dominant over the intuitive one that an intuitive response is not even implicitly detected during problem solving. Plenty of recent studies confirm this. For example, in studies done using the so-called two response paradigm, plenty of subjects give correct responses even when their capacities for deliberation are completely depleted in various ways, meaning that their intuitive response is a correct one (e.g., Bago & De Neys, 2017, 2019). Nevertheless, it seems probable that even those people who respond in this way are on some level aware of the existence of different intuitive response and if prompted can articulate it.

Conversely, intuitively incorrect responders should less often be aware that other responses rather than the intuitive one could be given to the task at hand. This again follows directly from the default-interventionist view as intuitive responders never even arrived at the deliberative phase of responding. However, a similar outcome follows from the logical intuition view as well. From this view, an intuitive response was given because an incorrect intuition was predominant and stronger than the correct one, for whatever reason. And even though plenty of research shows that intuitive responders are at least implicitly aware that their response could be conflicted with the correct one (e.g., Bago & De Neys, 2017; De Neys et al., 2011, 2013; Frey, Johnson, & De Neys, 2018; Mevel et al., 2015; Stupple, Ball, & Ellis, 2013), it is not so clear that they could articulate what this correct response is. Two-response paradigm studies confirm this. Apart from showing that a non-negligible number of subjects responds intuitively correctly, these studies also show that only a minority of participants change their responses from intuitive to correct when given a chance. In other words, the majority of intuitive incorrect responders stick to their original response when given the chance to think carefully about the problem, meaning that only a minority of intuitive responders are actually explicitly aware of the correct solution.

This is indeed what Mata, Ferreira, and Sherman (2013) showed in a series of their studies. A general conclusion of their studies is that correct responders are aware of both solutions, correct one and intuitive one, while incorrect responders are generally aware only of intuitively incorrect solution. For example, in their Study 1, across the three problems, 96.4–100% of incorrect responders thought that most of the other participants had also given the intuitively incorrect response, not realizing that there was another solution. This also made them underestimate the difficulty of the tasks and overestimate their own success rates. Conversely, most of the correct responders (61.5– 85.7%) guessed that majority of others had given the intuitively incorrect response, even though they themselves did not give that answer. In another study, Mata (2019) found that this awareness of the existence of intuitively alluring, but incorrect, solution gave a confidence boost to correct responders in comparison with incorrect responders, even though incorrect responders were unjustifiably confident in their responses. The authors concluded that correct responders are at a metacognitive advantage in comparison to incorrect responders which allows them to be better calibrated in their judgments and better at assessing how they compare to others.

Recently, Mata (2020) linked the findings from the "metacognitive advantage" literature with those from the conflict detection literature. Specifically, he demonstrated that metacognitive experiences of the trickiness of a problem and social inference about how other people might respond to the same problem are also valid indicators of conflict detection. He found that correct responders are both at metacognitive advantage compared to incorrect responders, judging more often than incorrect responders that others might not give the same response to conflict items as they did, and better at conflict detection than incorrect responders, reporting higher experiences of the trickiness of conflict items than incorrect responders.

This study aims to test the metacognitive asymmetry model (Mata et al., 2013; Mata, 2020) by measuring subjective experiences of CRT items difficulty, a measure somewhat similar but not identical to the trickiness measure (Mata, 2020), and social inferences about the most frequent incorrect responses of other participants. The general idea is the following: if participants who respond correctly on CRT items have a metacognitive advantage over those who respond incorrectly, then these responders should be more aware than incorrect responders (even after prolonged deliberation) that others might often respond in an intuitive, but wrong way, and because of this also find the tasks to be more difficult. Specifically, we set out to investigate three research problems.

First, we examined whether there are differences between correct and incorrect responders in their perception about the most prominent errors of others. Here, we hypothesized that correct responders will correctly guess the most prominent errors that others make when solving CRT tasks more often than incorrect responders. This hypothesis follows from the "default-interventionist" dual-process model, but also from the "logical intuition" model and recent findings that social inferences about others' responses are a valid measure of conflict detection at which correct CRT responders excel.

Second, we examined whether this awareness that most other people make intuitive errors will be related to the subjective experience of difficulty on CRT tasks. Here we hypothesized that the awareness of most prominent errors will be positively correlated with a subjective experience of difficulty, since those who are aware of the appeal of the incorrect response should find these tasks to be tricky and, therefore, more difficult. A similar result was recently obtained in Mata's (2020) study where the correlation between the experience of trickiness and inference about other people's responses (operationalized as estimation of the percentage of participants that gives the same response as subject) was $r = -.47$.

Finally, we wanted to know whether the subjective experience of difficulty is related to success on CRT tasks. Here, there are at least two logical possibilities. First, it seems logical that incorrect responders, not being aware that they are wrong or that there exists another plausible (and correct) response to the task, will find CRT tasks quite easy, while correct responders, given that they think about them harder and are aware that the tasks are "tricky" will find them difficult. Therefore, one possibility is that there will be a positive relationship between difficulty and the number of correct responses and a negative relationship between difficulty and the number of intuitively incorrect responses. However, it is also possible that correct responders will also find the tasks to be relatively easy. After all, they solved the tasks correctly and the tasks require only simple math knowledge. Therefore, if both correct and incorrect responders find the tasks to be easy, then we would not expect to find a correlation between task difficulty and performance. Given these two plausible expectations, we did not make a specific hypothesis for this research problem.

Methods

Participants

A total of 169 participants who were attending a pre-calculus course for the entrance exam at the School of Economics and Business in Sarajevo, Bosnia and Herzegovina participated in our study. Participants were 18 and 19 years old and mostly females (72.8%).

Procedure

Participation in the research was on a voluntary basis. A two-part questionnaire was distributed to the participants via the e-learning environment Moodle. The first part of the questionnaire consisted of six questions designed to collect responses to the three-item cognitive reflection test (CRT) and participants' perceptions of difficulty for each of these items (see Table 1 in the Appendix for all the questions). Participants had 7 minutes to complete this questionnaire.

The second part of the questionnaire was distributed to the participants one hour later, with the aim of measuring metacognitive awareness. We asked participants for their opinion about the most common incorrect answer that others gave to a given CRT task. This was a multiple-choice question with four alternatives (see Table 2 in the Appendix for all the questions). Due to the participation being completely voluntary and unincentivized, some participants dropped out between the first and second part of the questionnaire, which left us with *N* = 94 participants solving the second part of the questionnaire.

Measurements

Cognitive reflection test. We used Frederick's original three items CRT (Frederick, 2005). We coded each of the responses as either correct, intuitive, or other (neither correct nor intuitive). We calculated three total scores: the total number of correct responses, the total number of intuitive responses, and the total number of other responses on three CRT items.

CRT difficulty. After each CRT item, we asked participants to rate whether they found that item to be 1 = easy, 2 = neither easy nor difficult or 3 = difficult. We report the average difficulty estimate a person gave on the three tasks.

Metacognitive awareness. We measured metacognitive awareness by asking participants to guess, for each of the three CRT tasks, the most frequent incorrect response that others gave. If a participant correctly guessed that most others gave an intuitively incorrect response, we scored this as correct and awarded one point. We calculated the total score as the sum of correct guesses for the three tasks. Thus, the higher the score on metacognitive awareness, the more often the participants correctly guessed that others mostly gave intuitively incorrect responses to CRT tasks.

Results

In order to test our hypotheses and answer our research problems, we conducted a correlational analysis. The results of this analysis, together with descriptive statistics and reliabilities of our variables, are shown in Table 1.

Regarding the first research problem, we found a relatively high positive correlation between the number of correct CRT responses and metacognitive awareness and a high negative correlation between the number of intuitive CRT responses and metacognitive awareness. Unlike intuitively incorrect responses, a total number of "other" incorrect responses was positively correlated with metacognitive

Table 1 *Descriptive statistics and correlations between the variables*

	M	*SD*	Cronbach α	CRT correct	CRT intuitive	CRT other	Difficulty	Awareness
CRT correct	0.87	1.02	.62	1	-.82**	-.17*	.19*	.47**
CRT intuitive	1.70	1.10	.60		1	-.42**	-.35**	-.53**
CRT other	0.43	0.63	.13			1	.31**	.22*
Difficulty	1.51	0.47	.63				1	.14
Awareness	1.55	1.02	.48					1

Note. CRT correct = sum of correct responses to the three CRT tasks; CRT intuitive = sum of intuitively incorrect responses to the three CRT tasks; CRT other = sum of incorrect responses (other than intuitively incorrect) to the three CRT tasks; Difficulty = average difficulty estimation for the three CRT tasks; Awareness = sum of correct guesses about the most prevalent incorrect responses to the three CRT tasks.

awareness. This confirms our hypothesis that correct responders will guess that the most prominent errors that others make are intuitive ones more often than intuitively incorrect responders, but it also shows that the three types of CRT responses are underpinned by substantially different metacognitive experiences.

Regarding the second problem, although there was a positive correlation between metacognitive awareness and subjective difficulty, it nevertheless failed to reach significance. Therefore, we did not confirm our hypothesis of a positive relationship between awareness of others' intuitive responses and perceived difficulty of the tasks.

Finally, regarding our third hypothesis, we found a small but significant positive correlation between the perceived difficulty of the tasks and the number of correct CRT responses, a somewhat higher negative correlation between perceived difficulty and the number of intuitively incorrect responses, and a positive correlation between perceived difficulty and the number of "other" responses. This pattern of results implies that the three response types are underpinned by different perceptions of difficulty, where those who gave intuitively incorrect responses should find the tasks to be easiest, followed by those who responded correctly and those who responded in "other" way and who should find the task to be hardest. To test this, we compared how the three types of responses differ in underlying perceptions of difficulty for each of the three CRT tasks. Results are shown in Figure 1.

As can be seen, in comparison to other response types, when giving intuitively incorrect responses, participants generally found the tasks to be the easiest. Conversely, those who responded correctly generally found the tasks to be somewhat more difficult than intuitively incorrect responders (except perhaps for CRT 3), but "other" responders consistently found the tasks to be the most difficult. Sometimes the difference in difficulty perception between correct and other response types is not significant, as illustrated by overlapping 95% confidence intervals based on standard errors, but this is, as expected, due to relatively infrequent incidence of participants responding in "other" way (i.e., due to low statistical power).

To get a better grasp of these results, but also to increase statistical power, we restructured the data into a "long" format. This way we made a CRT item, and not the participant, the unit of analysis, increasing the "sample size". Of course, this created a

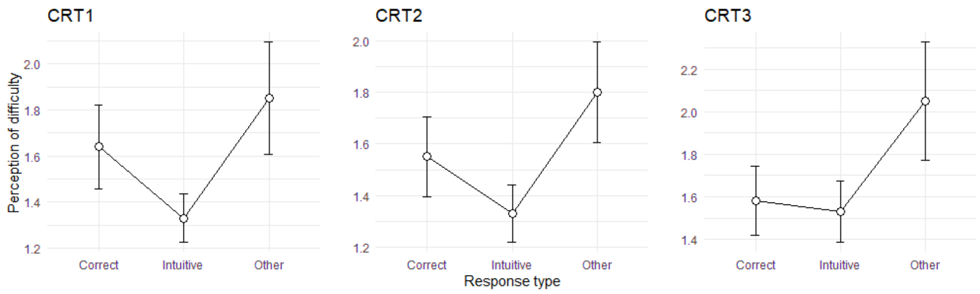

Figure 1 Perceptions of difficulty of three CRT tasks for each of the response type

multilevel structure of the data: responses given to CRT tasks and other measures represented a level one, whereas the subject ID represented a level two under which the responses were nested. We then conducted a multilevel regression analysis looking at the effects of response type (correct vs. intuitively incorrect vs. other) on difficulty perception (level one variables), controlling for the effects of participant (level two variable). To do this, we first created three dummy variables ("Correct dummy", "Intuitive dummy", "Other dummy"). We then conducted multilevel regressions with difficulty perception as an outcome and our dummy variables as level one predictors, accounting for the subject ID as level two variable (random effects). We tested two models with different dummy variables to be able to discriminate between the effects of each of the three response types. In Model 1 we tested the effects of "Correct dummy" and "Other dummy" against the baseline of an intuitively incorrect response, effectively looking at whether the perceptions of difficulty differ between correct and intuitively incorrect responses and between "other" and intuitively incorrect responses. In Model 2 we tested the effects of "Intuitive dummy" and "Other dummy" to see whether the perceptions of difficulty differ between correct and "other" responses. The results are shown in Table 2.

As the effects in Table 2 show, in Model 1 the coefficients for both "Correct dummy" and "Other dummy" were significant and positive, basically meaning that both correct and "other" responses were accompanied by higher perceptions of task difficulty compared to intuitively incorrect responses. In addition to this, the positive and significant effect of "Other dummy" in Model 2 shows that "other" responses were accompanied by higher perceptions of task difficulty compared to correct responses. Thus, the results seem to confirm our assumption that the three response types are underpinned by different perceptions of difficulty where intuitively incorrect responders find the tasks to be the easiest, followed by correct responders and finally "other" responders, who find the tasks to be the hardest.

These results testify to the metacognitive lacking of intuitively incorrect responders, resulting in their fluent responding and feeling that the tasks are easy. On the other hand, correct responders, being aware that the tasks are tricky, found them to be more difficult. Finally, "other" responders found the tasks to be even more difficult, possibly because they both found them to be tricky and very hard to calculate.

Table 2 *Results of the multilevel regression analyses with response types as predictors and difficulty estimates as an outcome*

	Model 1		Model 2	
	Estimate	SE	Estimate	SE
Intercept	1.42**	0.04	1.55**	0.05
Correct dummy	0.13*	0.06		
Other dummy	0.41**	0.07	0.29**	0.08
Intuitive dummy			-0.13*	0.06

Note. **p* < .05; ***p* < .001

Discussion

In this research, we set out to test several hypotheses that followed from the so-called "metacognitive asymmetry" model according to which correct responders are at a metacognitive advantage in comparison to intuitive responders that allows them to be more correct in their own responses, better at assessing their own performance, but also better at inferring what other people would do and how others would perform in a similar situation (Mata et al., 2013; Mata & Almeida, 2014; Mata, 2020). Our results confirm the basic assumption of this model. Specifically, we showed that the performance on CRT was positively correlated both with (correctly) inferring that others will most likely err by giving intuitively incorrect responses and with subjective experiences of the difficulty of the tasks. Conversely, when scored as a total number of intuitive responses given, CRT negatively correlated with these same variables. Therefore, the more successful people are at solving CRT tasks, the more insight they have into how other people respond, and the more they feel that the tasks are not as easy as they might seem. On the contrary, people with a greater tendency towards intuitively incorrect responding have lower awareness of others' possible errors (and consequently of their own errors) and find the tasks to be relatively easy.

Regarding our first research problem, as we noted, we found a positive correlation between correct and a negative correlation between intuitively incorrect responding and metacognitive awareness of others' mistakes. This basically means that intuitively incorrect responders, even after prolonged deliberation, failed to catch their own wrong responses. These results, apart from confirming the "metacognitive asymmetry" assumptions, are also in line with two-response paradigm results, where people only rarely change their initial incorrect response after deliberation (Bago & De Neys, 2017, 2019). Indirectly, this also speaks in favor of the validity of social inferences about others' responses as a conflict detection indicator (Mata, 2020).

Not surprisingly, as they mostly do not realize that their fluent, intuitive response was wrong, intuitively incorrect responders find the tasks to be quite easy. On the other hand, the more correct one was, the more that person found the tasks to be hard. This probably reflects the metacognitive advantage of correct responders – being aware that the tasks are trying to lure us into giving a wrong response and that many people will probably fall for this, correct responders find the tasks to be harder than the intuitively incorrect responders. At first glance, the fact that intuitively incorrect responses are accompanied by lowest difficulty perceptions and lowest metacognitive awareness speaks against the "logical intuition" model, which presumes that even those who give intuitive responses detect the conflict on some level and that this detection should be reflected at least in elevated difficulty perceptions. However, we must warn that our research design does not permit drawing any definite conclusions about the validity of "logical intuition" model based on current results. To be able to confidently speak about whether intuitively incorrect responders managed to detect the conflict, parallel CRT tasks that do not lure responders into giving incorrect responses are needed. Only if intuitively incorrect responders exhibit similar (and not lower) difficulty perceptions responding to such parallel tasks in comparison with original CRT tasks would we be able to claim that they did not detect the conflict, thus calling in question the validity of the "logical intuition" model.

Another interesting thing to notice, regarding the relationship between CRT responses and metacognitive awareness, is the positive correlation between the number of "other" responses (i.e., neither correct nor intuitive responses) and metacognitive awareness and difficulty. This clearly illustrates that not all incorrect responses on CRT are the same and that, somewhat surprisingly, those who give "other" responses that sometimes may even look nonsensical might be metacognitively more "equipped" than those who respond in a more usual, intuitively incorrect way. These responders are generally more aware than intuitively incorrect responders that intuitive response is an incorrect one and that others might respond in this way, but perhaps lack the ability or skills to calculate the correct response. This is also evident from the fact that they find the tasks to be the most difficult, perhaps reflecting the fact that they recognize that tasks are both tricky (similarly as correct responders) and hard to calculate (unlike correct responders, who either responded intuitively correctly or managed to easily calculate the right response). Given that metacognitive awareness can be taken as an indicator of conflict detection (Mata, 2020) and that conflict detection is dependent on mindware development, cognitive abilities, and different thinking dispositions (e.g., Erceg, Galic, Bubic, & Jelic, 2022; Purcell, Wastell, & Sweller, 2020; Stanovich, 2018), it is plausible to conclude that these traits are underdeveloped in intuitively incorrect responders even in comparison to those who mostly give non-sensical, "other" responses.

Finally, moving onto the third problem and looking at two possibilities we specified, the pattern of results implies that they are both correct. Namely, a positive correlation between the number of correct CRT responses and perceived difficulty implies that correct responders recognized that CRT tasks are tricky and, therefore, somewhat difficult. However, it also seems that this perception of difficulty was alleviated by the fact that correct responders found it easy to solve the tasks, in comparison to responders who tended to give "other" responses and who found the tasks to be especially hard. It follows from this that the experience of the difficulty of a task, although useful and important information about metacognitive experiences of participants, is not identical to the measure of "trickiness" used by Mata (2020), as responders seem to be able to differentiate between whether the task was tricky and whether it was hard. Therefore, the perceived difficulty of a task is perhaps not as good an indicator of conflict detection as the trickiness measure (and awareness of other responses).

Conclusion

In the current study, we set out to test several implications of the "metacognitive asymmetry" theory (Mata et al., 2013, Mata, 2020). We found that correct responders indeed are at a metacognitive advantage in comparison with intuitive responders – they have more correct insight about how other people will err on CRT tasks and this perhaps translates into their subjective experience that the tasks are more difficult than they seem to be for intuitively incorrect responders. Our results speak in favor of the "metacognitive asymmetry" model and lend credence to social inference about others' responses as a valid conflict detection indicator. In addition to this, our results point to the importance of the distinction between different forms of incorrect responses (intuitive vs. "other" responses), as these responses were underpinned by substantially different metacognitive experiences.

Authors' ORCID
Lamija Šćeta
https://orcid.org/0000-0002-0410-0311
Josip Sliško
https://orcid.org/0000-0002-5805-4808
Nikola Erceg
https://orcid.org/0000-0002-9056-4592

References

Bago, B., & De Neys, W. (2017). Fast logic?: Examining the time course assumption of dual process theory. *Cognition, 158*, 90–109. https://doi.org/10.1016/j.cognition.2016.10.014

Bago, B., & De Neys, W. (2019). The smart System 1: Evidence for the intuitive nature of correct responding on the bat and ball problem. *Thinking & Reasoning, 25*(3), 257–299. https://doi.org/10.1080/13546783.2018.1507949

De Neys, W. (2012). Bias and conflict: A case for logical intuitions. *Perspectives on Psychological Science, 7*(1), 28–38. https://doi.org/10.1177/1745691611429354

De Neys, W. (2014). Conflict detection, dual processes, and logical intuitions: Some clarifications. *Thinking & Reasoning, 20*(2), 169–187. https://doi.org/10.1080/13546783.2013.854725

De Neys, W. (2015). Heuristic bias and conflict detection during thinking. In *Psychology of learning and motivation* (Vol. 62, pp. 1–32). Academic Press. https://doi.org/10.1016/bs.plm.2014.09.001

De Neys, W., Cromheeke, S., & Osman, M. (2011). Biased but in doubt: Conflict and decision confidence. *PloS one, 6*(1), e15954. https://doi.org/10.1371/journal.pone.0015954

De Neys, W., Rossi, S., & Houdé, O. (2013). Bats, balls, and substitution sensitivity: Cognitive misers are no happy fools. *Psychonomic Bulletin & Review, 20*(2), 269–273. https://doi.org/10.3758/s13423-013-0384-5

Erceg, N., Galić, Z., Bubić, A., & Jelić, D. (2022). Who detects and why: how do individual differences in cognitive characteristics underpin different types of responses to reasoning tasks? *Thinking & Reasoning,* 1-49. https://doi.org/10.1080/13546783.2022.2108897

Evans, J. S. B. (2006). The heuristic analytic theory of reasoning: Extension and evaluation. *Psychonomic Bulletin & Review, 13*(3), 378–395. https://doi.org/10.3758/BF03193858

Evans J. S. B., Stanovich K. E. (2013). Dual process theories of higher cognition: Advancing the debate. *Perspectives on Psychological Science, 8*(3), 223–241. https://doi.org/10.1177/1745691612460685

Frey, D., Johnson, E. D., & De Neys, W. (2018). Individual differences in conflict detection during reasoning. *The Quarterly Journal of Experimental Psychology, 71*(5), 1–52. https://doi.org/10.1080/17470218.2017.1313283

Handley, S. J. J., & Trippas, D. (2015). Dual processes and the interplay between knowledge and structure: A new parallel processing model. In *Psychology of learning and motivation* (Vol. 62, pp. 33–58). Academic Press. https://doi.org/10.1016/bs.plm.2014.09.002

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

Kahneman, D., & Frederick, S. (2005). A model of heuristic judgment. In K. J. Holyoak & R. G. Morrison (Eds.), *The Cambridge handbook of thinking and reasoning* (pp. 267–293). New York, NY, US: Cambridge University Press.

Mata, A. (2019). Further tests of the Metacognitive Advantage Model: Counterfactuals, confidence and affect. *Psihologijske teme, 28*(1), 115–124. https://doi.org/10.31820/pt.28.1.6

Mata, A. (2020). Conflict detection and social perception: Bringing meta-reasoning and social cognition together. *Thinking & Reasoning, 26*(1), 140–149. https://doi.org/10.1080/13546783.2019.1611664

Mata, A., & Almeida, T. (2014). Using metacognitive cues to infer others' thinking. *Judgment & Decision Making, 9*(4), 349–359.

Mata, A., Ferreira, M. B., & Sherman, S. J. (2013). The metacognitive advantage of deliberative thinkers: A dual-process perspective on overconfidence. *Journal of Personality and Social Psychology, 105*(3), 353. https://doi.org/10.1037/a0033640

Mevel, K., Poirel, N., Rossi, S., Cassotti, M., Simon, G., Houdé, O., & De Neys, W. (2015). Bias detection: Response confidence evidence for conflict sensitivity in the ratio bias task. *Journal of Cognitive Psychology, 27*(2), 227–237. https://doi.org/10.1080/20445911.2014.986487

Pennycook, G., Fugelsang, J. A., & Koehler, D. J. (2015). What makes us think? A three stage dual process model of analytic engagement. *Cognitive Psychology, 80*, 34–72. https://doi.org/10.1016/j.cogpsych.2015.05.001

Purcell, Z. A., Wastell, C. A., & Sweller, N. (2020). Domain-specific experience and dual-process thinking. *Thinking & Reasoning, 27*(2), 239–267. https://doi.org/10.1080/13546783.2020.1793813

Sloman, S. A. (1996). The empirical case for two systems of reasoning. *Psychological Bulletin, 119*(1), 3–22. https://doi.org/10.1037/0033-2909.119.1.3

Stanovich, K. E. (2009). Distinguishing the reflective, algorithmic and autonomous minds: Is it time for a tri process theory? In J. St. B. T. Evans & K. Frankish (Eds.), *In two minds: Dual processes and beyond* (pp. 55–88). Oxford, England: Oxford University Press. https://doi.org/10.1093/acprof:oso/9780199230167.003.0003

Stanovich, K. E. (2018). Miserliness in human cognition: The interaction of detection, override and mindware. *Thinking & Reasoning, 24*(4), 423–444. https://doi.org/10.1080/13546783.2018.1459314

Stanovich, K. E., West, R. F., & Toplak, M. E. (2016). *The rationality quotient: Toward a test of rational thinking*. Cambridge, MA, USA: MIT. https://doi.org/10.7551/mitpress/9780262034845.001.0001

Stupple, E. J., Ball, L. J., & Ellis, D. (2013). Matching bias in syllogistic reasoning: Evidence for a dual process account from response times and confidence ratings. *Thinking & Reasoning, 19*(1), 54–77. https://doi.org/10.1080/13546783.2012.735622

Travers, E., Rolison, J. J., & Feeney, A. (2016). The time course of conflict on the Cognitive Reflection Test. *Cognition, 150*, 109–118. https://doi.org/10.1016/j.cognition.2016.01.015

Trippas, D., & Handley, S. (2017). The parallel processing model of belief bias: Review and extensions. In W. De Neys (Ed.), *Dual process theory 2.0* (pp. 28–46). Oxon, UK: Routledge. https://doi.org/10.4324/9781315204550-3

Appendix

Table 1 *Questions from the first part of the questionnaire*

Notation	Question
CRT 1	A bat and a ball cost \$1.10 in total. The bat costs \$1.00 more than the ball. How much does the ball cost?
PPD 1	I find this problem (CRT 1): 1. Easy 2. Neither easy nor difficult 3. Difficult
CRT 2	If it takes 5 machines 5 minutes to make 5 widgets, how long would it take 100 machines to make 100 widgets?
PPD 2	I find this problem (CRT 2): 1. Easy 2. Neither easy nor difficult 3. Difficult
CRT 3	In a lake, there is a patch of lily pads. Every day, the patch doubles in size. If it takes 48 days for the patch to cover the entire lake, how long would it take for the patch to cover half of the lake?
PPD 3	I find this problem (CRT 3): 1. Easy 2. Neither easy nor difficult 3. Difficult

Table 2 *Questions from the second part of the questionnaire*

Question	Proposed answers
What do you think the most common incorrect response to the task CRT 1 was?	a. \$0.5 b. \$0.1 c. \$0.05 d. \$1
What do you think the most common incorrect response to the task CRT 2 was?	a. 5 minutes b. 100 minutes c. 20 minutes d. 25 minutes
What do you think is the most common incorrect response to the task CRT 3 was?	a. 24 days b. 47 days c. 28 days d. 30 days