Article:
Spears, D, Okan, Y orcid.org/0000-0001-7963-1363, Hinojosa-Aguayo, I et al. (3 more authors) (2021) Can induced reflection affect moral decision making? Philosophical Psychology, 34 (1). pp. 28-46. ISSN 0951-5089

https://doi.org/10.1080/09515089.2020.1861234

Can induced reflection affect moral decision-making?

Daniel Spears[1], Yasmina Okan[2], Irene Hinojosa-Aguayo[1], José César Perales[1], María Ruz[1], & Felisa González[1]

[1]*Mind, Brain and Behavior Research Center (CIMCYC), Universidad de Granada, Granada, Spain.*

[2]*Centre for Decision Research, Leeds University Business School, University of Leeds, Leeds, United Kingdom*

Corresponding Author: Daniel Spears, Daniel.sprs@gmail.com

Daniel Spears and Irene Hinojosa-Aguayo are PhD candidates at the University of Granada.

Yasmina Okan is a Cancer Research UK Fellow and Associate Professor in Behavioral Decision Making at the University of Leeds.

María Ruz is Associate Professor and José César Perales and Felisa González are Full Professors in the Department of Experimental Psychology at the University of Granada.

Word count: 7,062

Abstract

Evidence about whether reflective thinking may be induced and whether it affects utilitarian choices is inconclusive. Research suggests that answering items correctly in the Cognitive Reflection Test (CRT) before responding to dilemmas may lead to more utilitarian decisions. However, it is unclear to what extent this effect is driven by the inhibition of intuitive wrong responses (reflection) vs. the requirement to engage in deliberative processing. To clarify this issue, participants completed either the CRT or the Berlin Numeracy Test (BNT)—which does not require reflection—before responding to moral dilemmas. To distinguish between the potential effect of participants' previous reflective traits and that of performing a task that can increase reflectivity, we manipulated whether participants received feedback for incorrect items. Findings revealed that both CRT and BNT scores predicted utilitarian decisions when feedback was not provided. Additionally, feedback enhanced performance for both tasks, although it only increased utilitarian decisions when it was linked to the BNT. Taken together, these results suggest that performance in a numeric task that requires deliberative thinking may predict utilitarian responses to moral dilemmas. The finding that feedback increased utilitarian decisions only in the case of BNT casts doubt upon the reflective-utilitarian link.

Keywords: Berlin numeracy test, Cognitive reflection test, moral dilemma, deliberation.

1: Introduction

There is substantial research examining the mechanisms underlying decision making in complex moral scenarios. A common method is to present people with hypothetical dilemmas where they must decide whether they would be willing to kill one stranger to save a greater number of people. A prominent example is the *Footbridge* dilemma (Foot, 1978), where participants must indicate whether they would be willing to throw a large man over a footbridge onto rail tracks to stop a runaway train from killing five other people. The dilemma pits deontological rule-based responses ("do no harm") against utilitarian or consequentialist ones ("maximize aggregate welfare", e.g., Greene, Nystrom, Engell, Darley, & Cohen, 2004). The conflict relates to whether one should inflict harm on one person to reduce the aggregate amount of damage done to other people: if the large man is pushed off the bridge, the five people will be saved, but the man will have been sacrificed.

It has been argued that responses to moral dilemmas can be driven by either intuitive processes or more deliberative ones (Greene, Morelli, Lowenberg, Nystrom, & Cohen, 2008; Greene, et al., 2004; Greene, Sommerville, Nystrom, Darley, & Cohen, 2001). From this perspective, deciding to push the large man off the footbridge would be the deliberative choice. To make this choice, one would need to overcome the initial emotional response associated with the possibility of killing an innocent individual in such a way. Supporting this notion, Greene et al. (2001) observed that, when participants decided to sacrifice the man, areas of the brain involved in cognitive control were activated. Additionally, participants' responses were slower than when they decided not to push the man. According to this account, the decision not to sacrifice the man would be the result of fast, emotional, and intuitive processes.

This "dual process model of morality," in one form or another, has received behavioral support (Greene et al., 2008; Li, Xia, Wu, & Chen, 2018; Paxton, Ungar, & Greene, 2012). For instance, Greene et al. (2008) manipulated cognitive load by asking participants to perform a digit search task while they responded to moral dilemmas. Participants in the cognitive load condition exhibited longer response times for utilitarian decisions, relative to the no-load (control) condition. Other studies have found that utilitarian decisions are less likely when participants are required to complete other demanding tasks that may interfere with deliberative processes (e.g., Timmons & Byrne, 2018; Trémolière, De Neys, & Bonnefon, 2012). Instead, utilitarian decisions can become more likely when participants are primed to deliberate either directly (Li et al., 2018), or indirectly by responding to dilemmas in a difficult to read font (Spears, Fernández-Linsenbarth, Okan, Ruz, & González, 2018). A recent review also found that time pressure and cognitive load reduced utilitarian decisions, while individual differences in cognitive abilities, like working memory, were associated with utilitarian decisions (Trémolière, De Neys, & Bonnefon, 2017). Taken together, these findings suggest that deliberative cognition is important for utilitarian decisions.

However, some studies have questioned whether utilitarian choices are always the product of deliberative processes. For instance, there is evidence that utilitarian decisions correlate with psychopathy and other anti-social personality traits not generally considered to reveal rationality (e.g., Bartels & Pizarro, 2011; Kahane, Everett, Earp, Farias, & Savulescu, 2015). Both callous affect (a facet of psychopathy) and measures of cognitive reflection (Cognitive Reflection Test, CRT; Frederick, 2005) have been reported to be positively correlated with utilitarian decisions, but not with each other (Spears, Okan, Cándido, & González, 2014). People with anti-social traits seem to make utilitarian decisions because they are not averse to causing harm (Patil,

2015), and they would sacrifice one person to avoid others being injured (Conway, Goldstein-greenwood, Polacek, & Greene, 2018). Relatedly, alcohol intoxication—which impairs higher order cognitive reasoning and may decrease aversion to harming others—can be related to more utilitarian decisions (Duke & Bègue, 2015).

Other authors have also emphasized that CRT scores are not always correlated with utilitarian responses (Baron, Scott, Fincher, and Metz, 2015; Royzman, Landy, & Leeman, 2015). For example, Royzman et al. (2015) found that CRT scores were instead related with a 'morally minimalistic' judgment pattern whereby harm-inducing acts are as seen as morally permissible but not required. That is, people with high CRT scores would deliberate about both deontological and utilitarian arguments, resulting in no behavioral preference for either action. Relatedly, Baron et al. (2015) suggested that the links between CRT scores and utilitarian responses (when found) are likely due to the existing link between CRT and the belief that it is good to question initially favored conclusions (i.e., 'open-minded thinking').

Finally, other studies have questioned the utilitarian-deliberative link by suggesting that some utilitarian decisions can be intuitive, such as not telling a friend about her husband's one-time affair to avoid causing her pain (Kahane, Wiech, Shackel, Farias, Savulascu, & Tracey, 2012). In such 'white lie' dilemmas, deliberation may be required to overcome the intuitive utilitarian response (i.e., lying) and reach the counter-intuitive *deontological* response (e.g., telling the truth). However, subsequent research found that reflective thinking (i.e., higher CRT scores) was associated with utilitarian decisions on both 'white lie' and standard footbridge dilemmas (Paxton, Bruni, & Greene, 2013).

To shed light on the role of deliberation in moral decisions, some authors have investigated specifically whether manipulations that induce reflective processes affect

utilitarian responding . For instance, Paxton et al. (2012) examined the effect of answering the CRT items on people's responses to moral dilemmas. The CRT (Frederick, 2005) is thought to measure the tendency to check and inhibit prepotent intuitive responses (see Materials section, for a detailed description of the test). Responding successfully to CRT questions may make participants more reflective, leading to more utilitarian responses to moral dilemmas. Supporting this prediction, Paxton et al. (2012) found that participants who answered at least one question correctly before (but not after) responding to moral dilemmas viewed the utilitarian actions as more acceptable.

However, it is also possible that the effect of answering CRT items on people's responses to moral dilemmas found by Paxton et al. (2012) was not due specifically to increased cognitive reflection caused by the CRT, but instead merely to increased deliberation due to the requirement to engage in a numeric task prior to responding to the dilemmas. Indeed, the ability to answer numeric tasks correctly is related with deliberative thinking (Ghazal, Cokely, & Garcia-Retamero, 2014). Because Paxton et al. did not include a control condition with a different numeric task not involving cognitive reflection specifically, it is not possible to determine whether increased utilitarian decisions were specifically due to increased reflective cognition, or to deliberation based on numeric ability.

In the present work we aimed to shed light on the role of cognitive reflection vs. deliberation on moral decision making. Specifically, we conducted a study involving two different samples, including psychology college students and participants from the general population. Participants were allocated to complete either the CRT or a different numerical task that does not require the inhibition of intuitive responses, (i.e., the Berlin Numeracy Test; BNT; Cokely, Galesic, Schulz, Ghazal, & Garcia-Retamero, 2012), and

subsequently responded to a series of moral dilemmas. BNT scores are positively correlated with CRT scores, as well as with working memory span (Turner, & Engle, 1989; Cokely, et al., 2012). However, unlike the CRT, the BNT was not designed to lure people towards intuitive incorrect responses. That is, reaching the correct answer in the BNT does not require inhibition of preponderant intuitive responses triggered by the content of the question. Instead, correct responses on BNT items often result from increased deliberation, or "deep, elaborate processing" (Cokely, & Kelley, 2009; Cokely, et al., 2012) during decision-making and better self-monitoring of performance (i.e., less overconfidence; Ghazal et al., 2014). Thus, administering both the BNT and the CRT allowed us to distinguish between the effects on moral judgments of performing a numerical task that requires deliberative processes (CRT and BNT) from the (additional) inhibition of incorrect automatic responses (CRT only). If cognitive reflection is needed to endorse utilitarian actions, we would expect participants completing the CRT to exhibit more utilitarian responses than those completing the BNT.

To distinguish between the potential effect of participants' previous reflective traits and that of performing a task that can increase reflectivity, some participants were asked to reconsider their wrong responses to either the CRT or the BNT. Specifically, participants received: a) item-by-item warning about their incorrect responses; b) a clue to solve the problem satisfactorily, and c) a chance to change their answer and respond correctly—that is, they were *further* forced to reflect (see Meyer, Spunt, & Frederick, 2015, for a similar procedure). We reasoned that providing explicit feedback on incorrect responses should encourage participants–even those who are not naturally reflective–to reconsider their responses, hence involving further reflection.

Overall, if inhibition of prepotent intuitive response is needed to make utilitarian decisions, we should find more utilitarian choices in the CRT Feedback condition than in the CRT (no Feedback) condition. If that were the case, any effect of BNT on moral choices should not, in principle, be affected by feedback. However, if the induction of deliberative thinking itself prompts utilitarian responses, feedback should increase utilitarian choices regardless of whether it is provided in connection to CRT items or to BNT items.

2: Method

2.1: Participants

2.1.1: Sample A

A total of 248 undergraduate students from the University of Granada took part in the study in the laboratory in exchange for course credit. Following a priori exclusion criteria, we omitted 18 participants from all analyses because they declared having prior knowledge of either CRT or BNT items. Thus, the final sample consisted of 230 participants (154 female, age M = 19.62, SD = 2.72, range = 17 – 36).

2.1.2: Sample B

A total of 232 participants residing in Spain completed the study online. We omitted 10 participants from analyses because they declared having prior knowledge of CRT or BNT items. Thus, the final sample consisted of 222 participants (134 female) with a wider age range than Sample A (M = 28.07, SD = 10.85, range = 18 – 68). Education level was also more heterogeneous in Sample B, which included participants with no

formal education (n = 1), primary education (n = 3), secondary education (n = 74), university degree (n = 90), master's (n = 33), and doctorates (n = 21) [1].

2.2: Materials and design

All procedures were approved by the local Ethics Committee (#934/CEIH/2014). All the study materials described below, data files, and analyses scripts are available at the Open Science Framework (OSF): https://osf.io/8s42h/.

2.2.1: Tasks and feedback

2.2.1.1: Cognitive Reflection Test (CRT)

For Sample A, we used the original CRT 3-item task (Frederick, 2005). An example item is: *'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?'* Respondents often provide the intuitive incorrect answer, 10 cents, instead of the correct answer, 5 cents. For Sample B, we used the new CRT version (Primi, Morsanyi, Chiesi, Donati, and Hamilton, 2016), so as to increase generalizability of our findings using a similar and equally valid task. An example item in the new version is: *'Jerry received both the 15th highest and the 15th lowest mark in the class. How many students are in the class?',* with the intuitive answer being 30, and the correct answer 29. Participants in both samples also completed a practice trial

[1] Of the 222 participants in Sample B, 47 were recruited through Amazon's Mechanical Turk, filtered for participants registered in Spain, and 175 were recruited through a blog hosted by the University of Granada, which was advertised in student portals and using social media. Participants recruited through the latter method included 26 undergraduate Psychology students taking part in exchange for course credit and 149 who took part without compensation. Further details on demographics for each of these subgroups can be found in Supplementary materials.

involving an additional item selected from a four-item version of the CRT (Toplak, West, & Stanovich, 2014; the "*Water Barrel*" question; see Procedure). [2]

2.2.1.2: Berlin Numeracy Test (BNT)

The BNT (Cokely et al., 2012) was used for both samples—a four-item test that measures statistical numeracy, without explicitly inducing any intuitive incorrect response. An example item is: "*Image we are throwing a 5-sided die 50 times. On average, out of these 50 throws how many times would this five-side die show an odd number?*" We used three items for the target task, whereas the remaining one (the "*Loaded Die"*) was used in the practice trial.

2.2.1.3: Feedback

We developed feedback statements for each item in each of the tasks described above. For example, if a participant in the CRT Feedback condition answered the *Bat and Ball* item incorrectly, they would be directed to a page displaying the following feedback: "*I'm sorry, your answer is incorrect – have you checked how much the total for the ball and bat would be according to your answer?*", with the item appearing below to be answered again. Participants in the Feedback conditions received feedback and a second chance to respond if, and only if, their response was incorrect. Each response was

[2] Analyses of the distribution of responses for all individual CRT (original and new) and BNT items before feedback are presented in Supplementary materials. For the CRT items, the expected incorrect answers were provided frequently, whereas other types of incorrect responses were infrequent. In contrast, for BNT items, there were no specific incorrect answers that were particularly frequent. This suggests that, as expected, only the CRT induces specific incorrect (intuitive) responses.

scored for accuracy (0 = incorrect, 1 = correct), with a maximum total possible score of 3 in each task. In the Feedback conditions, if a participant did not answer one item correctly, it was initially scored 0. However, if after feedback they answered correctly, it was scored 1. Therefore, for participants who failed at least one item, we computed both pre and post feedback scores, in order to determine the effectiveness of the manipulation.

2.2.2: Moral dilemmas

We used three personal, self, inevitable dilemmas: two selected from the set used by Greene et al. (2004; Crying Baby and Submarine) and one from Moore, Clark, and Kane (2008; Rescue 911)[3]. We focused on this kind of dilemmas because Moore and colleagues found that responses to personal and inevitable dilemmas were affected by individual differences in working memory—a cognitive ability that is positively correlated with both CRT (Toplak, West, & Stanovich, 2011) and BNT scores (Cokely et al., 2012). After reading each dilemma, participants indicated whether they thought they should perform the action proposed in each case (e.g., *Do you think that you should asphyxiate your child to save yourself and the other people hidden?*). The response scale ranged from 1 (definitely "no", do not sacrifice), to 6 (definitely "yes", do

[3] Moore et al. (2008) distinguished between impersonal/personal, self/other, and inevitable/avoidable dilemmas. A personal dilemma is one in which the person must directly sacrifice another in order to save several lives (e.g. by strangling or throwing from a helicopter) while an impersonal dilemma is less direct (e.g. pushing a button or pulling a lever). In "self" dilemmas, the person who makes the decision will also die if he/she decides not to sacrifice; while "other" dilemmas are those in which the life of the person who makes the decision is not at stake. Finally, dilemmas where the victim will die regardless of the choice are "inevitable", whereas "avoidable" dilemmas are those where the victim will live if the decision is not to sacrifice.

sacrifice). This scale was used because it allows considering the answer as a dichotomy (1-3, non-utilitarian, 4-6 utilitarian) as well as grading the response (Bartels & Pizarro, 2011). All three dilemmas were translated into Spanish by the first author, who is a native English speaker also proficient in Spanish, and were reviewed by the last author, a native Spanish speaker with excellent knowledge of English.

2.2: Procedure

All materials were implemented as an electronic survey in Unipark (www.unipark.de). Sample A participants were seated at individual computers in the laboratory, whereas Sample B participants completed the study online. In all cases, participants provided informed consent (either in writing or online) before proceeding to the study. Next, they read instructions indicating that they would need paper and pen to work out the problems and write down their answers before entering them on the computer. In the feedback conditions, this allowed participants to check their initial response and change it in their second attempt, if necessary. They were then allocated to one of the four experimental conditions: Sample A: CRT, $n = 56$; BNT, $n = 48$; CRT_Fb, $n = 90$; and BNT_Fb, $n = 36$; Sample B: CRT, $n = 56$; BNT, $n = 55$; CRT_Fb, $n = 57$; and BNT_Fb, $n = 54$ (Fb = feedback groups). Demographics for each of the experimental conditions are provided in Supplementary Materials.

Before starting the experiment, participants completed a practice trial to become familiarized with its structure. The practice trial consisted of one item (either from the CRT or the BNT, depending on the experimental condition), followed by a detailed explanation of the steps required to solve the problem and arrive at the correct answer. This aimed to demonstrate to participants in the feedback conditions that they were not

being "tricked", and that there was indeed an error in their answers[4]. Only participants in feedback conditions received feedback if they answered the practice question incorrectly.

After the practice trial, participants were presented either with the three CRT (original or new, for Sample A and B, respectively) or BNT items. In the feedback conditions, participants received feedback if they responded incorrectly, and were given the chance to respond again; this occurred just once for each wrong answer. If despite the feedback they responded incorrectly a second time, the program proceeded to the next question without further comments on their performance (see Figure 1, for a flow chart of the experimental procedure). After completing the three items, participants responded to the three moral dilemmas in a randomized order. Finally, participants were asked if they had prior knowledge of any of the CRT or BNT items. Upon completion of the experiment, participants were offered a debriefing session.

[Figure 1 near here]

3: Results

3.1: Manipulation check: feedback effect on CRT/BNT performance

As described in the Procedure section, feedback was only provided to participants in the feedback conditions who did not reach a perfect performance in the CRT/BNT task (3 correct responses). These participants entered the present analysis to test whether feedback was effective at improving CRT/BNT performance. After removal of the

[4] In a pilot study we asked participants to comment on any aspect of the experiment they found relevant. Several participants signalled that they knew very well that the feedback was just a "trick" manipulation, and that they were quite confident that their responses were correct. This is congruent with Frederick's (2005) observation that participants with lower CRT scores generally evaluated the problems as easier than those with higher scores.

individuals who did not receive any feedback the analysis sample consisted of 208 participants. This included 121 participants from Sample A (85 female, age M = 19.17, SD = 2.55, range 17 - 36) and 87 from Sample B (53 female, age M = 29.17, SD = 10.01, range 18 – 68).

Figure 2 displays the distribution of observations across performance levels (0, 1, 2, or 3 correct responses) before and after the feedback manipulation. Given that people who showed a perfect performance before feedback were excluded from the analysis, there were no observations in level 3 prior to feedback delivery. Results are shown separately for sample A (upper panel) and sample B (bottom panel), and for the CRT and the BNT tasks.

These data were analyzed following a Time (pre/post feedback) x Sample (A, B) x Task (CRT, BNT) design. As shown in Figure 2, a consistent distribution displacement to the right –performance improvement– occurred after providing feedback. This was confirmed by a Generalized Linear Mixed-effects model (i.e. Cumulative Link Mixed Model fitted with the Laplace approximation, using the *clmm* function from the *ordinal* R package; Christensen, 2018). Ordinal modeling was used in view of the fact that CRT/BNT performance is not a continuous measure (it ranges from 0 to 3, representing the number of correct responses), and should not be treated as such (Liddell & Kruschke, 2018). A logit link and flexible thresholds were used for analyses. Task (CRT, BNT), Sample (A, B), Time (pre-feedback, post-feedback), and their first- and second-order interactions entered the model as fixed factors, whereas participant was considered a random-effects factor.

[Figure 2 near here]

The analysis yielded a significant Time (pre-post feedback) effect (B = 1.612, SE = 0.548, z = 2.944, p = .003, OR = 5.01). Additionally, there was a Task effect (B = -

3.745, SE = 0.934, z = -4.009, p < .001, *OR* = 0.02), with the CRT eliciting on average fewer correct responses than the BNT; and a Task x Sample interaction (B = 3.188, SE = 1.276, z = 2.499, p = .012, *OR* = 24.23), indicating that the difference between tasks was larger for Sample A than for Sample B participants (or, in other words, Sample B performed the CRT better than Sample A, a difference that was not evident for BNT). Marginal/conditional R^2 values for the model were 0.27/0.84.

3.2: Matching check: baseline BNT/CRT performance differences across groups

A supplementary analysis was run to check whether the two Feedback conditions (feedback/no feedback) differed in baseline CRT/BNT performance, i.e. whether CRT/BNT performance differed between the no-feedback group and the feedback group before feedback was delivered. After removal of the individuals who did the task perfectly (n = 9 in Sample A and n = 37 in Sample B), the analysis sample consisted of 406 participants in total. This included 221 participants from Sample A (148 female, age *M* = 19.70, *SD* = 2.77, range 17 - 36) and 185 from Sample B (121 female, age *M* = 27.60, *SD* = 10.40, range 18 – 68).

With regard to modeling, the analysis paralleled the one described in the previous section, except for the fact that there was no within-subject manipulation and thus no random intercept for participant either. (All predictors were fixed-effects factors, and the *clm* function instead of *clmm* was used for fitting). Task (CRT, BNT), Sample (A, B), and Feedback (feedback, no feedback), and their first- and second-order interactions entered the model as fixed factors. Most importantly, the effect of Feedback condition on baseline CRT/BNT performance (henceforth, *Baseline*) did not reach significance (B = - 0.307, SE = 0.413, z = - 0.742, p = .458, *OR* = 0.74). Interactions involving feedback also remained far from significance (min. p = .351). Paralleling the

previous analysis, the number of correct responses at baseline was smaller for CRT than for BNT (B = - 1.654, SE = 0.384, z = - 4.306, p < .001, OR = 0.19), and task interacted with sample, again in such a way that Sample B outperformed Sample A in the CRT, but not in the BNT (B = 1.387, SE = 0.558, z = 2.486, p = .013, , OR = 4.00, for the interaction). Nagelkerke's R^2 for the model was 0.15.

3.3: Main analysis: Effects of baseline CRT/BNT performance and feedback on responses to moral dilemmas

Main analyses were aimed at testing whether receiving feedback for CRT/BNT performance (vs. performing the BNT/CRT task just once) had any effect on participants' responses to moral dilemmas. Again, only participants who did not perform the task perfectly in the first place were included in these analyses. The sample was thus the same as in the previous section.

Figure 3 displays the distribution of frequencies across utilitarianism scores (collapsed across dilemmas), for the two samples, the two tasks, and the two feedback conditions. Analyses obeyed to a Sample (A, B) x Feedback (feedback, no feedback) x Task (CRT, BNT) design, with responses to dilemmas as the dependent variable. Generalized Linear Mixed-effects (Ordinal) models were fitted to responses to the three dilemmas. In order to use the three dilemmas as different items for the same construct (stronger/weaker utilitarianism), Dilemma (Crying baby, Submarine, and Rescue 911) was treated as a random-effects factor, along with Participant. Sample (A, B), Feedback (feedback, no feedback), Task (CRT, BNT), and all possible interactions entered the initial (saturated) model as fixed-effects factors. The score in each dilemma (considered as an ordinal measure) was the output variable.

Given the large number of possible interactions, a backward hierarchical procedure was firstly followed to exclude the interactions that did not contribute to model fit. The removal of the three-way interaction (Sample x Task x Feedback) from the initial (saturated) model improved model fit by a difference in the Akaike Information Criterion (ΔAIC) of - 1.539. Removals of the Feedback x Sample interaction did not hamper model fit either (ΔAIC = - 0.902). However, removal of the Task x Sample (ΔAIC = 3.245) and the Task x Feedback (ΔAIC = 3.615) interactions did reduce model fit, and were kept in the final (best-fitting) model. Given that all main factors are involved in the interactions preserved in the final model, none of them can be further removed. The final model thus consisted of Task, Sample, Feedback, Task x Sample, and Task x Feedback in the fixed part.

[Figure 3 near here]

This model yielded significant effects of Task (B = -1.081, SE = 0.334, z = -3.238, p = .001), Feedback (B = - 0.680, SE = 0.290, z = -2.342, p = .019, OR = 0.51), Task x Feedback (B = 0.877, SE = 0.393, z = 2.230, p = .026, OR = 2.40), and Task x Sample (B = 0.882, SE = 0.398, z = 2.215, p = .027, OR = 2.42). The signs of effect estimates reveal slightly more utilitarian responses, in general, after receiving the CRT, but this effect was mostly attributable to Sample B (who actually did the CRT better than Sample A to begin with). Most importantly, however, participants become more utilitarian after receiving feedback (vs. not receiving it), but this effect was mostly restricted to participants who received feedback for the BNT (Figure 3, left panels). As shown in the right panels of Figure 3, feedback for the CRT was virtually ineffective to further increase utilitarianism. Marginal/conditional R^2 values for the model were 0.04/0.59.

Finally, a supplementary analysis was run to test the well-known relationship between performance in reasoning tasks and utilitarianism. This analysis was performed only in individuals who did not receive feedback for their BNT/CRT performance. Contrasting with previous analyses, participants who performed perfectly at baseline were not removed (so for the present analysis, $n = 215$). Baseline CRT and BNT scores were separately standardized before entering the model. Responses in the three dilemmas were regressed over initial BNT/CRT performance, task type (BNT/CRT), and sample (A/B). As in previous analyses, dilemma and participant were considered random-effects factors. Additionally, prior to analysis, BNT and CRT performance were separately standardized to remove scalar differences between them. Utilitarianism scores were higher for sample B individuals (B = 0.845, SE = 0.276, $z = 3.069$, $p = .002$, $OR = 2.33$), and also (and independently) for people with higher initial BNT/CRT scores (B = 0.651, SE = 0.146, $z = 4.472$, $p < .001$, $OR = 1.92$). Utilitarianism scores were not significantly affected by the type of reasoning task used ($p = .304$). Marginal/conditional R^2 values for the model were 0.08/0.61.

4: Discussion

4.1: General Discussion

The main aim of this work was to shed light on the role of cognitive reflection vs. deliberation on moral decision making. Participants responded to moral dilemmas after completing a task that requires both inhibiting intuitive responses and deliberation (Cognitive Reflection Test, CRT), or a task that recruits deliberative processing, but does not require inhibiting intuitive responses (the Berlin Numeracy Test; BNT). We reasoned that if intuition inhibition (and not just deliberative thinking) increases utilitarian responses, then such responses should be more common among individuals

who respond to the CRT compared to the BNT. Additionally, to distinguish between the potential effect of natural reflective traits or thinking dispositions (Baron et al., 2015) and that of induced reflection (Paxton et al., 2012), we manipulated whether participants received feedback on their performance in the CRT or the BNT. Feedback was designed to encourage even those participants who are not naturally reflective to reconsider their responses. We reasoned that, if the inhibition of prepotent intuitive responses drives utilitarian responses to moral dilemmas, then feedback linked to CRT items should lead to more utilitarian responses. In contrast, any effect of BNT on responses to moral dilemmas should not be affected by feedback.

Our data, however, did not fully support these predictions. Although feedback resulted in more utilitarian responses to moral dilemmas, this effect was mostly attributable to feedback on the BNT. The effect was not attributable to differences in baseline task performance. Additionally, both CRT and BNT scores predicted utilitarian responses when feedback was not provided. That performance in the CRT predicts utilitarian decisions is in agreement with a previous study linking cognitive reflection to utilitarian choice (Paxton et al., 2012; but see Sirota, Kostovicova, Juanchich, & Dewberry, pre-print, for the absence of effect when using a verbal CRT without numeric component). Our results also show that performance in a numeracy task which has been reported to predict better performance across diverse tasks—such as distinguishing between profound statements and pseudo-profound bullshit (Erlandsson, Nilsson, Tinghög, & Västfjäll, 2018), superior judgment and decision making (Cokely et al., 2012), and meta-cognitive performance (Ghazal et al., 2014)—also predicts utilitarian responding. These results are in agreement with recent evidence that inducing analytical thinking outside the numeric domain, directly by instructing participants to use this thinking mode (Li et al., 2018) or indirectly by inducing processing disfluency

(Spears et al., 2018), leads to more utilitarian decisions. More generally, our results are consistent with the notion that deliberative reasoning predicts utilitarian decisions, and provide support for the deliberative-utilitarian link (vs. a reflective-utilitarian link). Specifically, our data suggest that an increase in utilitarian responses may be induced by performing a numeric task that triggers deliberative thinking. However, generalizing our results to any cognitive (i.e., non-numeric) task may be premature.

Concerning the effect of feedback, participants in feedback conditions likely engaged in 'deeper deliberation' to reach an accurate response (Ghazal et al., 2014), leading to more utilitarian moral decisions. The fact that feedback mostly affected responses to moral dilemmas when it was linked to the BNT (and not to the CRT) casts more doubts upon the reflective-utilitarian link. However, we cannot rule out the possibility that responses to moral dilemmas were affected to some extent by the numerical nature of both tasks (see Sirota et al. 2018). The requirement to complete either task before responding to dilemmas could potentially make the numeric aspects in dilemmas more salient, thus increasing utilitarian decisions (Bialek & Terbeck, 2016; Bialek, & De Neys, 2017). Feedback may further increase attention to the numerical nature of the tasks. This account, however, would not explain why the effect of feedback on responses to moral dilemmas was larger in the case of BNT, even though feedback improved performance for both tasks. That feedback did not increase utilitarian responses among participants who completed the CRT could be related to the effects of the lures on this task. In order to respond correctly to CRT items, participants are first drawn to the intuitive response (induced by the lures) before reflecting, and correcting the error. We may speculate that such lures strongly attract people's attention to intuitive incorrect answers, thus limiting the process of deliberation and, consequently, its impact on moral judgments.

It is also worth considering other criticisms of the deliberative-utilitarian connection which are more philosophical and directed toward the interpretation of the dilemmas themselves. Although we have concluded that correct answers on the CRT and BNT tasks predict utilitarian decisions, some might argue that these tasks only predict a particular, consequentialist aspect of utilitarianism. Specifically, Kahane et al., (2018) have argued that utilitarianism advocates both doing the least harm but also bringing about the greater good including altruistic acts – an aspect we cannot measure using the specific (sacrificial) dilemmas we chose. As noted in the Introduction, the utilitarian response might be chosen, for instance, by a participant exhibiting the callous affect psychopathic personality trait. However, Conway, Goldstein-Greenwood, Polacek, and Greene (2018) found that people who make more utilitarian decisions on sacrificial moral dilemmas also reported being more utilitarian in other aspects of utilitarianism, such as giving more money to charity and being more pro-social. Another study also found that participants who score higher on the BNT and CRT reported giving more to charity and/or volunteering in the past year (Erlandson et al., 2018). In summary, people who are more deliberative may be more utilitarian not only in the instrumental harm aspects, but also in the altruistic aspects of utilitarianism.

4.2: Limitations

One limitation of our work is that we did not measure participants' mood, which may affect responses to moral dilemmas. It is possible that the happiness resulting from the knowledge that a question was answered correctly (for example, by not receiving negative feedback) increased utilitarian responses to moral dilemmas to some extent (Gawronski, Conway, Armstrong, Fiesdorf, & Hütter, 2018; Valdesolo, & DeSteno, 2006). It is also possible that the difficulty of the tasks and/or the negative feedback

gave rise to negative mood, possibly affecting participants' responses to moral dilemmas to some extent (Pastötter, Gleixner, Neuhauser, & Bäuml, 2013).

Another limitation of our work is that it focused on sacrificial dilemmas, which are often considered to be unrealistic (e.g., Bauman, McGraw, Bartels, & Warren, 2014) or ill-suited to capture different dimensions of utilitarianism (Kahane, et al, 2018). Yet, some of these dilemmas resemble real life situations. For instance, programming an autonomous or driver-less car involves decisions concerning whether to save a set of pedestrians crossing the street or the passenger of the car, in the event of an unavoidable accident (Bonnefon, Shariff, & Rahwan, 2016; Powell, Cheng, & Waldmann, 2016). Future research could examine whether the pattern of results documented here generalizes to a more diverse set of ecological dilemmas.

Finally, future research could also examine whether moral judgments and decisions are affected by feedback provided in connection to other numerical tasks without lures or even to lexical tasks, such as a syllogistic one (Baron et al., 2015). This could contribute to determine to what extent deliberation per se vs. performing tasks involving a numeric aspect associates with utilitarian decisions. This could also help to understand to what extent moral judgments and decisions are affected by performance feedback for different tasks.

4.3 Conclusions

The current findings suggest that individual differences on both CRT and BNT performance predict utilitarian responses to moral dilemmas. While feedback enhanced performance in both tasks, it only increased utilitarian responses in connection to the BNT. These results suggest that performance in a numeric task requiring deliberative thinking (CRT or BNT) may predict utilitarian responses to moral dilemmas, and that

the inhibition of intuitive wrong responses (reflection) may not always be necessary to induce utilitarian decisions.

Acknowledgements:

This work was supported by the Ministerio de Economía y Competitividad, FEDER fund under Grant PSI2015-64345-R, and internal funding from the University of Leeds.

References

Baron, J., Scott, S., Fincher, K., & Metz, E. S. (2015). Why does the cognitive reflection test (sometimes) predict utilitarian moral judgment (and other things)? *Journal of Applied Research in Memory and Cognition*, *4*, 265–284.

Bartels, D. M., & Pizarro, D. A. (2011). The mismeasure of morals: Antisocial personality traits predict utilitarian responses to moral dilemmas. *Cognition*, *121*, 154–161.

Bauman, C. W., Mcgraw, A. P., Bartels, D. M., & Warren, C. (2014). Revisiting external validity: Concerns about trolley problems and other sacrificial dilemmas in moral psychology. *Social and Personality Psychology Compass*, *8*, 536–554.

Bialek, M., & De Neys, W. (2017). Dual process and moral conflict: evidence for deontological reasoners' intuitive utilitarian sensitivity. *Judgment and Decision Making, 12,* 148 – 167.

Bialek, M., & Terbeck, S. (2016). Can cognitive psychological research on reasoning enhance the discussion around moral judgments? *Cognitive Processing, 17,* 329 – 335.

Bonnefon, J. F., Shariff, A., & Rahwan, I. (2016). The social dilemma of autonomous vehicles. Science, 352(6293), 1573–1576.

Christensen R. H. B. (2018). "ordinal—Regression models for ordinal data." R package version 2018.8-25, URL http://www.cran.r-project.org/package=ordinal/.

Cokely, E. T., Galesic, M., Schulz, E., Ghazal, S., & Garcia-Retamero, R. (2012). Measuring risk literacy: The Berlin Numeracy Test. *Judgment and Decision*

Making, *7*, 25–47.

Cokely, E. T., & Kelley, C. M. (2009). Cognitive abilities and superior decision making under risk: A protocol analysis and process model evaluation. *Judgment and Decision Making*, *4*, 20–33.

Conway, P., Goldstein-Greenwood, J., Polacek, D., & Greene, J.D. (2018). Sacrificial utilitarian judgments do reflect concern for the greater good: Clarification via process dissociation and the judgments of philosophers. *Cognition, 179*, 241 – 265.

Duke, A. A., & Bègue, L. (2015). The drunk utilitarian: Blood alcohol concentration predicts utilitarian responses in moral dilemmas. Cognition, 134, 121-127.

Erlandsson A, Nilsson A, Tinghög, G., Västfjäll, D. (2018). Bullshit-sensitivity predicts prosocial behavior. PLoS ONE 13(7): e0201474.

Foot, P. (1978). The Doctrine of Double Effect. *A Companion to the Philosophy of Action*, (5), 324–330.

Frederick, S. (2005). Cognitive reflection and decision making. *Journal of Economic Perspectives*, *19*, 25–42.

Gawronski, B., Conway, P., Armstrong, J., Friesdorf, R., & Hütter, M. (2018). Effects of incidental emotions on moral dilemma judgments: An analysis using the CNI model. *Emotion, 18,* 989-1008.

Ghazal, S., Cokely, E. T., & Garcia-Retamero, R. (2014). Predicting biases in very highly educated samples: Numeracy and metacognition. *Judgment and Decision Making*, *9*, 15–34.

Greene, J. D., Morelli, S. A., Lowenberg, K., Nystrom, L. E., & Cohen, J. D. (2008). Cognitive load selectively interferes with utilitarian moral judgment. *Cognition*, *107*, 1144–1154.

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

Greene, J. D., Sommerville, R. B., Nystrom, L. E., Darley, J. M., & Cohen, J. D. (2001). An fMRI investigation of emotional engagement in moral judgment. *Science*, *293*(5537), 2105–2108.

Kahane, G., C Everett, J. A. C., Earp, B. D., Caviola, L., Faber, N. S., Crockett, M. J., & Savulescu, J. (2018). Beyond sacrificial harm: A two-dimensional model of utilitarian psychology. *Psychological Review*, *125*, 131-164.

Kahane, G., Everett, J. A. C., Earp, B. D., Farias, M., & Savulescu, J. (2015). "Utilitarian" judgments in sacrificial moral dilemmas do not reflect impartial concern for the greater good. *Cognition*, *134*, 193–209.

Kahane, G., Wiech, K., Shackel, N., Farias, M., Savulescu, J., & Tracey, I. (2012). The neural basis of intuitive and counterintuitive moral judgment. *Social Cognitive and Affective Neuroscience, 7,* 393 – 402.

Li, Z., Xia, S., Wu, X, & Chen, Z. (2018). Analytical thinking style leads to more utilitarian moral judgments: An exploration with a process-dissociation approach. *Personality and Individual Differences, 131*, 180 – 184.

Liddell, T. M., & Kruschke, J. K. (2018). Analyzing ordinal data with metric models: What could possibly go wrong? *Journal of Experimental Social Psychology*, *79*, 328-348.

Meyer, A., Spunt, B., & Frederick, S. (2015). The bat and ball problem. Unpublished manuscript.

Moore, A. B., Clark, B. A., & Kane, M. J. (2008). Who shalt not kill? Individual differences in working memory capacity, executive control, and moral judgment. *Psychological Science*, *19*, 549–557.

Pastötter, B., Gleixner, S., Neuhauser, T., & Bäuml, K. H. T. (2013). To push or not to push? Affective influences on moral judgment depend on decision frame. *Cognition*, *126*, 373–377.

Patil, I. (2015). Trait psychopathy and utilitarian moral judgement: The mediating role of action aversion. *Journal of Cognitive Psychology*, *27*, 349-366.

Paxton, J. M., Bruni, T., & Greene, J. D. (2013). Are "counter-intuitive" deontological judgments really counter-intuitive? An empirical reply to Kahane et al. (2012). *Social Cognitive and Affective Neuroscience*, *9*, 1368–1371.

Paxton, J. M., Ungar, L., & Greene, J. D. (2012). Reflection and reasoning in moral judgment. *Cognitive Science*, *36*(1), 163–177.

Powell, D., Cheng, P., & Waldmann, M. R. (2016). How should autonomous vehicles behave in moral dilemmas? Human judgments reflect abstract moral principles. *Proceedings of the 38th Annual Conference of the Cognitive Science Society.* Austin, TX: Cognitive Science Society.

Primi, C., Morsanyi, K., Chiesi, F., Donati, M. A., & Hamilton, J. (2016). The Development and Testing of a New Version of the Cognitive Reflection Test Applying Item Response Theory (IRT). *Journal of Behavioral Decision Making*, *29*(5), 453–469.

Royzman, E. B., Landy, J. F., & Leeman, R. F. (2015). Are thoughtful people more utilitarian? CRT as a unique predictor of moral minimalism in the dilemmatic context. *Cognitive Science*, *39*(2), 325–352.

Sirota, M., Kostovicova, L., Juanchich, M., & Dewberry, C. (2018). Measuring Cognitive Reflection without Maths: Developing and Validating the Verbal Cognitive Reflection Test, (December). https://www.researchgate.net/publication/329463465_Measuring_cognitive_reflection_without_maths_Developing_and_validating_the_Verbal_Cognitive_Reflection_Test

Spears, D., Fernández-Linsenbarth, I., Okan, Y., Ruz, M., & González, F. (2018). Disfluent fonts lead to more utilitarian decisions in moral dilemmas. *Psicológica, 39*, 41–63.

Spears, D., Okan, Y., Cándido, A., & González, F. (2014). Cognitive Reflection and Callous Affect: Two independent factors related to utilitarian decisions on moral dilemmas. En A. Acosta, J. L. Megías and J. Lupiáñez (Eds.), Avances en el estudio de la motivación y la motivación, pp. 128-134. Madrid: AME.

Timmons, S., & Byrne, R. M. (2018). Moral fatigue: the effects of cognitive fatigue on moral reasoning. *Quarterly Journal of Experimental Psychology, 72,* 943-954.

Toplak, M. E., West, R. F., & Stanovich, K. E. (2011). The Cognitive Reflection Test as a predictor of performance on heuristics-and-biases tasks. *Memory and Cognition,*

39, 1275 - 1289.

Trémolière. B., De Neys, W., & Bonnefon, J.F. (2012). Mortality salience and morality: Thinking about death makes people less utilitarian. *Cognition, 124,* 379 – 384.

Trémolière, B., De Neys, W., & Bonnefon, J. F. (2017). Reasoning and moral judgment: A common experimental toolbox. In L. J. Ball & V. A. Thompson (Eds.), International handbook of thinking and reasoning, pp 575-589. Hove, UK: Psychology Press.

Toplak, M. E., West, R. F., & Stanovich, K. E. (2014). Assessing miserly information processing: An expansion of the Cognitive Reflection Test. *Thinking and Reasoning*, *20*, 147–168.

Turner, M., & Engle, R. (1989). Is working memory capacity task dependent? *Journal of Memory and Language, 28,* 127 – 154.

Valdesolo, P., & DeSteno, D. (2006). Manipulations of emotional context shape moral judgment. *Psychological Science*, *17*(6), 476–477.

Figure captions

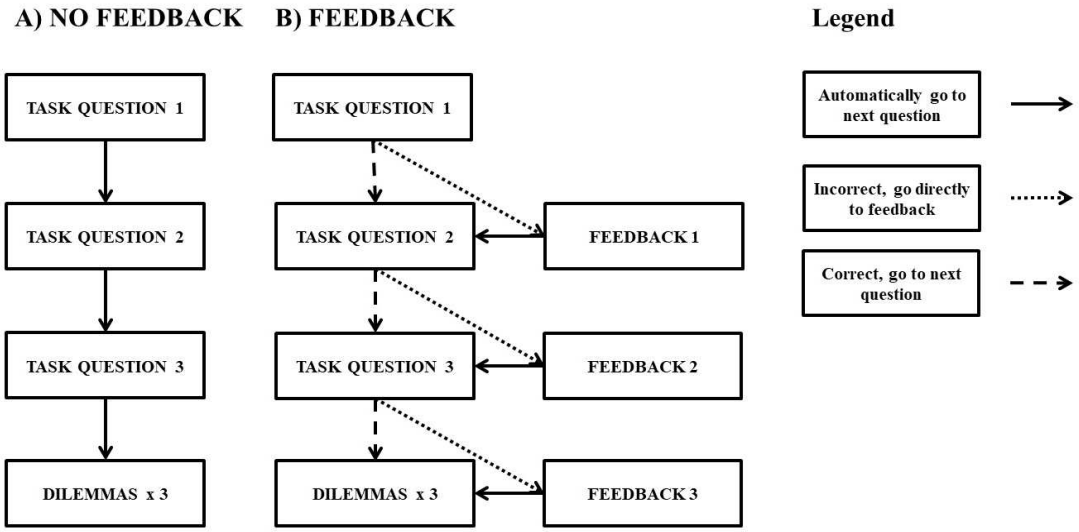

Figure 1. Flow chart of the experimental procedure. Participants were allocated to one of the four experimental conditions: CRT, CRT with feedback (CRT_Fb), BNT, or BNT with feedback (BNT_Fb). After responding to each question, participants in conditions without feedback were presented directly with the next question independently of whether their answer was correct. In conditions involving feedback, participants viewed the same question again only if they answered it incorrectly, along with feedback to help them reflect on their answer. Feedback was only given once for each question. After the three task questions, participants read and responded to three moral dilemmas, which were presented in a randomized order.

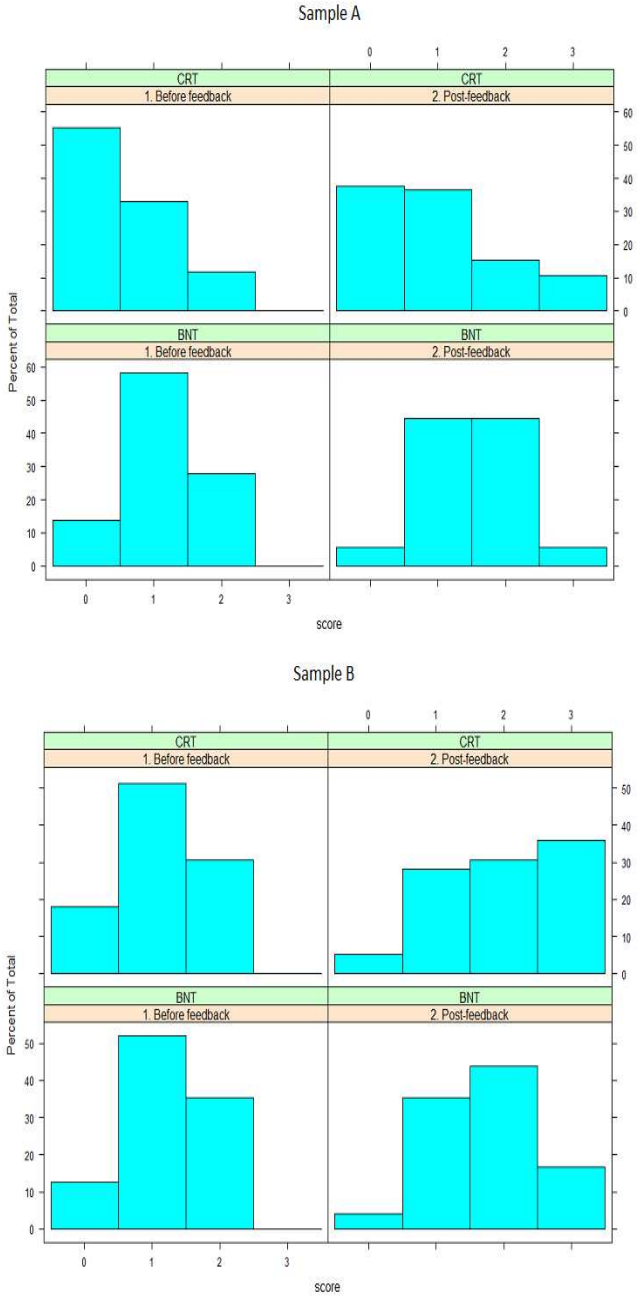

Figure 2. Distribution of observations across CRT/BNT performance levels for Sample A and Sample B.

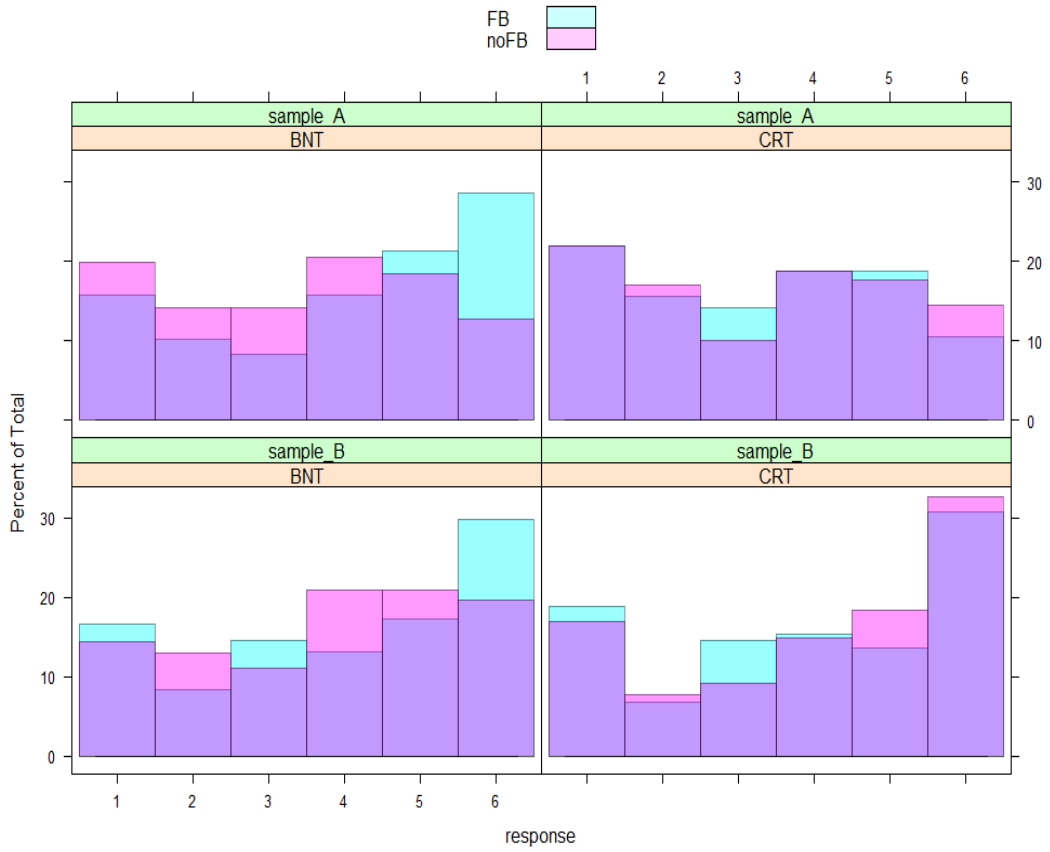

Figure 3. Distribution of observations across utilitarianism scores (accumulated across dilemmas) for the two Tasks (BNT/CRT), Samples (A/B) and Feedback conditions (FB/noFB). Note. Purple areas correspond to the overlapping between FB (blue) and noFB (pink) conditions.

Materials (English)

Spears, Okan, Hinojosa-Aguayo, Perales, Ruz, & González: Can induced reflection affect moral decision-making?

Tasks and feedback

CRT Practice:

If John can drink one barrel of water in 6 days, and Mary can drink one barrel of water in 12 days, how long would it take them to drink one barrel of water together? ____ [Correct answer = 4 days; intuitive answer = 9].

Feedback:

I'm sorry, your response is not correct. Maybe it would be easier if you imagine that the barrel has a certain capacity. For example, how much would Juan and Mary drink individually each day if the barrel has 12 liters?

Practice Explanation (for both feedback and no feedback):

Many people think that the answer is 9, but, if you look at the question, John would finish the barrel in three days earlier by himself. Therefore, the answer has to be less than 6 days. Further, if you imagine that it's a 12-liter barrel, this means that John has to drink 2 liters of water each day to finish it in 6 days, and Mary needs to drink a liter everyday to finish in 12 days. Therefore, together, they drink 3 liters each day and finish in 4 days.

Day 1: 3 liters drunk, John = 2 liters, Mary = 1 liter

Day 2: 6 liters drunk, John = 2 liters, Mary = 1 liter

Day 3: 9 liters drunk, John = 2 liters, Mary = 1 liter

CRT questions

CRT 1:

A bat and a ball costs 1.10 € total. The bat costs one euro more than the ball. How much does the ball cost?

Please, enter the answer and mark it down on your piece of paper too. Use whole numbers, no decimals.

____ cents

[Correct answer = .05 or 5; intuitive answer = .10 or 10]

Feedback:

I'm sorry, your response was not correct. Did you check how much the ball and bat cost together according to the answer you have given?

[Repeat question]

Please, modify your answer now. Remember to use whole numbers, without decimals.

CRT 2:

If it takes 5 machines 5 minutes to make 5 objects, how long would it take 100 machines to make 100 widgets?

Please, enter the answer and mark it down on your piece of paper too.

____ minutes [Correct answer = 5; intuitive answer = 100]

Feedback:

I'm sorry, your response is not correct. Have you considered that each machine makes one complete object in your calculations and how much time it takes a machine to make 1 object?

[Repeat question]

Please, modify your response now.

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?

Please, enter the answer and mark it down on your piece of paper too.

____days [Correct answer = 47; intuitive answer = 24]

Feedback:

I'm sorry your answer is incorrect. Have you considered the proportion of lily pads that there are in the lake on any day in respect to the day before?

[Repeat question]

Please, modify your response now.

CRT New

CRT New 1:

If three elves can wrap three toys in an hour, how many elves are needed to wrap six toys in 2 hours?

Please, enter the answer and mark it down on your piece of paper too.

____ elves [Correct answer = 3; intuitive answer = 6]

Feedback:

I'm sorry, your answer is incorrect. Have you considered how much time it takes an Elf to wrap a toy in your calculations?

[Repeat question]

Please, modify your response now.

CRT New 2:

Jerry received both the 15th highest and the 15th lowest mark in the class. How many students are there in the class?

___ students [Correct answer = 29; intuitive answer = 30]

Please, enter the answer and mark it down on your piece of paper too.

Feedback:

I'm sorry. Your answer is incorrect. Have you considered imagining how many students remain below and above Jerry so that Jerry is always the fifteenth place regardless if you start counting from below or from above.

[Repeat question]

Please, modify your response now.

CRT New 3:

In an athletics team, tall members are three times more likely to win a medal than short members. This year the team has won 60 medals so far. How many of these have been won by short athletes?

Please, enter the answer and mark it down on your piece of paper too.

___ medals [Correct answer = 15; intuitive answer = 20]

Feedback:

I'm sorry, your answer is incorrect. Have you checked that if you multiplied your response by three, then added your answer to the result equals sixty?

[Repeat question]

Please, modify your response now.

BNT Practice:

Imagine we are throwing a loaded die (6 sides). The probability that the die shows a 6 is twice as high as the probability of each of the other numbers. On average, out of these 70 throws how many times would the die show the number 6?

Please, enter the answer and mark it down on your piece of paper too.

_____out of 70 throws [Correct answer = 20]

Feedback:

I'm sorry, your response is not correct. Have you thought about how many sides there are in total and how many you have to take account of according to the question?

[Repeat question]

Please, modify your response now.

Practice Explanation (for both feedback and no feedback):

To resolve the problem we have to first consider that a 6 sided die that one side has double the probability to land more than the others is really more like a die with seven

sides. This is because if we roll the die an infinite amount of times, 6 will be rolled two times more than any other side. It is as though the 6 occupies two places at once; as though it would have been an extra number. If this is true, the probability of each number, except for 6, would be 1/7, while the number 6 would be 2/7. Therefore, if we roll a die 70 times, each number should be rolled 10 times, except 6 which would be 20. Numbers 1 to 5: 70 * 1/7 = 10 times each (in total, these numbers would be rolled 50 times) Number 6: 70 * 2/7 = 20 times

BNT questions:

BNT 1:

Imagine we are throwing a five-sided die 50 times. On average, out of these 50 throws how many times would this five-sided die show an odd number (1, 3 or 5)?

Please, enter the answer and mark it down on your piece of paper too.

_____out of 50 throws [Correct answer = 30]

Feedback:

I'm sorry your answer is incorrect. Did you consider how many faces the die has in total and how many you have to take into account according to the question?

[Repeat question]

Please modify your answer

BNT 2:

Out of 1,000 people in a small town 500 are members of a choir. Out of these 500 members in the choir 100 are men. Out of the 500 inhabitants that are not in the choir 300 are men. What is the probability that a randomly drawn man is a member of the choir?

Please, enter the answer and mark it down on your piece of paper too.

Please indicate the probability in percent _____ % [Correct answer = 25]

Feedback:

I'm sorry your answer is incorrect. Have you considered how many men there are in the village and how many of them are in the chorus?

[Repeat question]

Please, modify your answer.

BNT 3:

In a forest 20% of mushrooms are red, 50% brown and 30% white. A red mushroom is poisonous with probability of 20%. A mushroom that is not red is poisonous with a probability of 5%. What is the probability that a poisonous mushroom in the forest is red?

Please, enter the answer and mark it down on your piece of paper too.

_____% [Correct answer = 50]

Feedback:

I'm sorry, your answer is incorrect. Have you considered the proportion of red poisonous mushrooms over the total number of poisonous mushrooms supposing that there are 1000 mushrooms in the forest?

[Repeat question]

Please, modify your answer.

Moral Dilemmas

Walnuts (Practice):

A girl decided to make a chocolate cake. She looks in a recipe book and finds one that calls for a cup of walnuts. She does not like walnuts, but she does like almonds. Unfortunately, she has the right amount of walnuts and almonds; therefore she can make the cake with either nut.

Do you think that the girl should substitute the walnuts for almonds in order to avoid eating walnuts?

Definitely No Definitely Yes

1 2 3 4 5 6

Crying Baby:

Enemy soldiers have taken over your village. They have orders to kill all they encounter. You and some of your townspeople have sought refuge in the basement of a large house. Outside you hear the voices of soldiers who have come to search the house for valuables. Your baby, who is with you, begins to cry loudly. You put your hand over his mouth to block the sound of its cries. If you uncover the baby's mouth, its cries will call attention to the soldiers, who will kill everyone they find in the basement, including you and your baby. In order to save yourself and the others you must keep your hand on his mouth and smother your baby to death.

Do you think you should smother your child in order to save yourself and the other hidden townspeople?

Definitely No Definitely Yes

1 2 3 4 5 6

Submarine:

You are a crewperson on a marine research submarine traveling underneath a large iceberg. An on board explosion has damaged the ship, and it's losing the majority of its oxygen. One of the sailors is injured is quickly losing blood. The injured sailor will die from his injuries regardless of what happens. The remaining oxygen is not sufficient for the whole team to make it to the surface. The only way to save the rest of the crew is to shoot the injured sailor in order for there to be enough oxygen for the rest of the crew to survive.

Do you think you should shoot the sailor to save yourself and the rest of the crew?

Definitely No Definitely Yes

1 2 3 4 5 6

Rescue 911:

You are the sole paramedic riding on a rescue helicopter, responding to a devastating flood. You have rescued several critically injured people and you have been treating them to keep them alive. Suddenly, the pilot notifies you that there has been an engine malfunction and the helicopter can no longer support the weight of you, the pilot, and all the injured people on board. If the helicopter crashes, it will kill everyone on board including you, the pilot, and the injured people that have rescued. In order to avoid a crash that will kill everyone on the helicopter, you realize that you must lighten the load enough to keep the helicopter aloft. Because all f the equipment is bolted down, and the injured people need you, the only way to do this is to throw one of the injured people off the helicopter. This will lighten the load enough to keep the helicopter in the air but will cause the death of the person thrown off.

Do you think you should throw one of the injured people from the helicopter in order to save yourself and everyone else on board?

Definitely No Definitely Yes

1 2 3 4 5 6

Previous knowledge question

Thank you for your participation! It's important for the objectives of this investigation that your responses only reflect your personal judgments and estimations close to the questions that were presented to you. Thus we ask that if you have used any additional information (class notes, internet searches, consulting other people, etc…) or, for example, you had previously seen the answers to the mathematical tasks, simply mark the option 'yes'. In this case, please indicate in the commentary window, which will appear next page, what you remember in respect to those questions. On the contrary, mark the option 'no'. In either case, this response will not have any repercussions to you, but this information will help give us an idea about the validity about our data. Thank you.

Materials (Spanish)

Spears, Okan, Hinojosa-Aguayo, Perales, Ruz, & González: Can induced reflection affect moral decision-making?

Tareas y feedback

CRT Práctica:

Si Juan se puede beber un barril de agua en 6 días, y María se puede beber un barril de agua en 12 días, ¿cuánto tiempo tardarán en beber un barril de agua juntos? ____

[Respuesta correcta = 4 días; respuesta intuitiva = 9].

Feedback:

Lo siento, tu respuesta no es correcta. Quizás sea más fácil si imagines que el barril tiene una cierta capacidad. Por ejemplo,

¿Cuánto beben Juan y María individualmente cada día si un barril tiene 12 litros?

Explicación práctica (tanto para feedback como no feedback):

Mucha gente piensa que la respuesta es 9, pero si consideras la pregunta, Juan terminaría el barril tres días antes por sí mismo. Entonces, la respuesta tiene que ser menos de 6 días. Además, si imaginas que un barril tiene 12 litros, eso significaría que

Juan tiene que beber 2 litros de agua cada día para terminarlo en 6 días, y María tiene que beber un litro cada día para eliminar el barril en 12 días. Por tanto, juntos beben 3 litros cada día y terminarían el barril en 4 días.

Día 1: 3 litros bebidos, John = 2 litros, Mary = 1 litro

Día 2: 6 litros bebidos, John = 2 litros, Mary = 1 litro

Día 3: 9 litros bebidos, John = 2 litros, Mary = 1 litro

Preguntas de CRT

CRT 1:

Un bate y una pelota cuestan 1.10€ en total. El bate cuesta 1.00 € más que la pelota. ¿Cuánto cuesta la pelota?

Por favor, introduce la respuesta y anótala también en la hoja de papel. Utiliza un número entero, no decimales.

_____ céntimos

[Respuesta correcta = .05 ó 5; respuesta intuitiva = .10 ó 10]

Feedback:

Lo siento, tu respuesta no es correcta. ¿Has comprobado cuánto costarían el bate y la pelota juntos según la respuesta que has dado?

[Se repite la pregunta]

Por favor, modifica ahora tu respuesta. Recuerda utilizar números enteros, sin decimales.

CRT 2:

Si 5 máquinas tardan 5 minutos en hacer 5 objetos, ¿cuánto tardarán 100 máquinas en hacer 100 objetos?

Por favor, introduce la respuesta y anótala también en la hoja de papel.

____ minutes [Respuesta correcta = 5; respuesta intuitiva = 100]

Feedback:

Lo siento, tu respuesta no es correcta. ¿Has considerado en tu cálculo que cada máquina fabrica un objeto completo y cuánto tiempo tarda una máquina en fabricar 1 objeto?

[Se repite la pregunta]

Por favor, modifica ahora tu respuesta.

CRT 3:

En un lago hay un manto de nenúfares. Cada día el manto duplica su tamaño. Si el manto tarda 48 días en cubrir el lago, ¿cuánto tardaría en cubrir la mitad del lago?

Por favor, introduce la respuesta y anótala también en la hoja de papel.

____días [Respuesta correcta = 47; respuesta intuitiva = 24]

Feedback:

Lo siento, tur respuesta no es correcta. ¿Has considerado qué proporción de nenúfares hay en el lago un día cualquiera con respecto al día siguiente?

[Se repite la pregunta]

Por favor, modifica ahora tu respuesta.

CRT New

CRT New 1:

Si tres elfos pueden envolver tres juguetes en una hora, ¿cuántos elfos se necesitan para envolver seis juguetes en dos horas?

Por favor, introduce la respuesta y anótala también en la hoja de papel.

____elfos [Respuesta correcta = 3; respuesta intuitiva = 6]

Feedback:

Lo siento, tu respuesta no es correcta. ¿Has considerado en tu cálculo cuánto tiempo tarda un elfo en fabricar un juguete?

[Se repite la pregunta]

Por favor, modifica ahora tu respuesta.

CRT New 2:

Gerardo recibió la decimoquinta nota más alta y la decimoquinta nota más baja de la clase. ¿Cuántos estudiantes hay en la clase?

___ estudiantes [Respuesta correcta = 29; respuesta intuitiva = 30]

Por favor, introduce la respuesta y anótala también en la hoja de papel.

Feedback:

Lo siento, tu respuesta no es correcta. ¿Has considerado imaginar cuántos estudiantes quedan por encima y por debajo de Gerardo de forma que él queda siempre el decimoquinto lugar tanto si empiezas a contar desde arriba o como si lo haces desde abajo?

[Se repite la pregunta]

Por favor, modifica ahora tu respuesta.

CRT New 3:

En un equipo de atletismo los miembros de mayor altura tienen tres veces más probabilidades de ganar una medalla que los miembros de menor altura. Este año el

equipo ganó 60 medallas. ¿Cuántas de estas medallas han sido ganadas por los atletas más bajos?

Por favor, introduce la respuesta y anótala también en la hoja de papel.

____ medallas [Respuesta correcta = 15; respuesta intuitiva = 20]

Feedback:

Lo siento, tu respuesta no es correcta. ¿Has comprobado si al multiplicar tu respuesta por tres y sumarle una vez más tu respuesta el resultado es 60?

[Se repite la pregunta]

Por favor, modifica ahora tu respuesta.

Práctica BNT:

Imagina que tiramos un dado trucado de 6 caras. La probabilidad de que salga un 6 al tirar el dado es el doble que la probabilidad de que salga cada uno de los demás números. Imagina que tiras este dado 70 veces. De estas 70 tiradas, ¿en cuántas crees que saldría el número 6 en el dado?

Por favor, introduce la respuesta y anótala también en la hoja de papel.

_____de 70 tiradas [Respuesta correcta = 20]

Feedback:

Lo siento, tu respuesta no es correcta. ¿Has considerado que un dado trucado de seis caras en el que una cara tiene el doble de probabilidad de salir es como si tuviera una cara extra, eso es, siete caras?

[Se repite la pregunta]

Por favor, modifica ahora tu respuesta.

Explicación práctica (tanto para feedback como no feedback):

Para resolver el problema tenemos que considerar en primer lugar que un dado de 6 caras, en el que una tiene el doble de probabilidad de salir que las otras, se parece más a un dado de siete caras. Eso es así porque si tirásemos el dado un número indefinido de veces, el 6 saldría el doble de veces que los demás. Es como si "ocupara" el lugar de dos números, como si hubiera un número extra. Si eso es así, la probabilidad de cada número, excepto el 6, sería 1/7, mientras que la del 6 sería 2/7. Entonces, si tiramos el dado 70 veces, cada número saldría en 10 ocasiones, salvo el 6 que saldría en 20. Números 1 a 5: 70 * 1/7 = 10 veces cada uno (en total estos números habrán salido 50 veces) Número 6: 70 * 2/7 = 20 veces.

Preguntas de BNT

BNT 1:

Imagina que tiramos un dado de cinco caras 50 veces. De estas 50 tiradas, ¿cuántas veces crees que saldría un número impar (1,3, ó 5)?

Por favor, introduce la respuesta y anótala también en la hoja de papel.

____de 50 tiradas [Respuesta correcta = 30]

Feeback:

Lo siento, tu respuesta no es correcta. ¿Has pensado cuántas caras hay en total en el dado y cuántas tienes que tener en cuenta según la pregunta que se te plantea?

[Se repite la pregunta]

Por favor, modifica ahora tu respuesta.

BNT 2:

En un pequeño pueblo viven 1.000 personas. De ellas, 500 pertenecen a un coro. Entre estos 500 miembros que pertenecen al coro, 100 son hombres. Entre los 500 habitantes que no pertenecen al coro, 300 son hombres. ¿Cuál es la probabilidad de que un hombre seleccionado al azar sea miembro del coro?

Por favor indica la probabilidad en porcentaje _____% [Respuesta correcta = 25]

Por favor, introduce la respuesta y anótala también en la hoja de papel.

Feedback:

Lo siento, tu respuesta no es correcta. ¿Has considerado cuántos hombres hay en el pueblo y cuántos de ellos están en el coro?

[Se repite la pregunta]

Por favor, modifica ahora tu respuesta.

BNT 3:

En un bosque, el 20% de las setas son rojas, el 50% son marrones, y el 30% son blancas. La probabilidad de que una seta roja sea venenosa es del 20%. La probabilidad de que una seta que no sea roja sea venenosa es del 5%.

¿Cuál es la probabilidad de que una seta venenosa escogida al azar en el bosque sea roja?

Por favor, introduce la respuesta y anótala también en la hoja de papel.

_____% [Respuesta correcta = 50]

Feedback:

Lo siento, tu respuesta no es correcta. ¿Has considerado la proporción de setas rojas venenosas sobre el total de setas venenosas suponiendo que hay 1000 setas en el bosque?

[Repeat question]

Por favor, modifica ahora tu respuesta.

Dilemas morales

Nueces (Practice):

Una chica decide hacer una tarta de chocolate. Busca en el libro de recetas y encuentra una para la que necesita una taza de nueces. No le gustan las nueces y sí las almendras. Afortunadamente tiene nueces y almendras suficientes, de tal modo que podría hacer la tarta con cualquiera de las dos.

¿Crees que la chica debería substituir las nueces por almendras para evitar comer nueces?

Definitivamente No Definitivamente Sí

1 2 3 4 5 6

Crying Baby:

Soldados enemigos se han apoderado de tu pueblo. Tienen órdenes de matar a todos los civiles que encuentren. Tú y un grupo de personas del pueblo habéis encontrado refugio en el sótano de una casa grande. Afuera se escuchan las voces de los soldados que vienen a la casa en busca de objetos valiosos. Tu bebé, quien está contigo, empieza a llorar con fuerza. Le cubres la boca para amortiguar el sonido de su llanto. Si retiras la mano de su boca, su llanto llamará la atención de los soldados, quienes matarán a todos los que se encuentran en el sótano, incluyéndote a ti y a tu bebé. Para salvarte a ti y salvar a los demás tienes que asfixiar a tu hijo hasta que muera.

¿Crees que deberías asfixiar a tu hijo para salvarte a ti y salvar al resto de personas que están escondidas?

Definitivamente No					Definitivamente Sí
1	2	3	4	5	6

Submarine:

Eres el capitán de un submarino militar viajando debajo de un iceberg. Una explosión en el submarino ha hecho que el barco pierda la mayoría de su oxígeno. Uno de los marineros ha resultado herido y está perdiendo sangre rápidamente. El marinero herido morirá a causa de sus heridas pase lo que pase. El oxígeno que queda no es suficiente para que todo el equipo llegue a la superficie. La única manera de salvar al resto de la tripulación es disparar al marinero herido para que así haya el oxígeno justo para que el resto de la tripulación sobreviva.

¿Crees que deberías dispararle al marinero para salvarte a ti y al resto de la tripulación?

Definitivamente No					Definitivamente Sí
1	2	3	4	5	6

Rescue 911:

Eres el único paramédico en un helicóptero de rescate, atendiendo una inundación devastadora. Has rescatado varias personas en estado crítico y las has tratado para mantenerlas con vida. De repente, el piloto te informa de que ha habido un problema con el motor y el helicóptero ya no puede aguantar tu peso, el del piloto y el de todos

los heridos a bordo. Si e helicóptero se estrella, matará a todos los que van a bordo, incluidos tú, el piloto y los heridos. Te das cuenta de que, para evitar la colisión que mataría a todos los pasajeros, necesitas echar fuera el peso suficiente para mantener el helicóptero volando. Debido a que el equipamiento está atornillado al suelo y los heridos te necesitan, la única manera de conseguirlo es tirar a uno de los heridos fuera del helicóptero. Eso disminuirá el peso lo suficiente para mantener al helicóptero volando, pero causará la muerta de la persona que tires fuera.

¿Crees que deberías tirar uno de los heridos fuera del helicóptero para salvaros a ti y al resto de pasajeros?

Definitivamente No Definitivamente Sí

1 2 3 4 5 6

Pregunta sobre conocimiento previo

¡Gracias por tu participación! Es importante para los objetivos de esta investigación que tus respuestas reflejen solamente tus propios juicios y estimaciones acerca de las preguntas que se te presentaron. Por ello te pedimos que en el caso de que hayas utilizado información adicional (apuntes de clase, búsquedas en internet, consulta a otras personas, etc…) o por ejemplo conocieras previamente las respuestas a la tarea de matemáticas, simplemente marques la opción “sí”. En este caso por favor indica en la ventana de comentarios, que aparecerá a continuación, lo que recuerdes al respecto. En caso contrario marca la opción “no”. En ningún caso esta respuesta tendrá repercusión

alguna para ti pero a nosotros nos servirá para tener una idea más aproximada de la validez de nuestros datos. Muchas gracias.