Cognitive reflection predicts real-life decision outcomes, but not over and above personality and decision-making styles.

Marie Juanchich, Chris Dewberry, Miroslav Sirota and Sunitha Narendran

Corresponding author: Marie Juanchich: Kingston Business School, Kingston University London, Kingston Hill, KT2 7LB, UK. Email: M.Juanchich@kingston.ac.uk

Chris Dewberry: Birkbeck, University of London, Malet Street, London, WC1E 7HX, UK. Email: c.dewberry@bbk.ac.uk.

Miroslav Sirota: Department of Psychology, Kingston University, Penrhyn Road, Kingston upon Thames, Surrey KT1 2EE, United Kingdom. Email: miroslav.sirota@kingston.ac.uk.

Sunitha Narendran: Kingston Business School, Kingston University London, Kingston Hill, KT2 7LB, UK. Email: S.Narendran@kingston.ac.uk

Word count: 4804 (excluding abstract and references).

Biographical sketch:

Marie Juanchich is a Senior Lecturer in Kingston Business School. Her research focuses on judgment and decision making. She is particularly interested in risk communication and risk perception.

Chris Dewberry is a Senior Lecturer at Birkbeck, University of London where he teaches statistics and selection and assessment. He is author of Statistical Methods for Organizational Research: Theory and Practice. His research interests include judgement and decision-making, and the psychological and social processes involved in the subjective evaluation of human performance.

Miroslav Sirota is a Lecturer at Kingston University. His research interests include risk communication, statistical reasoning and medical decision making.

Sunitha Narendran is Head of the Department of Management at Kingston University. Her research interests include personality and individual differences, decision making styles and decision making competence.

Acknowledgement:

We are very grateful to anonymous reviewers for their insightful comments and advise on previous versions of this manuscript.

Abstract

The Cognitive Reflection Test (CRT), designed to assess the ability to inhibit intuition to process a problem analytically, predicts people's performance in many normative judgment and decision-making tasks (e.g., Bayesian reasoning, conjunction fallacy, ratio bias). However, how the CRT predicts normative decision-making performance is unclear, and little is known about the extent to which the CRT predicts real-life decision outcomes. We investigate the role of CRT in predicting real-life decision outcomes and examine whether the CRT predicts real-life decision outcomes after controlling for two related individual differences: the Big Five personality traits and decision-making styles. Our results show that greater CRT scores predict positive real-life decision outcomes measured by the Decision Outcome Inventory. However, the effect size was small, and the relationship became non-significant after statistically controlling for personality and decision-making styles. We discuss the limited predictive role of cognitive reflection in real-life decision-making outcomes, along with the roles of personality and decision-making styles.

Key words: cognitive reflection, decision outcome, decision-making styles, personality, individual differences.

Introduction

Three factors determine decision-making quality: the nature of the decision, the situation in which the decision is made, and the characteristics of the decision-maker (Einhorn, 1970; Hunt, Krzystofiak, Meindl, & Yousry, 1989). The influence of the characteristics of the decision-maker have primarily been investigated in relation to normative decision-making performance, and hence aimed to assess the characteristics that predict compliance with normative decision-making principles derived from logic or theoretical models (e.g. the extensionality principle in the framing task, expected utility theory in the time preference task, Bayesian theorem in the Bayesian reasoning task). Currently, one of the key predictors of normative decision-making performance is the Cognitive Reflection Test (CRT), designed to measure people's ability to inhibit a first intuitive answer to process information analytically (Frederick, 2005). This paper builds on previous research by investigating the extent to which the CRT predicts everyday real-life decision outcomes.

The role of cognitive reflection in decision making

Recent evidence (Frederick, 2005; Toplak, West, & Stanovich, 2011; Toplak, West, & Stanovich, 2014) suggests that individual differences in the ability to engage in cognitive reflection is one of the most important predictors of normative decision-making performance.

In order to define cognitive reflection, it is necessary to clarify the cognitive framework in which it is rooted: dual system theory. The dual system theory posits that when making a decision, people can follow either their intuition (fast and frugal, known as System 1) or an analytical reasoning process (slower and more cognitively taxing, System 2) Epstein, 1994; Evans, 2008; Kahneman, 2003; Sloman, 1996; Stanovich &West, 2000). For example, when choosing a house, some may rely on their gut feelings on whether one house is better than the others that they have looked at, whereas others may systematically and assiduously assess and compare a list of qualities associated with the different houses. Whilst there are many

debates about dual system theories (e.g., Krugrlansky & Gigerenzer, 2011; De Neys & Glumicic, 2008), it is widely accepted that whilst intuitive processes typically activate first, they can be interrupted or over-ridden by conscious and analytical processes which in many situations lead to more optimal decisions (e.g., De Neys, 2006; Pacini & Epstein, 1999; Tversky & Kahneman, 1974). Cognitive reflection is that mechanism which regulates this interplay between intuition and deliberation as it denotes the ability, when appropriate, to interrupt the use of intuition and switch to a more deliberative thought process (Frederick, 2005).

The Cognitive Reflection Test (CRT). The CRT is presented in the literature as a short but effective measure of the ability to inhibit a first plausible (and incorrect) intuitive answer so as to opt for the deliberative processing of information which is more likely to lead to a correct solution (Frederick, 2005; Toplak, et al., 2014). The CRT is composed of three simple questions, as follows:

> (a) A bat and a ball cost $1.10 in total. The bat costs a dollar more than the ball. How much does the ball cost? ____ cents
>
> (b) If it takes 5 machines 5 min to make 5 widgets, how long would it take 100 machines to make 100 widgets? ____ min
>
> (c) 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? ____ days

The CRT predicts normative decision-making performance. CRT performance has been found to predict success in a number of normative decision-making performance tasks, including probabilistic reasoning (e.g., disjunction, conjunction, Bayesian tasks; Lesage, Navarrete & De Neys, 2013; Liberali, Jordana, Reyna, Furlan, Stein, & Pardo, 2011; Sirota et al., 2014; Sirota, Juanchich & Hagmayer, 2014) and inter-temporal choice (Nofsinger & Varma, 2008), risky preferences and over-confidence levels (Oechssler, Roider, & Schmitz,

2009) or biases in probability judgments such as the denominators (Toplak, West & Stanovich, 2011; Toplak et al., 2014).

Furthermore, it appears that when the impact of cognitive reflection on normative decision-making performance is assessed along with other individual difference variables, the CRT uniquely explains a substantial proportion of the variance (Toplak, West & Stanovich, 2011; Toplak et al., 2014). For example, in an extensive investigation of the predictive power of cognitive reflection, intelligence, executive function and thinking dispositions on a rational thinking composite score (based on a set of 15 normative decision tasks), Toplak et al., (2011) found that cognitive reflection was the best predictor of normative judgments and decisions. The CRT explained 11.2% of the variance in the rational thinking score over and above intelligence, executive function and thinking dispositions.

Whilst the above studies serve to substantiate the positive relationship between cognitive reflection ability and normative decision-making in what are primarily laboratory tasks, we are not aware of any studies on the extent to which cognitive reflection ability influences the quality of decision outcomes in everyday life. Given that cognitive reflection predicts normative decision-making performance (Toplak, West & Stanovich, 2011; Toplak et al., 2014), and that normative decision-making performance predicts real-life decision outcomes ($r = .22$, $p < .001$; Bruine de Bruin, et al., 2005) we hypothesise that cognitive reflection will predict real-life decision-making.

What does the CRT actually measure?

The CRT is a powerful predictor of normative decision-making performance. However, the reason why is unclear because what the CRT actually measures is a point of debate. There exist two non-exclusive accounts of what the CRT measures in the existing literature.

On one hand, some researchers stress that cognitive reflection measures a broader set of dispositions than originally suggested by Frederick (Campitelli & Gerrans, 2014; Campitelli & Labollita, 2010; Cokely & Kelley, 2009; Liberali, Reyna, Furlan, Stein & Pardo, 2012). The view is that the CRT assesses the tendency to be thorough and/or to actively engage in open-minded thinking (Baron, 1985) in addition to assessing the ability to inhibit a first intuitive answer. The main line of argument here is that people who perform better in the CRT do not necessarily engage in effortful System 2 thinking, but develop a more persistent and elaborate use of heuristics (Campitelli & Gerrans, 2014; Campitelli & Labollita, 2010, Cokely et al, 2009; Cokely & Kelley, 2009). According to this line of research the CRT measures not only the ability to inhibit an intuitive and incorrect answer, but also the ability to use intuition when it is appropriate. Viewed in this context cognitive reflection is a psychological device to select the cognitive processes most suited to a specific situation.

On the other hand, other researchers have proposed a different and non-exclusive view stressing that the CRT assesses general knowledge as well as the inhibition of intuition. Specifically, given that the CRT is a set of three mathematical problems, it had been posited that it captures numeracy. Consistent with this, the CRT correlates positively with numeracy scales (Campitelli & Gerrans, 2014; Sirota & Juanchich, 2011; Weller et al., 2013). A more pronounced version of this view has led some researchers to use the CRT items as additional items in a numeracy test (Weller et al., 2013). However, evidence indicates that CRT items are distinct from those used in numeracy scales: an exploratory factor analysis including both numeracy and CRT items found that they loaded on separate factors (Liberali et al., 2012). Four further findings support that the view CRT is not simply another numeracy scale. First, the CRT predicts decision-making outcomes over and above numeracy (Cokely & Kelley, 2009). Second, numeracy does not mediate the effect of the CRT on reasoning abilities

(Sirota & Juanchich, 2011). Third, CRT performance cannot be fully accounted for by numeracy (Campitelli & Gerrans, 2014). Finally, the CRT predicts performance in tasks that do not require numerical computations, such as guessing the nationality of a chest player (Campitelli & Labollita, 2010).

Overall, evidence converges to suggest that the CRT does measure cognitive reflection (i.e. the ability to inhibit an intuitive answer), but that it also captures numerical abilities and other thinking dispositions (Campitelli & Gerrans, 2014; Campitelli & Labollita, 2010; Liberali et al., 2011). The key finding of this line of research is that the extent to which the CRT predicts decision-making is via cognitive reflection but also by other individual differences that the CRT might capture such as general knowledge (e.g. geographical knowledge, Campitelli & Labollita, 2010; numeracy, Sirota & Juanchich, 2011) or by a more general disposition to activate or not heuristic processing when appropriate (Campitelli & Labollita, 2010). Building on these findings it can be expected that the CRT will predict real-life decision-outcomes, but possibly less so than normative decision-making because the latter relies to a greater extent on numerical ability.

Indirect evidence indicates that cognitive reflection shares some variance with decision-making styles and personality. For example, cognitive reflection is related to cognitive styles (Frederick, 2005; Campitelli & Labollita, 2010) that are in turn related to both decision-making styles and personality traits (Dewberry et al., 2013a). The CRT is a performance measure, whereas personality and decision-making styles measures are typically self-report measures. However, there is evidence that decision-making styles and personality traits are related. In Dewberry et al.'s study, the avoidant decision-making style had a medium positive correlation with the personality trait neuroticism (r = .53), and a weak to moderate negative correlation with the personality traits of extraversion and openness (r = -26 and r = -17). Similarly, the decision style of vigilance was positively correlated with the

personality trait of conscientiousness (r = .36). If, as these findings suggest, decision-making styles and personality share some variance with cognitive reflection, it becomes necessary to control for these characteristics in order to establish their relative effects on real-life decision outcomes.

Objectives

This study focuses on how individual differences predict real-life decision outcomes by examining: (a) the extent to which cognitive reflection (i.e. the ability to inhibit a first intuition to follow a deliberative rule-based approach) predicts real-life decision outcomes, and (b) the extent to which cognitive reflection accounts for variance in these outcomes over and above personality traits and decision-making styles.

Method

Participants

A total of 401 British participants took part in the study. The sample was recruited via a marketing agency and participants were rewarded with shopping vouchers for participating in the study. We excluded 17 participants from the sample because the time they took to complete the questionnaire was either less than 5 minutes or more than three standard deviations over the average (*Min*: 3 min., *Max*: 263 min.; M = 20 min., SD = 19 min.).

The remaining 384 participants were aged between 18 and 85 years (M = 44.25, SD = 13.18; 1 participant reported an age of 5 years and therefore this value was excluded). Fifty three percent of the participants were males, 82% were White British and 41.2% had a higher education degree. Overall, 15% indicated that they were unemployed and 13% that they were retired.

Materials and Procedure

Participants completed an online questionnaire measuring cognitive reflection, decision-making styles, personality, and real-life decision outcome. The order of presentation of the four measures was randomised for each participant.

Predictors

Cognitive reflection. The three items of the Cognitive Reflection Test were presented with the following instructions: *Below are several problems that vary in difficulty. Try to answer as many as you can*. The mean CRT score was 0.97 (*SD* = 1.11). These results are similar to those obtained by Toplak et al. (2011) and Frederick (2005). The items were presented to participants in a randomised order for each participant. Note that this version of the CRT has been criticised for its limited number of items, deemed to reduce its reliability (Toplak, West, & Stanovich, 2014). Very recently a revised version of the cognitive reflection test with four extra items has been developed (Toplak, et al., 2014). In the present study, the internal reliability of the original 3 item CRT was satisfactory (Cronbach's alpha = .71) along with the distribution of scores, with slightly more than 50% of the participants who had at least one answer correct, skewness = .67 and kurtosis = -1.01.

Decision-making styles. We measured a total of 10 decision-making styles, which represents a comprehensive sample of generic decision-making style measures (Dewberry et al., 2013b). We chose not to include measures that were context specific (e.g., career decision-making style). Nine of the decision-making styles were measured with items derived from the Decision Styles Questionnaire (DSQ) developed by Leykin and DeRubeis (2010; 43 items): anxious (5 items, e.g. 'I feel very anxious when I need to make a decision.'), avoidance (5 items, e.g. 'I don't make decisions unless I really have to.'), brooding (5 items, e.g. 'When I make decisions, my top priority is to not get "burned."'), dependent (6 items, e.g. 'I need the assistance of other people when making important decisions.'), vigilance (6 items, e.g. 'I like to consider all the alternatives.'), intuition (5 items, e.g. 'When I make decisions, I tend to

rely on my intuition.'), spontaneity (4 items, e.g., 'I make impulsive decisions.'), confident (5 items, e.g., 'I have faith in my decisions.') and respected (2 items, e.g. 'Others seek my help in making their decisions.'). In addition, we also included the revised version of Diab's et al. (2008) Maximization Tendency Scale developed by Weinhardt, Morse, Chimeli and Fisher (RMTS; 2012). This scale features 6 items, such as 'I don't like having to settle for good enough.' All the decision-making style responses were collected on a 5-point Likert scale ranging from *Strongly disagree* to *Strongly agree*. The two questionnaires concerned with decision-making styles were presented on different pages and in a randomised order for each participant.

Personality. The Big Five personality traits were assessed with the short version of the IPIP Big-Five factor markers (50 items; Goldberg et al., 2006; Gow, Whiteman, Pattie, & Deary, 2005). Each personality trait was assessed by 10 items: extraversion (e.g. 'I make friends easily'), agreeableness (e.g, 'I make people feel at ease'), conscientiousness (e.g. 'I pay attention to details'), emotional Stability (e.g. 'I rarely get irritated') and intellect (e.g. 'I enjoy hearing news ides'). The items within the personality questionnaire were randomised for each participant.

All the scales had satisfactory reliability with Cronbach's alphas ranging from .71 to .91 (see third column of Table 1). Summation indexes were computed for the personality traits, decision-making styles and cognitive reflection.

Outcome variable

Decision outcome in everyday life. Decision outcome in everyday life situations was assessed by means of the Decision Outcome Inventory (DOI; Bruine de Bruin, et al., 2007; Parker & Fischhoff, 2005). The DOI is a self-reported measure of decision-making outcome.

The items measured whether participants had experienced any of 41 negative outcomes over the past 10 years (Cronbach's alpha = .88). For 34 of those outcomes, a preceding question assessed whether participants had had a chance to experience this outcome. For example the question: "In the last 10 years, have you ever taken a trip by airplane" preceded the question "In the last 10 years, have you ever missed a flight". Participants simply responded *yes* or *no*. Some of the items of the original North American version of the DOI were adapted for a British audience as in Dewberry et al. (2013a). For example, "dollars" was replaced by "pounds", "having a DUI" was replaced by "having a fine for drunk driving".

Decision performance score computation. The DOI scores were derived as recommended by Bruine de Bruin et al. (2007). Each outcome was coded into three categories: missing value; outcome not possibly experienced; 0 outcome avoided; or 1 outcome experienced. Then, each outcome score was multiplied by the percentage of people who avoided it. We then computed an average of all the weighted outcome scores for each participant. Finally, this weighted average was subtracted from 0. DOI scores therefore ranged from -1 to 0. The DOI responses were weighted by the proportion of individuals who did not experience the target outcome, as a proxy for a severity weighting (i.e., more severe outcomes were experienced less frequently and received a greater weight). Greater DOI scores represent a greater number of negative outcomes that participants successfully avoided and therefore indicate more positive decision outcomes.

In the DOI, participants reported experiencing on average 25 of the 34 negative outcomes. For example, 12% of the participants reported having missed a flight, 33% reported having ruined their clothes because of not following washing instructions, and 40% had received blisters from sun burn. The average weighted real-life decision outcome score was similar to the one observed in Bruine de Bruin et al. (2007): M = -.13, SD = .12 in the present sample, as compared to M = -.15, SD = 0.1 observed by Bruine de Bruin et al. (2007).

Results

Cognitive reflection predicts real-life decision outcome.

Cognitive reflection was positively correlated with decision-making outcome (r = .14). The zero-order correlations between these scales, along with their reliability coefficients and descriptive statistics, are presented in Table 1. A regression analysis of CRT on DOI scores indicates that cognitive reflection accounted for 2% of the variation in real-life decision outcomes, $F(1, 383) = 7.54$, $p = .006$, $R^2 = .02$, Standardised Beta = .14).

< Insert Table 1 about here >

Effect of cognitive reflection while controlling for personality and decision-making styles.

The correlation table shows some statistically significant correlations between personality, decision-making styles and cognitive reflection indicating that these variables share some variance. Cognitive reflection was significantly correlated with one of the five personality traits (a small negative correlation with extraversion), and to two of the ten decision-making styles (negative correlations with the intuitive and spontaneous decision-making styles).

To test whether the CRT predicted decision-making outcomes while controlling for decision-making style and personality, we conducted a regression analysis with real-life decision outcome as the outcome variable and the following 16 variables as predictor variables: the CRT, the 5 personality variables, and the 10 decision-making style variables. We also conducted a commonality analysis to assess the variance in the DOI explained by the CRT that was unique or common to other variables in the regression analysis using the *R*

package recommended by Nimon, Lewis, Kane and Haynes (2008). The outputs of the regression analysis and the commonality analysis are shown in Table 2.

The regression analysis showed that cognitive reflection did not uniquely predict decision-making outcomes after controlling for personality and decision-making styles. CRT scores accounted for 2% of the variance in real-life decision outcomes but this was not statistically significant (p = .076). The commonality analysis indicates that out of the 2% of variance explained by the CRT, 1% of variance was common to one or more of the other predictive variables and 1% of variance was unique.

The results also indicate that the personality traits of extraversion and conscientiousness uniquely predicted decision outcome scores. Conscientiousness had a positive relationship with decision outcome, whereas extraversion had a negative one. The other personality traits and decision-making styles did not significantly predict real-life decision outcome.

< Insert Table 2 about here >

Table 2.

Findings of the regression analysis showing how CRT predict real-life decision outcome while controlling for the effect of the big five personality traits and decision-making styles (N = 384) along with output of the commonality analysis showing the unique and common and variance of DOI explained by cognitive reflection, personality traits and decision-making style. $R^2 = .11$.

Predictor variables	B	Stand. Beta	95% CI	*p*	Unique	Common
CRT	.01	.09	[.00, .02]	.076	.01	.01
Emotional stability	-.01	-.03	[-.28, .13]	.619	|.01| <	.01
Extraversion	-.02	-.15	[-.03, .02]	.026	.01	-.01
Openness	|.01| <	-.01	[-.05, .00]	.801	|.01| <	|.01| <
Agreeableness	.01	.04	[-.02, .02]	.484	|.01| <	.02
Conscientiousness	.03	.16	[-.02, .03]	.029	.01	.03
Vigilant	.02	.08	[.00, .05]	.224	|.01| <	.01
Intuitive	-.01	-.06	[-.01, .04]	.305	|.01| <	.01
Spontaneous	|.01| <	-.02	[-.03, .01]	.731	|.01| <	.02
Avoidant	|.01| <	-.01	[-.02, .01]	.890	|.01| <	.02
Dependent	|.01| <	.01	[-.02, .02]	.871	|.01| <	|.01| <
Anxious	-.01	-.07	[-.02, .02]	.462	|.01| <	.02
Brooding	-.01	-.07	[-.03, .01]	.301	|.01| <	.02
Confident	|.01| <	-.01	[-.03, .01]	.951	|.01| <	.02
Respect	|.01| <	-.03	[-.03, .03]	.596	|.01| <	|.01| <
Maximisation	-.01	-.06	[-.02, .01]	.291	|.01| <	|.01| <

Discussion

We investigated whether the Cognitive Reflection Test, designed to measure the ability to inhibit intuitive thinking to carry out analytical information processing, predicted real-life decision outcomes and whether it did so over and above personality and decision-making styles. Participants completed the Cognitive Reflection Test (CRT) and the Decision Outcome Inventory (DOI) and provided self-reported judgment assessing the Big Five personality traits and decision-making styles.

CRT predicts real-life decision outcome – but very little, and not over and above personality traits and decision-making styles

Data showed that cognitive reflection positively predicts real-life decision outcomes. This result is in line with the results of Campitelli and Labollita's (2010) study showing that the CRT predicted responses to questions not involving numerical calculations (such as guessing the nationality of a set of chess players). The finding is also consistent with the positive correlation found between cognitive reflection and normative decision performance (Lesage et al., 2013; Liberali, et al., 2011; Nofsinger & Varma, 2008; Oechssler, et al, 2009; Sirota & Juanchich, 2011; Sirota et al., 2014, Toplak et al., 2011; Toplak et al., 2014). Despite this, it is important to note that the CRT only explained 2% of the variance in real-life decision outcome.

Furthermore, the present findings indicate that the CRT does not predict real-life decision outcomes over and above personality and decision-making styles. Previous research has controlled for many variables to assess the effect of CRT (intelligence, executive functions, thinking dispositions; Toplak et al., 2011), but none to our knowledge accounted for the role of personality and decision-making styles along with the CRT. Future research replicating the present design with a set of normative decision-making tasks would make it possible to directly compare the effect of CRT in the two types of tasks.

After considering correlation magnitudes it appears that the CRT is more strongly correlated with measures of normative decision performance than with a measure of real-life decision outcome. We also note that whilst Toplak et al., (2011, 2014) found medium size correlations ($.30 < rs < .42$) between CRT and a composite score of normative decision-making, the correlation between cognitive reflection and real-life decision outcome was two to three times smaller in the present study ($r = .14$).

How our findings inform the debate on the nature of CRT

The CRT predicted real-life decision outcome when it was considered in isolation, but not when we controlled for the effect of personality and decision-making styles. This indicates that the impact that the CRT has on real-life decision-outcome may be explained by the variance that the CRT shares with shares personality and decision-making styles.

The present findings show that cognitive reflection shares some variance with 1 personality trait out of 5 (extroversion, $r = -11$) and 2 decision-making styles out of 10 (intuitive and spontaneous decision-making styles, $r = -.15$ and $r = -.12$). In addition, the fact that there were only two statistically significant correlations between the CRT and the 10 decision-making styles, and that those correlations were small, does not support the view that the CRT can be considered as a thinking disposition as suggested by Cokely and Kelley (2009) or Campitelli and Labolita, (2010).

One possible explanation for the small predictive power of the CRT on a set of real-life decision outcomes, and of the difference of predictive value of the CRT on normative and real-life decision outcomes, is that most normative decision-making tasks require more numerical computation (e.g., computing a conditional probability) than the real-life decisions measured in our study (e.g., receiving a fine, losing your keys). This supports the position that the ability of the CRT to predict normative decision-making can be explained by the fact

that it captures numeracy as well as cognitive reflection (Campitelli & Gerrans, 2014; Sirota & Juanchich, 2011; Sirota et al., 2014; Weller et al., 2013).

The present findings, taken together with previous findings on the impact of the CRT on decision performance, suggest that normative and real-life decisions have different determinants. For example, cognitive reflection strongly predicts normative decision performance (Toplak et al., 2011; Toplak et al., 2014) but only weakly predicts real-life decision making outcomes. Conversely, but still illustrating an asymmetry, whilst the Big Five personality traits were not found to correlate with in-lab normative decision-making tasks (i.e., Iowa gambling task; Brand & Altstötter-Gleich, 2008) some personality traits have been found to be associated with real-life decision performance in the present study and in Dewberry et al. (2013a). Interestingly, previous research (Bruine de Bruin et al, 2007) also found a weak or no correlation between performance in normative decision making and real-life outcomes (from $r = .03$, $p > .05$ for the framing task to $r = .26$ in the decision rule task).

Limitations

In the present study we measured real-life decision outcomes using the Decision Outcome Inventory (Bruine de Bruin et al., 2005). The DOI measures the number of negative outcomes that people report experiencing in the last 10 years, weighed by the frequency of occurrence of the outcomes (used as proxy for the controllability and severity of the outcomes). The assessed decision outcomes cover a wide range of contexts including finance (e.g., having a cheque bounced), leisure (e.g., having sun burns), personal relationships (e.g., been divorced), and safety (e.g., receiving a fine for drunk driving). This variety can be seen as a strength, because it means that the DOI score is a generic measure of decision-making quality that is not bounded to a specific context. However, diversity can also be seen as a weakness, because the score is based on a set of outcomes that are not all related to each other and that may have different determinants. For example, losing keys is a different

outcome from divorcing, occasional absent-mindedness would certainly be more likely to cause one than the other. Finally, one could argue that the DOI only measures half of what makes a good decision-maker: the ability to avoid bad outcomes. The ability to generate good decision outcomes would be an interesting and straightforward indicator of decision-making quality. For example, the negative outcome 'quit a job' could be paired with the positive outcome 'being promoted'. A more holistic approach to decision outcomes could also focus on good outcomes to provide a more comprehensive picture of real-life decision outcome.

Determinants of real-life decision role of personality and decision-making styles

Our results emphasise the role of the Big Five personality traits in predicting everyday decision outcome. Personality was the only predictor of real-life decision outcome after controlling for CRT and decision-making styles (7.2%). An increase of 1 unit in extroversion was associated with a decrease of 0.02 units in decision outcome. An increase of 1 unit in conscientiousness was associated with an increase of 0.03 units in decision outcome. Post-hoc calculations based on the total number of negative outcomes experienced, divided by the weighed DOI scores, help us understand the meaning of the variation in the DOI scores. This computation translated DOI score variations in a rough number of negative outcomes avoided. On average, two decimals of the DOI score (0.02) reflect the avoidance of an extra negative outcome, therefore scoring one unit higher on the conscientiousness scale was associated with failing to avoid one extra negative outcome and an increase of 1 unit in conscientiousness was associated with avoiding successfully 1.5 negative outcomes.

In the present study, 8 out of 10 decision-making styles were correlated with real-life decision outcomes, which is consistent with the findings of Bruine de Bruin et al. (2007) and Dewberry et al. (2013a). However, findings also show that this predictive ability did not hold when personality and CRT were taken into account.

Conclusion

The gap observed between the predictive value of cognitive reflection in normative decision task (e.g., framing tasks, conjunction tasks, ratio bias, Bayesian reasoning) and real-life decision outcomes (e.g., I got blisters from sun burns, I lost my keys) calls for caution in extrapolating findings from normative decision-making tasks. The present study has provided evidence that although cognitive reflection predicts real-life decision outcome, it does not do so after controlling for decision-making styles and personality. Results show that the CRT shares a limited variance with personality and decision-making styles, but that this variance partly explains the effect of CRT on real-life decision outcomes.

References

Baron, J. (1985). *Rationality and intelligence.* Cambridge, England: Cambridge University Press.

Bruine de Bruin, W., Parker, A.-M. & Fischhoff, B. (2007). Individual differences in adult decision-making competence. *Journal of Personality and Social Psychology, 92*, 938-956. doi: 10.1037/0022-3514.92.5.938

Campitelli, G. & Labollita, M. (2010). Correlations of cognitive reflection with judgments and choices. *Judgment and Decision Making, 5*, 182-191.

Campitelli, G. & Gerrans, P. (2014). Does the cognitive reflection test measure cognitive reflection? A mathematical modeling approach. *Memory and Cognition, 42*, 434-447. doi: 10.3758/s13421-013-0367-9.

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.

Cokely, E. T., Parpart, P., & Schooler, L. J. (2009). On the link between cognitive control and heuristic processes. In N.A. Taatgen & H. van Rijn (Eds.), *Proceedings of the 31st Annual Conference of the Cognitive Science Society* (pp.2926–2931). Austin, TX: Cognitive Science Society.

De Neys, W. (2006). Automatic–heuristic and executive–analytic processing during reasoning: Chronometric and dual-task considerations. *Quarterly Journal Of Experimental Psychology, 59*, 1070–1100. doi: 10.1080/02724980543000123

De Neys, W., & Glumicic, T. (2008). Conflict monitoring in dual process theories of thinking, *Cognition, 106*, 1248 - 1299. doi: 10.1016/j.cognition.2007.06.002

Dewberry, C., Juanchich, M., & Narendran, S. (2013a). Decision-making competence in everyday life: The roles of general cognitive styles, decision-making styles and

personality. *Personality and Individual Differences, 55*, 783 - 788. doi: S0191886913002559

Dewberry, C., Juanchich, M., & Narendran, S. (2013b). The latent structure of decision styles. *Personality and Individual Differences, 54*, 566–571. doi: S0191886912005272

Diab, D. L., Gillespie, M. A., & Highhouse, S. (2008). Are maximizers really unhappy? the measurement of maximizing tendency. *Judgment and Decision Making 3*, 364-370.

Epstein, S. (1994). Integration of the cognitive and the psychodynamic unconscious. *American Psychologist, 49*, 709-724.

Evans, J. S. B. T. (2008). Dual-Processing Accounts of Reasoning, Judgment, and Social Cognition. *Annual Review of Psychology, 59*, 255-278.

Einhorn, H. J. (1970). The use of nonlinear non-compensatory models in decision making. *Psychological Bulletin. 73*, 221–230.

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

Goldberg, L. R., Johnson, J. A.; Eber, H. W.; Hogan, R.; Ashton, M. C.; Cloninger, C. R. & Gough, H. C. (2006). The International Personality Item Pool and the future of public-domain personality measures. *Journal of Research in Personality, 40*, 84-96. Doi: 10.1016/j.jrp.2005.08.007

Gow, A. J., Whiteman, M.C., Pattie, A. & Deary, I.J. (2005). Goldberg's IPIP big-five factor markers: internal consistency and concurrent validation in Scotland. *Personality and Individual Differences, 39*, 317–329. doi: 10.1016/j.paid.2005.01.011

Hunt, R., Krzystofiak, F., Meindl, J., & Yousry, A. (1989). Cognitive style and decision making. *Organizational Behavior and Human Decision Processes, 44,* 436-453. doi: 10.1016/0749-5978(89)90018-6

Kahneman, D. (2003). A perspective on judgment and choice: Mapping bounded rationality.

American Psycholologist, 58, 697-720. doi: 10.1037/0003-066X.58.9.697.

Kruglanski, A. W., & Gigerenzer, G. (2011). Intuitive and deliberate judgments are based on common principles. *Psychological Review, 118*, 97-109.

Lesage E., Navarrete G., De Neys W. (2013). Evolutionary modules and Bayesian facilitation: the role of general cognitive resources. *Thinking & Reasoning, 19*, 27–53. doi: 10.1080/13546783.2012.713177

Leykin, Y., & DeRubeis, R. J. (2010). Decision-making styles and depressive symptomatology: Development of the decision styles questionnaire. *Judgment and Decision Making, 5*, 506-515.

Liberali, J. M., Reyna, V. F., Furlan, S., Stein, L. M. & Pardo, S. T. (2012). Individual differences in numeracy and cognitive reflection, with implications for biases and fallacies in probability judgment. *Journal of Behavioral Decision Making, 25,* 361-381. doi: 10.1002/bdm.752

Nimon, K., Lewis, M., Kane, R., & Haynes, R. M. (2008). An R package to compute commonality coefficients in the multiple regression case: An introduction to the package and a practical example. *Behavior Research Methods, 40*, 457-466. doi: 10.3758/BRM.40.2.457

Nofsinger, J. R., & Varma, A. (2007). How analytical is your financial advisor? *Financial Services Review, 16*, 245–260.

Oechssler, J., Roider, A., & Schmitz, P.W. (2009). Cognitive abilities and behavioral biases. Journal of Economic Behavior and Organization, 72, 147–152. doi: 10.1016/j.jebo.2009.04.018

Pacini, R., & Epstein, S. (1999). The relation of rational and experiential information processing styles to personality, basic beliefs, and the ratio-bias phenomenon. *Journal of Personality and Social Psychology, 76*, 972-987.

Parker, A. M., Bruine de Bruin, W., & Fischhoff, B. (2007). Maximizers versus satisficers: Decision-making styles, competence, and outcomes. *Judgment and Decision Making, 2*, 342–350.

Parker, A. M., & Fischhoff, B. (2005). Decision-making competence: External validation through an individual-differences approach. *Journal of Behavioral Decision Making, 18*, 1-27.

Sirota, M., & Juanchich, M. (2011). Role of numeracy and cognitive reflection in bayesian reasoning with natural frequencies. *Studia Psychologica, 53*, 151-161.

Sirota, M., & Juanchich, M. (2012). To what extent do politeness expectations shape risk perception? Even numerical probabilities are under their spell! *Acta Psychologica, 141*, 391-399. doi: 10.1016/j.actpsy.2012.09.004

Sirota, M., Juanchich, M., & Hagmayer, Y. (2014). Ecological rationality or nested sets? Individual differences in cognitive processing predict Bayesian reasoning. *Psychonomic Bulletin & Review, 21,*198-204. doi: 10.3758/s13423-013-0464-6

Stanovich, K., & West, A. (2000). Individual differences in reasoning: implications for the rationality debate? *Behavioral and Brain Sciences, 23*, 645–726.

Sloman, S. A. (1996). The empirical case for two systems of reasoning. *Psychological Bulletin, 119*, 3-22.

Thunholm, P. (2004). Decision-making style: habit, style or both? *Personality and Individual Differences, 36*, 931-944. doi: 10.1016/S0191-8869(03)00162-4

Toplak, M. E., West, R. F., & Stanovich, K. (2011). The cognitive reflect ion test as a predictor of performance on heuristics-and -biases tasks. *Memory and Cognition, 39*, 1275-89. doi: 10.3758/s13421-011-0104-1

Toplak, M. E., West, R. F., & Stanovich, K. E. (2014). Assessing miserly information processing: An expansion of the Cognitive Reflection Test. *Thinking & Reasoning, 20*, 147-168. doi: 10.1080/13546783.2013.844729

Tversky, A., & Kahneman, D. (1974). Judgment under uncertainty: heuristics and biases. *Science, 185,*1124-1131.

Weinhardt, J. M., Morse, B. J., Chimeli, J., & Fisher, J. (2012). An item response theory and factor analytic examination of two prominent maximizing tendency scales. *Judgment and Decision Making, 7*, 644–658

Weller, J. A., Dieckmann, N. F., Tusler, M., Mertz, C. K., Burns, W. J. & Peters, E. (2013). Development and Testing of an Abbreviated Numeracy Scale: A Rasch Analysis Approach. *Journal of Behavioral Decision Making, 26*, 198-212. doi: 10.1002/bdm.1751

Table 1. *Correlation matrix between decision outcome, personality, decision-making styles and cognitive reflection and (N = 384).*

		M	SD	α	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1	DOI	-.13	.12	--	--	.14	-.12	-.08	-.02	.15	.19	.13	-.11	-.15	-.13	-.05	-.13	-.14	.13	.00	-.04	.30
2	CRT	.97	1.11	.71	.14	--	-.09	-.11	.04	-.02	.01	.03	-.15	-.12	.02	-.08	-.05	-.08	.05	-.06	-.07	.10
3	Emo. stability	2.84	.77	.87	-.12	-.1	--	-.48	-.17	-.38	-.51	-.18	.00	.05	.43	.12	.53	.31	-.50	-.27	-.15	-.25
4	Extraversion	3.01	.69	.85	-.08	-.11	-.48	--	.32	.13	.35	.06	.07	.20	-.34	.03	-.35	-.15	.32	.35	.28	.03
5	Openness	2.92	.37	71	-.02	.04	-.17	.32	--	.21	.08	.19	.08	.04	-.09	.06	-.12	-.02	.11	.21	.11	-.02
6	Agreeableness	3.55	.58	.80	.15	-.02	-.38	.13	.21	--	.46	.25	-.02	-.20	-.22	.16	-.19	-.17	.24	.17	.02	.15
7	Conscientiousness	3.49	.65	.84	.19	.01	-.51	.35	.08	.46	--	.33	.01	-.11	-.54	-.06	-.43	-.24	.52	.33	.32	.20
8	Vigilant	2.66	.86	.90	.13	.03	-.18	.06	.19	.25	.33	--	.01	-.38	-.20	.14	-.08	.12	.35	.33	.21	.13
9	Intuitive	3.22	.70	.85	-.11	-.15	.00	.07	.08	-.02	.01	.01	--	.38	-.05	.01	-.03	.07	.18	.10	.15	-.03
10	Spontaneous	2.77	.88	.90	-.15	-.11	.05	.20	.04	-.20	-.11	-.38	.38	--	.04	-.06	-.01	.08	-.03	.12	.01	-.13
11	Avoidant	3.85	.59	.90	-.13	.02	.43	-.34	-.09	-.22	-.54	-.20	-.05	.04	--	.32	.73	.43	-.66	-.31	-.15	-.18
12	Dependent	2.83	.80	.86	-.05	-.08	.12	.03	.06	.16	-.06	.14	.01	-.06	.32	--	.41	.30	-.31	.10	-.04	-.15
13	Anxious	3.36	.60	.79	-.13	-.05	.53	-.35	-.12	-.19	-.43	-.08	-.03	-.01	.73	.41	--	.52	-.69	-.32	-.16	-.23
14	Brooding	2.92	.69	.73	-.14	-.08	.31	-.15	-.02	-.17	-.24	.12	.07	.08	.43	.30	.52	--	-.43	-.03	.02	-.17
15	Confident	3.72	.76	.88	.13	.05	-.50	.32	.11	.24	.52	.35	.18	-.03	-.66	-.31	-.69	-.43	--	.43	.28	.20
16	Respect	3.35	.87	.88	.00<	-.06	-.27	.35	.21	.17	.33	.33	.10	.12	-.31	.10	-.32	-.03	.43	--	.28	-.02
17	Maximisation	3.18	.61	.77	-.04	-.07	-.15	.28	.11	.02	.32	.21	.15	.01	-.15	-.04	-.16	.02	.28	.28	--	-.02
18	Age	44.25	13.18	--	.30	.10	-.25	.03	-.02	.15	.20	.13	-.03	-.13	-.18	-.15	-.23	-.17	.21	-.02	-.02	--

Note: DOI: Decision Outcome Inventory; CRT: Cognitive reflection test. All correlations greater than |.11| are significant at $p < .05$, .12 < .02 and correlations greater than .17 < .001.

Table 2.

Findings of the regression analysis showing how CRT predict real-life decision outcome while controlling for the effect of the big five personality traits and decision-making styles (N = 384) along with output of the commonality analysis showing the unique and common and variance of DOI explained by cognitive reflection, personality traits and decision-making style. $R^2 = .11$.

Predictor variables	B	Stand. Beta	95% CI	*p*	Unique	Common
CRT	.01	.09	[.00, .02]	.076	.01	.01
Emotional stability	-.01	-.03	[-.28, .13]	.619	|.01| <	.01
Extraversion	-.02	-.15	[-.03, .02]	.026	.01	-.01
Openness	|.01| <	-.01	[-.05, .00]	.801	|.01| <	|.01| <
Agreeableness	.01	.04	[-.02, .02]	.484	|.01| <	.02
Conscientiousness	.03	.16	[-.02, .03]	.029	.01	.03
Vigilant	.02	.08	[.00, .05]	.224	|.01| <	.01
Intuitive	-.01	-.06	[-.01, .04]	.305	|.01| <	.01
Spontaneous	|.01| <	-.02	[-.03, .01]	.731	|.01| <	.02
Avoidant	|.01| <	-.01	[-.02, .01]	.890	|.01| <	.02
Dependent	|.01| <	.01	[-.02, .02]	.871	|.01| <	|.01| <
Anxious	-.01	-.07	[-.02, .02]	.462	|.01| <	.02
Brooding	-.01	-.07	[-.03, .01]	.301	|.01| <	.02
Confident	|.01| <	-.01	[-.03, .01]	.951	|.01| <	.02
Respect	|.01| <	-.03	[-.03, .03]	.596	|.01| <	|.01| <
Maximisation	-.01	-.06	[-.02, .01]	.291	|.01| <	|.01| <