# Not so fast: Individual differences in impulsiveness are only a modest predictor of cognitive reflection

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# Abstract

The extent to which a person engages in reflective thinking while problem-solving is often measured using the Cognitive Reflection Test (CRT; Frederick, 2005). Some past research has attributed poorer performance on the CRT to impulsiveness, which is consistent with the close conceptual relation between Type I processing and dispositional impulsiveness (and the putative relation between a tendency to engage in Type I processing and poor performance on the CRT). However, existing research has been mixed on whether such a relation exists. To address this ambiguity, we report two large sample size studies examining the relation between impulsiveness and CRT performance. Unlike previous studies, we use a number of different measures of impulsiveness, as well as measures of cognitive ability and analytic thinking style. Overall, impulsiveness is clearly related to CRT performance at the bivariate level. However, once cognitive ability and analytic thinking style are controlled, these relations become small and, in some cases, non-significant. Thus, dispositional impulsiveness, in and of itself, is not a strong predictor of CRT performance.


Key words: cognitive reflection, impulsiveness, intuitive thinking, delay discounting, dual process

## Introduction

A large body of work exists suggesting that a crucial element of optimal decision-making is the extent to which a person can override faster, more intuitive responses and engage in more cognitively reflective, critical thinking processes when appropriate. This *dual process* account of cognition has been articulated in numerous domains including reasoning and decision-making (Sloman, 1996), attitude change (Petty & Cacioppo, 1986), and social behaviour (Strack & Deutsch, 2004). While these models vary in important ways, they appear to share a core assumption that thinking processes (generally) are either faster and effortless or slower and reflective (Evans & Stanovich, 2013). To date, however, few studies have investigated the extent to which certain salient, theoretically adjacent dispositional attributes might be associated with engagement or avoidance in these cognitively reflective processes (e.g., Littrell, Fugelsang, & Risko, 2019). One such dispositional trait is impulsiveness, a trait-based lack of inhibitory control that, by definition, seems to reflect a propensity to favour faster, more intuitive responses across a broad range of tasks, making it an important trait to consider when investigating decision-making processes. The present investigation sought deeper a understanding of the associations between dispositional impulsiveness and the Cognitive Reflection Test (CRT) using a number of measures related to trait impulsiveness tested on large samples.

### ***Dual process theories***

In a broad sense, *dual process theory* (DPT) posits that human reasoning can be thought of as the product of two general classes of processes. Type I processes are defined as those that are autonomous and do not require working memory, while Type II processes allow for critical, reflective analysis and do require working memory (Evans & Stanovich, 2013). According to one account, the faster, Type I process often steers the decisional ship, as the speed with which it springs to mind generates an affective metacognitive sense of confidence in the response, known as the "Feeling of Rightness" (Thompson, Prowser Turner, & Pennycook, 2011). Consequently, this Type I response may be acted upon even in situations in which deeper application of the rules of logic would lead to more optimal decisions (Thompson & Morasanyi, 2012). The propensity to override these quicker, Type I responses and engage in more cognitively reflective, Type II processes can be influenced by factors such as the sufficiency of an individual's knowledge structures (Stanovich, 2018) or the amount of time allotted to processing the decision-salient information (Strack & Deutsch, 2004) and has been positively linked to cognitive ability as well as decreased susceptibility to fake news and pseudo-profound bullshit (Pennycook, Cheyne, Barr, Koehler, & Fugelsang, 2015; Pennycook & Rand, 2019a; Pennycook & Rand, 2019b).

***Dispositional impulsiveness and Type I thinking***

Thus far, the bulk of dual process research in cognitive psychology has focused on cognitive reflection's associations with a narrow set of individual differences in cognition, such as performance on Stroop-like logical reasoning tasks (Thompson, Pennycook, Trippas, & Evans, 2018), cognitive thinking styles (Pennycook, Cheyne, Barr, Koehler, & Fugelsang, 2015), and cognitive ability (Frederick, 2005). While informative, this approach seems to have overlooked the extent to which certain trait-level dispositional and personality attributes potentially influence these human reasoning processes. For instance, a propensity to rely on Type I rather than Type II thinking processes appears quite similar to trait-level (i.e., dispositional) impulsiveness.

Dispositional impulsiveness is often characterized as "acting without thinking" (Patton, Stanford, & Barratt, 1995). That is, across a broad range of situations, a dispositionally impulsive person tends to react to stimuli (both internal and environmental) in ways that are fast, poorly planned, risky, and with minimal consideration given to the potentially negative outcomes of their actions (Evenden, 1999; Moeller, Barratt, Dougherty, Schmitz, & Swann, 2001). Impulsiveness reflects a propensity toward satisfying immediate, short-term gratifications (Hofmann, Friese, & Strack, 2009), insufficient deliberation before taking quick action (Dickman, 1990), and a temporal focus on the present rather than the future (Moeller et al., 2001). Individual differences in impulsiveness have been operationally measured in various ways, such as the self-report Barratt Impulsiveness Scale (BIS-11; Patton et al., 1995), temporal discounting tasks (Bialek & Sawicki, 2018), and as reaction time on problem-solving tasks (Jimenez, Rodriguez-Lara, Tyran, & Wengström, 2018). It has also been linked to factors that share significant overlap with those associated with a lack of cognitive reflection such as preference for small, immediate rewards (Bialek & Sawicki, 2018), pathological gambling (MacLaren, Fugelsang, Harrigan, & Dixon, 2012), increased risk-taking (Kahn, Kaplowitz, Goodman, & Emans, 2002) and poorer probabilistic decision-making (Cáceres & San Martin, 2017).

When situated within a dual process framework, dispositional impulsiveness could arguably be characterized as a general proclivity toward defaulting to Type I processes and a decreased engagement in more controlled cognitive reflection. Indeed, a small number of studies have examined the association between cognitive reflection and various measures of impulsiveness but have yielded, at best, mixed results (e.g., Bialek & Sawicki, 2018; Jelihovschi, Cardoso, & Linhares, 2018; Jimenez, Rodriguez-Lara, Tyran, & Wengström, 2018). This is surprising, given how closely Type I processes and dispositional impulsiveness are defined.

***The Cognitive Reflection Test***

One of the most popular tools used to assess individual differences in thinking styles is the Cognitive Reflection Test (CRT), a collection of "brain teasers" designed to cue compelling, but incorrect, responses (Frederick, 2005, p. 27). Consider the following:

> *"A bat and a ball cost $1.10. The bat costs $1.00 more than the ball. How much does the ball cost?*

For many people, the answer that most quickly springs to mind and "feels right" is "10 cents." It is also incorrect and, upon further reflection, a smaller number of people will realize this error and deliberate further before responding with the correct answer of 5 cents.
Higher scores on the CRT are presumed to reflect the propensity to avoid miserly thinking processes and think more analytically (Toplak, West, & Stanovich, 2014) and have been linked to other measures of deliberative engagement such as heuristics-and-biases assessments (Toplak, West, & Stanovich, 2011), time discounting tasks (Bialek & Sawicki, 2018), and tests of objective numeracy (Liberali, Reyna, Furlan, Stein, & Pardo, 2012). Additionally, the association of CRT performance to other variables has been shown to be robust to multiple exposures (Bialek & Pennycook, 2015) and relatively stable across time (Stagnaro, Pennycook, & Rand, 2018).

As noted above, investigations into the relation between cognitive reflection and various aspects of impulsiveness have, thus far, been mixed. With respect to those employing CRT in particular, results have shown an association between CRT scores and impulsiveness measures ranging from moderate and significant (Bialek & Sawicki, 2018), to weak and significant (Jelihovschi, Cardoso, & Linhares, 2018), to still weaker and non-significant (Littrell et al., 2019) with likely sources of these discrepant findings being differences in the ways in which impulsiveness was measured as well as differences in sample sizes. The present investigation takes steps to address each of these limitations, and bring greater clarity to this issue, by examining the associations between dispositional impulsiveness and the CRT, while controlling for additional associated factors such as cognitive ability and cognitive thinking styles, and using a broader swath of impulsiveness measures tested on larger samples.

### ***Present Investigation***

Here, we report two large sample size studies investigating the relation between cognitive reflection and impulsiveness, broadly construed. In Study 1, we investigate the associations of the CRT with four measures related to various aspects of dispositional impulsiveness: two self-report measures of trait impulsiveness, a measure of delay discounting (the Monetary-Choice Questionnaire; Kirby, Petry, & Bickel, 1999), and a measure of present bias (the Consideration of Future Consequences Scale; Strathman, Gleicher, Boninger, & Edwards, 1994). Though there exists a number of self-report impulsiveness measures (e.g., BIS/BAS, Dickman Impulsivity Scale, Momentary Impulsivity Scale), we chose to focus on the Barratt Impulsiveness Scale (Patton et al., 1995) and the Eysenck $I_7$ Impulsiveness Scale (Eysenck, Pearson, Easing, & Allsopp, 1985) as they are two of the more widely-used measures across various research disciplines (Carver & White, 1994; Dickman, 1990).

In addition to these measures, we also attempted to account for other variables we thought could influence the relation between CRT and impulsiveness. For instance, past research has found strong associations between CRT scores and measures of cognitive ability such as verbal intelligence and numeracy (e.g., Liberali, Reyna, Furlan, Stein, & Pardo, 2011; Toplak, West, & Stanovich, 2014). Other research has found significant associations between dispositional impulsiveness, delay discounting, and cognitive ability and argued that cognitive ability should be controlled for when designing studies involving these variables (De Wit, Flory, Acheson, McCloskey, & Manuck, 2007). Additionally, Littrell, Fugelsang, and Risko (2019) found a considerable negative association between dispositional impulsiveness and Need for Cognition ($r$ = -.56), which remained stable when controlling for cognitive ability ($\beta$ = -.43). Therefore, we also collected data on cognitive ability (i.e., numeracy and verbal intelligence) and Need for Cognition in order to better understand the extent to which any relation between CRT and dispositional impulsiveness could be explained by overlap with these constructs.

Including these additional measures is an especially important consideration for studies involving the CRT, as it has been shown to be a stronger predictor of rational, reflective thinking over and above both intelligence and executive function (Bialek & Domurat, 2018; Pennycook & Ross, 2016; Toplak, West, & Stanovich, 2011). Measures of intelligence and reflective thinking are, in essence, capturing separate processes, as the former involves *computational power available to a person* while the latter involves the *depth of processing one typically engages in* (Toplak, West, & Stanovich, 2014). Thus, in order to offer a clearer consideration of the associations between our measures of impulsiveness and CRT scores (thus, the putative association between trait impulsiveness and the propensity to engage in reflective, rational thinking processes), controlling for cognitive ability (i.e., intelligence) is necessary in order to ensure that we better isolate the relations between the CRT and our measures of impulsiveness.

Lastly, incorrect responses on the CRT have been interpreted by some researchers as representing intuitive, rather than impulsive, thinking (e.g., Brosnan, Hollinworth, Antoniadou, & Lewton, 2014; Frederick, 2005; but see Pennycook, Cheyne, Koehler, & Fugelsang, 2016). Indeed, recent research has found small, negative correlations between CRT and Faith in Intuition (Littrell et al., 2019; Patel, Baker, & Scherer, 2019). Given that "going with your gut" (i.e., intuition) and "acting without thinking" (i.e., impulsiveness) seem, at least on their face, to be conceptually distinct, we also collected data on intuitive thinking style (i.e., Faith in Intuition) to more clearly isolate the association between impulsiveness and CRT, and to better understand the distinction between impulsiveness and intuition.

## Study 1

## Method

### *Participants*

Two hundred participants were recruited via Amazon's Mechanical Turk based on an a priori power analysis for attaining approximately .80 power to detect an effect of $r = .20$ at $\alpha = .05$ (g*power; Faul, Erdfelder, Buchner, & Lang, 2009). Selection was restricted to participants in the United States and Canada who had a 95% MTurk HIT (Human Intelligence Task) approval rating and had completed a minimum of 100 surveys and no more than 50,000. Each person was paid $4 for their participation.

### ***Materials***

Participants completed the following measures presented in a randomized order:

*Barratt Impulsiveness Scale.*

The 30-item Barratt Impulsiveness Scale (BIS-11; Patton et al., 1995) was used to measure each participant's dispositional impulsiveness (i.e., their self-reported propensity to "act without thinking"), characterized by rapid, unplanned reactions to stimuli and a decreased sensitivity to the negative outcomes of such behaviour (Moeller et al, 2001). Participants rated themselves according to a 4-point frequency scale (1 = Rarely, 4 = Almost always) using items such as, "I say things without thinking." The BIS-11 contains subscales for *attentional impulsiveness* (i.e., "focusing on the task at hand"), *motor impulsiveness* (i.e., "acting on the spur of the moment"), and *non-planning impulsiveness* (i.e., the extent to which one "plans and thinks carefully"). These subscales can be scored individually or combined to calculate a composite score. For greater investigative detail, we used both methods in our analyses. Past literature has shown the BIS-11 to demonstrate good average internal reliability ($\alpha = .81$, across four samples; Patton et al., 1995).

*$I_7$ Impulsiveness Scale.*

Participants also completed a second measure of dispositional impulsiveness, the $I_7$ Impulsiveness Scale (Eysenck et al., 1985). The $I_7$ is a 19-item self-report questionnaire which asks participants to rate their thinking and behaviour according to items such as, "Do you generally do and say things without stopping to think?" Though originally designed with a binary, "YES/NO" response format, participants in the current study rated their responses using the same 4-point frequency scale format as the BIS-11 (1 = Rarely, 4 = Almost always) as this has been shown to improve internal consistency (Luengo, Carillo de la Peña, & Otero, 1991). The $I_7$ has shown good internal reliability in prior research ($\alpha = .84$ across four studies; Eysenck, et al, 1985).

*Monetary-Choice Questionnaire (MCQ-27).*

Delay discounting preference was measured using the 27-item Monetary-Choice Questionnaire (MCQ-27; Kirby, Petry, & Bickel, 1999). The MCQ-27 is an index of the extent to which individuals discount the value of distal monetary rewards. Participants indicated their preferences for smaller-and-immediate or larger-and-delayed monetary rewards by responding to a fixed set of 27 items offering choices between options such as "$25 today" or "$30 in 80 days." Scores were calculated based on methods outlined by Myerson, Baumann, and Green (2014), where the number of responses in which participants chose the smaller, immediate reward (SIR) rather than the larger, delayed reward (LDR) was divided by the total number of scale items. Therefore, higher scores indicate a stronger preference for smaller, immediate rewards. Previous research has shown this scoring method (calculated using proportion of LDRs rather than SIRs) has been found to strongly correlate with scores obtained using traditional ($r = -.97$) and logarithmic ($r = -.99$) scoring methods, indicating that it retains the validity and reliability of the original, more complex scoring method (Myerson et al., 2014). Our calculations used proportion of SIRs rather than proportion of LDRs to ensure that statistical relations involving delay discounting were directionally consistent with those of our self-report impulsiveness measures.

*Consideration of Future Consequences Scale (CFCS)*

To assess future orientation (i.e., low present bias), participants completed the 12-item Consideration of Future Consequences Scale (CFCS; Strathman et al., 1994). Specifically, the

CFCS assesses the extent to which a person considers and is influenced by the potential future outcomes of their present behaviours. Participants rated items such as "I only act to satisfy immediate concerns, figuring the future will take care of itself," on a Likert scale from 1 ("very uncharacteristic of me") to 5 ("very characteristic of me"). The CFCS has demonstrated good reliability in past literature, with an average α = .82 across four samples in the original validation study (Strathman, et al, 1994).

*Cognitive Reflection Test – Long (CRT-L).*

Participants' propensity to inhibit quick, intuitive responses and engage in slower, reflective thinking when solving problems (Campitelli & Gerrans, 2014) was assessed using the Cognitive Reflection Test – Long (CRT-L; Primi, Morsanyi, Chiesi, Donati, & Hamilton, 2016). The CRT-L consists of 6 "brain teasers"; three from Frederick's (2005) original CRT and an additional three items added by Primi et al (2016). The CRT-L showed acceptable reliability (α = .74) when originally validated.

*Rational-Experiential Inventory (REI).*

Faith in Intuition (FI), characterized by the preference for thinking processes that involve "trusting one's gut" when making decisions, was assessed using the 20-item *experiential* subscale from the Rational Experiential Inventory (Pacini & Epstein, 1999). To measure intuitive thinking preferences, participants rated themselves on items such as, "I tend to use my heart as a guide for my actions," using a 5-point Likert scale. The FI subscale has shown good reliability in prior literature (α = .87 in the original sample),

The extent to which individuals are motivated to engage in and enjoy cognitively effortful endeavors, known as Need for Cognition (NFC), was measured using the 20-item *rationality* subscale of the REI. Participants rated themselves on items such as, "I prefer complex problems to simple problems" on a 5-point Likert scale. Pacini and Epstein (1999) reported excellent reliability (α = .90) for the NFC scale in their original sample.

*Cognitive ability*

Verbal intelligence was assessed using the 10-item version of the "Wordsum" vocabulary test (Thorndike, 1942; Malhotra, Krosnick, & Haertel, 2007). Participants also completed the 4-item, open-ended version of the Berlin Numeracy Test (BNT) which assesses one's ability to perform basic probability and mathematical operations (Cokely, Galesic, Schulz, Ghazal, & Garcia-Retamero, 2012).

***Procedure***

Participants were recruited through Amazon's Mechanical Turk (MTurk) website and asked to complete the survey which was developed and managed through Qualtrics online research and experience software platform. After reading a consent form, those who agreed to participate answered demographic questions covering age, gender, education level, and household income. Afterwards, participants completed all survey scales, presented in randomized order concluding with an informational feedback form. The survey took approximately 20 minutes to complete.

## Results

Table 1 lists descriptive statistics and Pearson's *r*-values for all variables. To better understand these associations and to identify potential predictor variables for our linear regression models, we next calculated partial correlations controlling for cognitive ability. Linear regression models were then created to test the predictive value of each impulsiveness measure for CRT scores (see Table 2). Four participants were eliminated from the dataset for failing attention checks. Mahalanobis distances were then calculated revealing two additional outliers, leaving data for 194 participants used in our final analyses (115 male, 78 female, 1 prefer not to answer, $M_{age}$ = 37.24, $SD_{age}$ = 10.65, Bachelor's degree or higher = 51.0%). We focus our discussion first on the bivariate and partial correlations followed by a discussion of the results of the linear regression analyses. All data for this study were analyzed using SPSS (version 25).

Table 1

*Study 1 descriptive and correlational data for all study variables.*

| | | *M* | *SD* | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | CRT-L | 4.15 | 2.03 | *(.84)* | | | | | | | | |
| 2 | BIS-11 impulsiveness | 1.83 | 0.37 | -.21** | *(.88)* | | | | | | | |
| 3 | $I_7$ impulsiveness | 1.65 | 0.40 | -.27** | .78** | *(.88)* | | | | | | |
| 4 | Delay discounting | -0.40 | 0.20 | -.27** | .16* | .16* | *(.93)* | | | | | |
| 5 | Future orientation | 41.23 | 6.57 | .15* | -.61** | -.44** | -.27** | *(.75)* | | | | |
| 6 | Faith in Intuition | 3.11 | 0.92 | -.24** | .15* | .14* | .17* | -.06 | *(.96)* | | | |
| 7 | Need for Cognition | 3.89 | 0.74 | .25** | -.61** | -.40** | -.26** | .50** | -.08 | *(.94)* | | |
| 8 | Verbal intelligence | 7.97 | 1.64 | .44** | -.18* | -.24** | -.38** | .13 | -.19* | .25** | *(.58)* | |
| 9 | Numeracy | 2.09 | 1.49 | . 65** | -.12 | -.18* | -.21** | .10 | -.25** | .19* | .41** | *(.76)* |

*Note: N* = 194. CRT = Cognitive Reflection Test - Long; BIS-11 = Barratt Impulsiveness Scale; $I_7$= Eysenck $I_7$ Impulsiveness Scale; Cronbach's coefficient scale reliabilities are italicized diagonally. **p < .01; *p < .05

### ***Bivariate Correlations***

CRT scores were significantly, negatively related to self-reported impulsiveness as measured by the BIS-11, $r(192) = -.21$, $p = .003$, and the Eysenck $I_7$ scale, $r(192) = -.27$, $p < .001$. Additionally, CRT scores were significantly, negatively related to delay discounting scores on the MCQ-27, $r(192) = -.27$, $p < .001$, and significantly, positively related to future orientation (CFCS), $r(192) = .15$, $p = .03$. The relations between CRT scores to measures of thinking styles were consistent with prior research. CRT performance was significantly, negatively related to Faith in Intuition, $r(192) = -.24$, $p = .001$, and significantly, positively related to Need for Cognition, $r(192) = .25$, $p < .001$. Lastly, CRT scores were significantly, positively related to verbal intelligence, $r(192) = .44$, $p < .001$, and numeracy, $r(192) = .65$, $p < .001$, which aligns with prior research (Littrell et al., 2019; Pennycook et al, 2015).

Turning to the intercorrelations between the impulsiveness variables, BIS-11 scores were significantly, positively correlated with the Eysenck $I_7$ scale, $r(192) = .78$, $p < .001$, demonstrating strong convergent validity between the measures. Mean BIS-11 scores and Eysenck $I_7$ scores were significantly, positively correlated with delay discounting (i.e., preference for SIRs), $r(192) = .16$, $p = .03$ (the effect sizes and significance levels for both impulsiveness measures were identical). Additionally, the BIS-11, $r(192) = -.61$, $p < .001$, the Eysenck $I_7$, $r(192) = -.44$, $p < .001$, and delay discounting, $r(192) = -.27$, $p < .001$, were each significantly, negatively correlated to future orientation.

In terms of the relations between our impulsiveness measures and other variables, BIS-11 scores were significantly, positively related to Faith in Intuition, $r(192) = .15$, $p = .04$, as were scores for the Eysenck $I_7$, $r(192) = .14$, $p = .045$, and delay discounting, $r(192) = .17$, $p = .02$.

Additionally, BIS-11, $r(192) = -.61$, $p < .001$, Eysenck $I_7$, $r(192) = -.40$, $p > .001$, and delay discounting, $r(192) = -.26$, $p < .001$, were significantly and negatively related to Need for Cognition.

Lastly, verbal intelligence was significantly, negatively related to scores on the BIS-11, $r(192) = -.18$ $p = .01$, Eysenck $I_7$ scale, $r(192) = -.24$, $p = .001$, delay discounting, $r(192) = -.38$, $p < .001$, and Faith in Intuition, $r(192) = -.19$, $p = .01$, and significantly, positively related to Need for Cognition, $r(192) = .23$, $p = .001$. Likewise, numeracy was significantly, negatively related to scores on the Eysenck $I_7$ scale, $r(192) = -.18$, $p = .01$, delay discounting, $r(192) = -.21$, $p = .003$, and Faith in Intuition, $r(192) = -.25$, $p < .001$, and significantly, positively related to Need for Cognition, $r(192) = .16$, $p = .03$. However, it was not significantly related to BIS-11 scores, $r(192) = -.12$, $p = .08$. Neither verbal intelligence nor numeracy was significantly related to future orientation, ($r(192) = .13$, $p = .08$, and , $r(192) = .10$, $p = .19$, respectively).

***Partial correlations***

Our data yielded significant bivariate correlations between our impulsiveness measures, CRT scores, and cognitive ability. Thus, in order to better isolate the bivariate relations between CRT and our impulsiveness measures, and better identify potential predictors for our linear regression models, we analyzed the partial correlations among these variables controlling for verbal intelligence and numeracy.

Scores on the CRT remained significantly, negatively related to scores on the BIS-11, $r(190) = -.14$, $p = .05$, and the Eysenck $I_7$ scale, $r(190) = -.17$, $p = .02$. The association between CRT scores and Need for Cognition also remained significant, $r(190) = .16$, $p = .03$. However, CRT scores were no longer significantly related to delay discounting, $r(190) = -.10$, $p = .16$, future orientation, $r(190) = .10$, $p = .16$, or Faith in Intuition, $r(190) = -.08$, $p = .25$. Lastly, as to the intercorrelations between the impulsiveness and temporal focus measures, the association between BIS-11 and the Eysenck $I_7$ was largely unaffected, $r(190) = .77$, $p < .01$. Likewise, the relations of future orientation to BIS-11, $r(190) = -.60$, $p < .01$, and Eysenck $I_7$, $r(190) = -.42$, $p < .01$, were relatively stable. However, the weak bivariate associations between delay discounting and the dispositional impulsiveness measures were further reduced and became nonsignificant when controlling for cognitive ability (BIS-11, $r(190) = .09$, $p = .21$; Eysenck $I_7$: $r(190) = .08$, $p = .30$).

### *Regressions*

We next created separate multiple linear regression models predicting CRT scores with the BIS-11 and the Eysenck $I_7$ scale. Our other impulsiveness measure, delay discounting, was excluded as a predictor based on the results of our partial correlation analysis, as were future orientation and Faith in Intuition. Cognitive ability measures were entered as covariates in Step 1 for each regression model, followed by the impulsiveness measure in Step 2, and Need for Cognition in Step 3. Standardized beta coefficients and fit information for all models are presented in Table 2.

Verbal intelligence, $\beta = .21$, $p < .001$, and numeracy, $\beta = .56$, $p < .001$, significantly and positively predicted CRT scores in Step 1 of each model. For Step 2 of Model 1, BIS-11 scores significantly, negatively predicted CRT scores, $\beta = -.11$, $p = .05$, while verbal intelligence, $\beta = .20$, $p = .001$, and numeracy, $\beta = .55$, $p < .001$, were positive predictors. BIS-11 scores negatively predicted CRT scores in Step 3, though this effect was small and non-significant, $\beta = -.06$, $p = .41$. Need for Cognition positively predicted CRT scores, but this effect was small and failed to reach statistical significance, $\beta = .09$, $p = .20$. However, verbal intelligence, $\beta = .19$, $p = .002$, and numeracy, $\beta = .55$, $p < .001$, remained significant, positive predictors.

In Model 2, Eysenck $I_7$ scale scores, $\beta = -.13$, $p = .02$, significantly, negatively predicted CRT scores in Step 2, with verbal intelligence, $\beta = .19$, $p = .002$, and numeracy, $\beta = .55$, $p < .001$, again remaining as positive predictors. Eysenck $I_7$ scores negatively predicted CRT scores in Step 3, though the effect was non-significant, $\beta = -.10$, $p = .09$. Need for Cognition positively predicted CRT scores, but this effect was not statistically significance, $\beta = .09$, $p = .20$. Verbal intelligence, $\beta = .18$, $p = .003$, and numeracy, $\beta = .54$, $p < .001$, remained significant, positive predictors.

Table 2

*Multiple linear regressions for BIS-11 and Eysenck $I_7$ predicting CRT scores*

| Model 1 | Step 1 | Step 2 | Step 3 | Model 2 | Step 1 | Step 2 | Step 3 |
|---|---|---|---|---|---|---|---|
| *Covariates* | | | | *Covariates* | | | |
| Verbal intelligence | .21*** | .20** | .19** | Verbal intelligence | .21*** | .19** | .18** |
| Numeracy | .56*** | .55*** | .55*** | Numeracy | .56*** | .55*** | .54*** |
| *Predictor variables* | | | | *Predictor variables* | | | |
| BIS-11 | | -.11*[a] | -.06 | Eysenck $I_7$ | | -.13* | -.10 |
| Need for Cognition | | | .09 | Need for Cognition | | | .09 |
| Adjusted $R^2$ | .45 | .46 | .46 | Adjusted $R^2$ | .45 | .46 | .47 |
| $\Delta R^2$ | .46 | .01 | .01 | $\Delta R^2$ | .46 | .02 | .01 |
| $F$ | 80.15*** | 55.55*** | 42.22*** | $F$ | 80.15*** | 56.62*** | 43.26*** |

*Note:* $N = 194$. Standardized beta coefficients listed. BIS-11 = Barratt Impulsiveness Scale;
***$p < .001$; **$p < .01$; *$p < .05$; *[a]$p = .05$

***Exploratory analyses***

Given that the BIS-11 contains subscales, we next conducted an exploratory analysis of the intercorrelations among the three BIS-11 subscales (BIS-attn, BIS-motor, and BIS-np) and our main study predictor variables (Table 3).

Table 3
*Study 1 descriptive and correlational data including BIS-11 subscales*

| | | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|---|
| 1 | CRT-L | | | | | |
| 2 | BIS-11 mean impulsiveness | -.21** | | | | |
| 3 | BIS-11 attention | -.15* | .81** | *(.76)* | | |
| 4 | BIS-11 motor | -.27** | .81** | .53** | *(.72)* | |
| 5 | BIS-11 non-planning | -.11 | .84** | .51** | .50** | *(.81)* |
| 6 | $I_7$ impulsiveness | -.27** | .78** | .60** | .81** | .55** |
| 7 | Faith in Intuition | -.24** | .16* | .07 | .20** | .10 |
| 8 | Need for Cognition | .25** | -.61** | -.41** | -.35** | -.70** |

*Note: N* = 194. Cronbach's coefficient scale reliabilities are italicized diagonally. Previously reported intercorrelations have been excluded.
$^{**}p < .01$; $^{*}p < .05$

When considering the BIS-11 subscales, CRT scores were most strongly related to BIS-motor (i.e., *motor impulsiveness*), $r(192) = -.27$, $p < .001$, followed by BIS-attn (i.e., *attentional impulsiveness*), $r(192) = -.15$, $p = .03$, but were not significantly related to BIS-np (i.e., *non-planning*), $r(192) = -.11$, $p = .12$.

The Eysenck $I_7$ scale was correlated with BIS-attn, $r(192) = .60$, $p < .001$, and BIS-np, $r(192) = .55$, $p < .001$, but its relation to BIS-motor was considerably larger, $r(192) = .81$, $p < .001$. This pattern of intercorrelations between the Eysenck $I_7$ and BIS-motor matches results found in previous work by Luengo, Carillo de la Peña, and Otero (1991), strongly suggesting that the Eysenck $I_7$ impulsiveness scale and the BIS-motor subscale capture largely isomorphic constructs.

The associations of the BIS-11 subscales with the remaining study variables follow patterns found for the overall BIS-11 composite scores, with a few exceptions. Need for Cognition was significantly and negatively related to attentional, $r(192) = -.41$, $p < .001$, and motor impulsiveness, $r(192) = -.35$, $p < .001$, however it was most strongly related to non-planning, $r(192) = -.70$, $p < .001$, suggesting that the non-planning subscale of the BIS-11 may be more accurately characterized as primarily measuring low Need for Cognition. Additionally, Faith in Intuition was significantly correlated only with BIS-motor $r(192) = .20$, $p = .006$, whereas its associations with BIS-attn, $r(192) = .07$ $p = .32$, and BIS-np, $r(192) = .10$, $p = .17$, were smaller and failed to reach significance.

*Partial correlations for BIS-11 subscales*

Given these differences in intercorrelations at the bivariate level among the BIS-11 subscales and our other predictor variables, we next conducted a partial correlation analysis on the subscales, controlling for verbal intelligence and numeracy as we did in our main analyses.

Scores on the CRT were significantly, negatively related to BIS-motor scores, $r(190) = -.19$, $p = .009$, but were not significantly related to BIS-attn, $r(190) = -.08$, $p = .28$, or BIS-np, $r(190) = -.09$, $p = .23$, subscales. Partial intercorrelations between the BIS-11 subscales and the other predictor variables did not substantially differ from the bivariate results, thus they are not discussed here.

*Regression analysis using BIS-11 motor subscale as a predictor*

Based on the results of the partial correlation analysis, BIS-motor emerged as the only viable predictor among the BIS-11 subscales. We therefore created a multiple linear regression model predicting CRT scores from BIS-motor. Cognitive ability measures and BIS-motor were entered in Step 1 and Need for Cognition was entered in Step 2. Standardized beta coefficients and fit information are presented in Table 4.

Verbal intelligence, $\beta = .19$, $p = .001$, numeracy, $\beta = .55$, $p < .001$, and BIS-motor scores, $\beta = -.14$, $p = .009$, significantly predicted CRT scores in Step 1. For Step 2, BIS-motor scores significantly, negatively predicted CRT scores, $\beta = -.12$, $p = .04$, while verbal intelligence, $\beta = .18$, $p = .003$, and numeracy, $\beta = .55$, $p < .001$, were positive predictors. Need for Cognition positively predicted CRT scores, $\beta = .08$, $p = .14$, though this association was small and not significant.

Table 4
*Multiple linear regressions for BIS-motor predicting CRT scores*

| | Step 1 | Step 2 |
|---|---|---|
| *Covariates* | | |
| Verbal intelligence | .19** | .18** |
| Numeracy | .55*** | .55*** |
| *Predictor variable* | | |
| BIS-motor | -.14** | -.12* |
| Need for Cognition | | .08 |
| Adjusted $R^2$ | .47 | .47 |
| $\Delta R^2$ | .02 | .01 |
| $F$ | 57.45*** | 43.91*** |

*Note:* $N = 194$. Standardized beta coefficients listed. ***$p < .001$; **$p < .01$; *$p < .05$

**Discussion**

In Study 1 we set out to gain a better understanding of the relation between dispositional impulsiveness and performance on a cognitive reflection test. To this end, we investigated the associations between the Cognitive Reflection Test and various dispositional measures of impulsiveness (BIS-11, Eysenck $I_7$, and MCQ-27), temporal focus (CFCS), and cognitive thinking style (i.e., Need for Cognition and Faith in Intuition). At the bivariate level, CRT scores were significantly related to each of these measures. However, once we control for cognitive ability, most of these relations are reduced substantially, suggesting that a significant portion of the variance in CRT scores related to dispositional impulsiveness is attributable to cognitive ability. Critically, however, even after controlling for cognitive ability, the two dispositional impulsiveness variables remained significant predictors of CRT. Furthermore, we found a strong relation between our impulsiveness measures and Need for Cognition both at the bivariate level and when Need for Cognition was included in a predictive model. That is, the impulsiveness measures were no longer significant, though the parameter estimates only changed minimally. This makes sense given the significant, negative bivariate and partial correlations between our impulsiveness measures and the Need for Cognition scale, suggesting either that these self-report impulsiveness measures are also capturing key aspects of the Need for Cognition construct or the Need for Cognition scale measures some aspects of impulsiveness. Taken together, it appears that, whether considered in isolation or when controlling for cognitive ability, impulsiveness (at the full-scale level) is negatively related to CRT. That said, this relation is small and, at least here, was non-significant when other related measures were included.

Our exploratory analyses revealed that the BIS-motor subscale was one of the strongest predictors of CRT performance. Indeed, it remained a significant predictor of CRT scores after controlling both for cognitive ability and Need for Cognition. This suggests that the BIS-motor subscale may capture a specific aspect of dispositional impulsiveness whose relation to CRT overlaps less with cognitive ability and need for cognition.

## Study 2

Given that some of the key associations found in Study 1 were small, our goal in Study 2 was to replicate the significant associations from Study 1 with a larger sample in order to provide a clearer picture of the relations between our measures. As our primary research goal was examining associations between CRT and more traditional measures of self-report impulsiveness, and only the BIS-11 and Eysenck $I_7$ were significant predictors in Study 1, we chose to exclude our delay discounting and future orientation variables from Study 2[1].

## Preregistration protocols

We preregistered our plan for Study 2 (https://osf.io/m2e4t), which was to replicate the general design of Study 1 while narrowing our focus to the BIS-11 and $I_7$ as our primary measures of dispositional impulsiveness. All data for Study 2 were analyzed using SPSS (version 25). Data files and SPSS syntax are available here: https://osf.io/2v4ym/

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[1] It is arguable whether the constructs of delay discounting and future orientation are truly representative of trait impulsiveness as it is commonly conceptualized and measured. Indeed, associations between delay discounting and measures of trait impulsiveness in past research have been consistently weak and often non-significant (Reynolds, Ortengren, Richards, & de Wit, 2006), leading some researchers to argue that discounting and trait impulsiveness are separate constructs (Holt, Green, & Myerson, 2003). Likewise, future orientation is arguably better viewed as a type of goal-focused time perspective involving an individual's expectations and interests, rather than being viewed as a "type" of impulsiveness, per se (Chen, & Vazsonyi, 2011).

## Method

### *Participants*

Three hundred forty participants were recruited for Study 2 via Amazon's Mechanical Turk and paid $3 for their participation. Based on an a priori power analysis using results from Study 1, the goal was to achieve approximately .80 power to detect an effect of $r = .20$ at $\alpha = .05$ (g*power; Faul, Erdfelder, Buchner, & Lang, 2009). Participant recruitment procedures and restriction criteria were identical to those of Study 1 with the additional restriction of excluding individuals who had participated in the previous study.

### *Materials*

Participants completed all scales from Study 1 except the Monetary-Choice Questionnaire (MCQ-27; Kirby et al., 1999) and the Consideration of Future Consequences Scale (CFCS; Strathman et al., 1994) which, as mentioned, were excluded from this study.

## Results

Descriptive statistics and Pearson r-values for bivariate correlations for all primary and exploratory variables are listed in Table 5. Coefficient data for primary and exploratory linear regression analyses are listed in Tables 6 and 7. Discussions for exploratory analyses will follow the main analysis for each section to align with each table. Mahalanobis distances were calculated revealing no outliers, leaving data for the full sample used in our final analyses ($N$ = 340; 190 male, 147 female, 2 prefer not to answer, 1 non-binary, $M_{age} = 37.03$, $SD_{age} = 11.53$, Bachelor's degree or higher = 46.8%). Our discussion focuses first on the bivariate and partial correlations followed by a summary of the results of the regression analyses.

Table 5

*Study 2 descriptive and correlational data for all study variables*

| | | *M* | *SD* | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | CRT-L | 3.75 | 1.97 | *(.79)* | | | | | | | | | |
| 2 | BIS-11 mean impulsiveness | 1.94 | 0.41 | -.19** | *(.89)* | | | | | | | | |
| 3 | BIS-11 attention | 1.91 | 0.52 | -.14** | .86** | *(.76)* | | | | | | | |
| 4 | BIS-11 motor | 1.83 | 0.42 | -.24** | .83** | .63** | *(.75)* | | | | | | |
| 5 | BIS-11 non-planning | 2.09 | 0.51 | .10 | .87** | .63** | .54** | *(.81)* | | | | | |
| 6 | $I_7$ impulsiveness | 1.79 | 0.45 | -.25** | .75** | .64** | .76** | .55** | *(.90)* | | | | |
| 7 | Faith in Intuition | 3.17 | 0.84 | -.24** | .19** | .15** | .24** | .12* | .18** | *(.95)* | | | |
| 8 | Need for Cognition | 3.63 | 0.86 | .18** | -.57** | -.43** | -.32** | -.68** | -.33** | -.12* | *(.95)* | | |
| 9 | Verbal intelligence | 7.68 | 1.87 | .46** | -.20** | -.14** | -.25** | -.12* | -.34** | -.16** | .27** | *(.66)* | |
| 10 | Numeracy | 1.75 | 1.43 | .59** | -.11* | -.02 | -.14* | -.12* | -.14* | -.18** | .21** | .28** | *(.72)* |

*Note:* $N = 340$. CRT = Cognitive Reflection Test - Long; BIS-11 = Barratt Impulsiveness Scale; I7= Eysenck I7 Impulsiveness Scale; Cronbach's coefficient scale reliabilities are italicized diagonally. **$p < .01$; *$p < .05$

***Bivariate Correlations***

*Main analysis*

Bivariate correlations followed the general patterns found in Study 1. CRT scores were significantly, negatively related to self-reported impulsiveness as measured by the BIS-11, $r(338) = -.19$, $p = .001$, and the Eysenck $I_7$ scale, $r(338) = -.25$, $p < .001$. CRT performance was also significantly, negatively related to Faith in Intuition, $r(338) = -.24$, $p < .001$, and significantly, positively related to Need for Cognition, $r(338) = .18$, $p = .001$. Additionally, CRT scores were significantly, positively related to verbal intelligence, $r(338) = .46$, $p < .001$, and numeracy, $r(338) = .59$, $p < .001$.

*Exploratory bivariate correlations for BIS-11 subscales*

Intercorrelations among the three BIS-11 subscales and our main study predictor variables followed expected trends with the exception that CRT scores were significantly, negatively related to BIS-attn, $r(338) = -.14$, $p = .008$, which was not the case in Study 1. CRT scores were again significantly, negatively related to BIS-motor, $r(338) = -.24$, $p < .001$, though the association with BIS-np, $r(338) = -.10$, $p = .07$, was non-significant. The Eysenck $I_7$ scale was correlated with BIS-attn, $r(338) = .64$, $p < .001$, BIS-motor, $r(338) = .76$, $p < .001$. and BIS-np, $r(338) = .55$, $p < .001$.

***Partial correlations***

*Main analysis*

We next calculated the partial correlations controlling for verbal intelligence and numeracy. Scores on the CRT remained negatively related to scores on the Eysenck $I_7$ scale, *r*(336) = -.11, *p* = .05, but the negative association with the BIS-11 was not significant, *r*(336) = -.09, *p* = .10. Scores on the CRT were significantly, negatively related to Faith in Intuition, *r*(336) = -.14, *p* = .01, but were not significantly related to Need for Cognition, *r*(336) = -.01, *p* = .81, neither of which was the case in Study 1. Both the BIS-11, *r*(336) = .16, *p* = .004, and the Eysenck $I_7$ scale, *r*(336) = .12, *p* = .02, were significantly, positively related to Faith in Intuition. Lastly, both the BIS-11, *r*(336) = -.55, *p* < .001, and the Eysenck $I_7$, *r*(336) = -.26, *p* < .001 were significantly, negatively related to Need for Cognition.

### *Exploratory partial correlations for BIS-11 subscales*

We also calculated the partial correlations for the BIS-11 subscales controlling for verbal intelligence and numeracy. Scores on the CRT were significantly, negatively related to scores on the BIS-motor subscale, *r*(336) = -.13, *p* = .02, and were not significantly related to scores on the BIS-np subscale, *r*(336) = -.00, *p* = .97. Scores on BIS-attn were significantly, negatively related to CRT scores, *r*(336) = -.12, *p* = .03, which was not the case in Study 1. Partial intercorrelations between the BIS-11 subscales and the other predictor variables did not substantially differ from the bivariate results.

***Regressions***

*Main regression analysis*

Multiple linear regression models were created predicting CRT scores with the BIS-11 (Model 1) and the Eysenck $I_7$ scale (Model 2). Standardized beta coefficients and fit information for all models are presented in Table 6. As the linear regression plots for both models are largely identical, for simplicity we present the regression plot only for the BIS-11 models in Figure 1 and Figure 2. Following the same procedures from Study 1, cognitive ability measures were entered as covariates in Step 1 for each model, followed by the impulsiveness measure in Step 2. A third predictor, either Need for Cognition or Faith in Intuition, was entered in Step 3. In the interests of space, both of these predictors have been listed within the table for each model as Step 3a (Need for Cognition) and Step 3b (Faith in Intuition).

Verbal intelligence, $\beta = .32$, $p < .001$, and numeracy, $\beta = .50$, $p < .001$, significantly and positively predicted CRT scores in Step 1 of each model. For Model 1, BIS-11 scores negatively predicted CRT scores in Step 2, $\beta = -.07$, $p = .10$, though this association was not significant. Verbal intelligence, $\beta = .31$, $p < .001$, and numeracy, $\beta = .50$, $p < .001$, were significant, positive predictors of CRT in Step 2. In Step 3a, BIS-11 scores negatively predicted CRT, $\beta = -.11$, $p = .03$, as did Need for Cognition, $\beta = -.07$, $p = .17$, though this association was not significant. Verbal intelligence, $\beta = .32$, $p < .001$, and numeracy, $\beta = .51$, $p < .001$, remained significant, positive predictors. For Step 3b, BIS-11 scores again negatively predicted CRT, though this effect was small and non-significant, $\beta = -.05$, $p = .20$, while Faith in Intuition significantly, negatively predicted CRT scores, $\beta = -.10$, $p = .023$. Verbal intelligence, $\beta = .30$, $p < .001$, and numeracy, $\beta = .49$, $p < .001$, remained significant, positive predictors.

In Model 2, Eysenck $I_7$ scale scores, $\beta = -.09$, $p = .05$, negatively predicted CRT scores in Step 2 (though this effect was marginally significant), with verbal intelligence, $\beta = .29$, $p < .001$, and numeracy, $\beta = .50$, $p < .001$, again remaining as significantly, positive predictors. In Step 3a, Eysenck $I_7$ scores again significantly, negatively predicted CRT scores, $\beta = -.09$, $p = .04$. However, Need for Cognition was not a significant predictor, $\beta = -.03$, $p = .44$. Verbal intelligence, $\beta = .30$, $p < .001$, and numeracy, $\beta = .50$, $p < .001$, were significant, positive predictors. In Step 3b, Eysenck $I_7$ scores negatively predicted CRT, but the effect was non-significant, $\beta = -.07$, $p = .09$. However, Faith in Intuition remained a significant, negative predictor of CRT scores, $\beta =-.10$, $p = .02$. Verbal intelligence, $\beta = .28$, $p < .001$, and numeracy, $\beta = .49$, $p < .001$, again remained significant, positive predictors.

Table 6

*Multiple linear regressions for BIS-11 and Eysenck $I_7$ predicting CRT scores*

| Model 1 | Step 1 | Step 2 | Step 3a | Step 3b | Model 2 | Step 1 | Step 2 | Step 3a | Step 3b |
|---|---|---|---|---|---|---|---|---|---|
| *Covariates* | | | | | *Covariates* | | | | |
| Verbal intelligence | .32*** | .31** | .32** | .30** | Verbal intelligence | .32*** | .29** | .30** | .28** |
| Numeracy | .50*** | .50*** | .51*** | .49*** | Numeracy | .50*** | .50*** | .50*** | .49*** |
| *Predictor variables* | | | | | *Predictor variables* | | | | |
| BIS-11 | | -.07 | -.11* | -.05 | Eysenck $I_7$ | | -.09*[a] | -.09* | -.07 |
| Need for Cognition | | | -.07 | | Need for Cognition | | | -.03 | |
| Faith in Intuition | | | | -.10* | Faith in Intuition | | | | -.10* |
| Adjusted $R^2$ | .44 | .44 | .45 | .45 | Adjusted $R^2$ | .44 | .45 | .44 | .45 |
| $\Delta R^2$ | .44 | .01 | .00 | .01 | $\Delta R^2$ | .44 | .01 | .00 | .01 |
| $F$ | 134.34*** | 90.95*** | 68.87*** | 70.20*** | $F$ | 134.34*** | 91.61*** | 68.78*** | 70.89*** |

*Note:* $N = 340$. Standardized beta coefficients listed. BIS-11 = Barratt Impulsiveness Scale; ***$p < .001$; **$p < .01$; *$p < .05$;

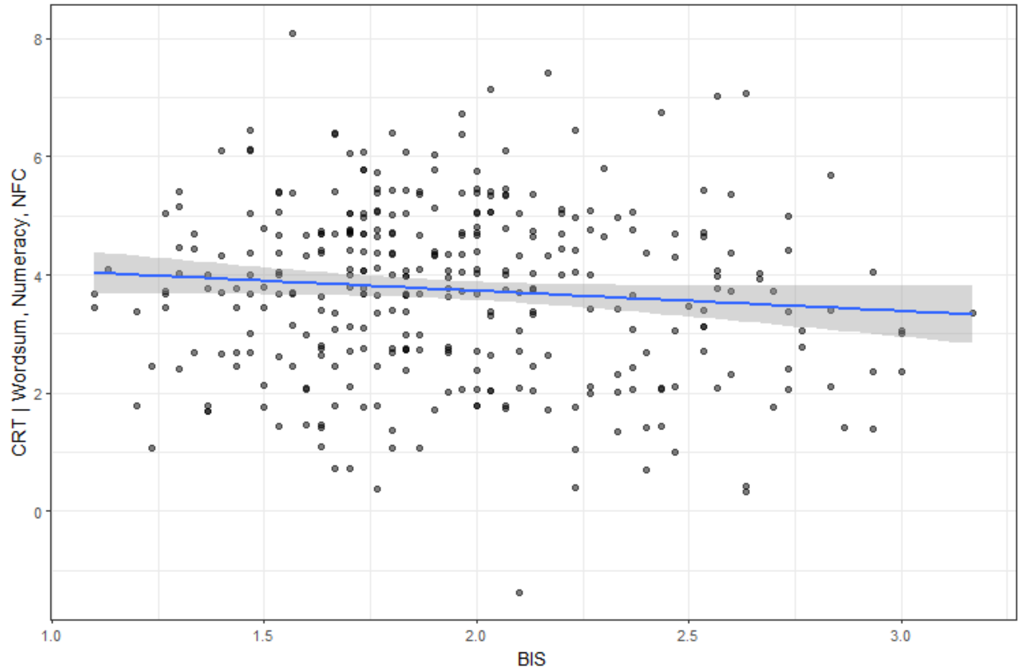


*Figure 1.* Plot of linear regression fit line for mean BIS-11 scores predicting CRT controlling for Wordsum, Numeracy, and Need for Cognition (Step 3a). Shaded spread lines represent standard error.

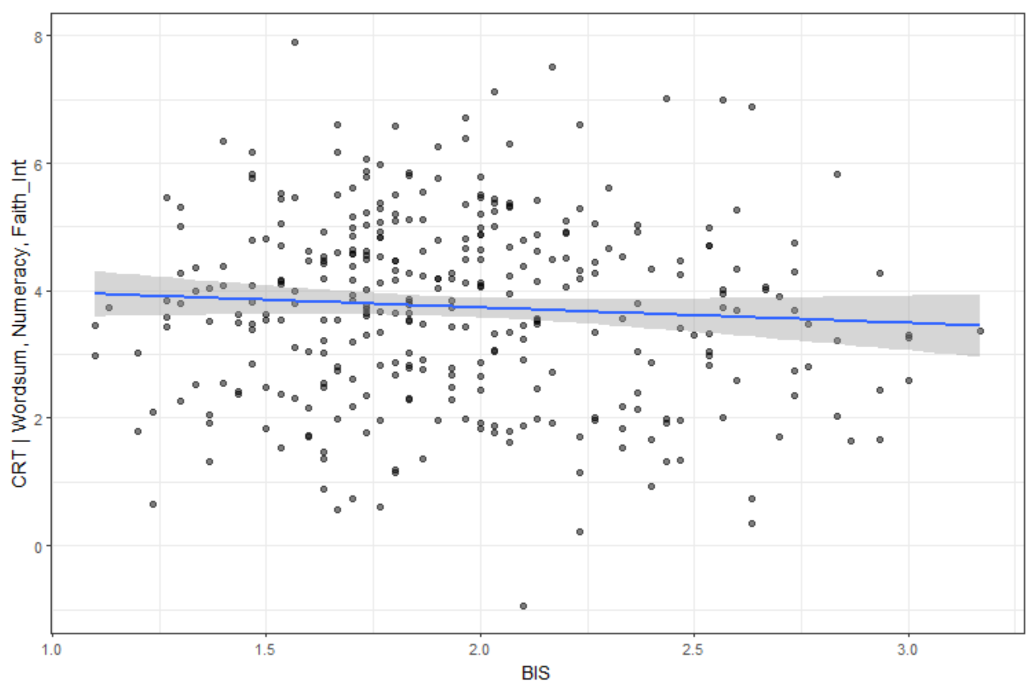


*Figure 2.* Plot of linear regression fit line for mean BIS-11 scores predicting CRT controlling for Wordsum, Numeracy, and Faith in Intuition (Step 3b). Shaded spread lines represent standard error.

*Exploratory regression analysis for BIS-11 subscales*

Results from partial correlation analysis revealed that the BIS-attn and BIS-motor subscales as well as Faith in Intuition emerged as viable predictors. As the association between Need for Cognition and CRT was small and non-significant ($r(336) = -.01$, $p = .81$), it was not included as a predictor. We therefore created two multiple linear regression models predicting CRT scores with the BIS-attn (Model 1) and BIS-motor (Model 2) subscales. For each model, the BIS-11 subscale, verbal intelligence, and numeracy were entered in Step 1, and Faith in Intuition was entered in Step 2. Standardized beta coefficients and fit information for both models are presented in Table 7.

In Model 1, verbal intelligence, $\beta = .31$, $p < .001$, numeracy, $\beta = .50$, $p < .001$, and BIS-attn, $\beta = -.09$, $p = .03$, significantly predicted CRT scores in Step 1. For Step 2, verbal intelligence, $\beta = .18$, $p = .003$, and numeracy, $\beta = .55$, $p < .001$, were positive predictors. BIS-attn scores negatively predicted CRT scores, $\beta = -.08$, $p = .06$, though this association was non-significant. Faith in Intuition significantly, negatively predicted CRT scores, $\beta = -.09$, $p = .03$.

In Model 2, verbal intelligence, $\beta = .30$, $p < .001$, numeracy, $\beta = .50$, $p < .001$, and BIS-motor, $\beta = -.10$, $p = .02$, significantly predicted CRT scores in Step 1. For Step 2, verbal intelligence, $\beta = .29$, $p < .001$, and numeracy, $\beta = .48$, $p < .001$, were positive predictors while the BIS-motor subscale, $\beta = -.09$, $p = .046$, and Faith in Intuition, $\beta = -.09$, $p = .039$, both significantly, negatively predicted CRT scores.

Table 7

*Study 2 multiple linear regressions for BIS-attention and BIS-motor predicting CRT scores*

| | Step 1 | Step 2 | | Step 1 | Step 2 |
|---|---|---|---|---|---|
| *Covariates* | | | *Covariates* | | |
| Verbal intelligence | .31*** | .30*** | Verbal intelligence | .30*** | .29*** |
| Numeracy | .50*** | .49*** | Numeracy | .50*** | .48*** |
| *Predictor variable* | | | *Predictor variable* | | |
| BIS-attention | -.09* | -.08 | BIS-motor | -.10* | -.09* |
| Faith in Intuition | | -.09* | Faith in Intuition | | -.09* |
| Adjusted $R^2$ | .45 | .45 | Adjusted $R^2$ | .45 | .45 |
| $\Delta R^2$ | .008 | .008 | $\Delta R^2$ | .01 | .007 |
| $F$ | 92.14*** | 71.22*** | $F$ | 92.89*** | 71.43*** |

*Note:* $N = 340$. Standardized beta coefficients listed. ***$p < .001$; *$p < .05$;

**Discussion**

Similar to Study 1, results from Study 2 again showed that while dispositional impulsiveness is related to CRT scores, the association is weak and its significance depends on whether certain other variables are controlled for. Specifically, scores on the BIS-11 and the Eysenck $I_7$ negatively predicted scores on the CRT after controlling for cognitive ability and Need for Cognition (NFC). However, when Faith in Intuition (FI) was entered into the model as a covariate rather than NFC, neither measure of impulsiveness reached significance. This makes sense given that, in this data set, the bivariate and partial correlations between our impulsiveness measures and FI were significant and positive, suggesting a possible small amount of construct overlap. That said, the relation between CRT, impulsiveness, and NFC took an unusual form in Study 2 in that the relation between NFC and CRT became negative and non-significant in our regression models, which is the reverse of Study 1 and conflicts with results from previous research examining these variables (Frederick, 2005; Littrell et al., 2019; Pennycook, Cheyne, Koehler, & Fugelsang, 2016). Though this result was unexpected, based on the large data sets in the literature supporting the associations we found between CRT and NFC in Study 1, the most plausible explanation for this isolated finding in Study 2 is a spurious relation due to sampling differences.

In the exploratory analyses, the BIS-motor and BIS-attn were both significant predictors of CRT performance, though only the BIS-motor remained significant after controlling both for cognitive ability and FI. This supports the findings of Study 1 and suggests that the BIS-motor captures some aspect of impulsiveness (or at least has less overlap with NFC and FI) that predicts CRT performance.

Overall, these results provide more evidence that lower CRT scores are related to aspects of dispositional impulsiveness, but only weakly. Contrary to Study 1, however, we did find some evidence that lower CRT scores might be associated with intuitive thinking processes. However, as this result conflicts with Study 1's findings which suggested that Need for Cognition, rather than Faith in Intuition, was a significant covariate, it is again important to emphasize that caution should be used when interpreting these results, as they continue to be small and may be largely explained by simple differences in natural variation within our samples.

## General Discussion

An influential framework in judgment and decision-making draws a critical distinction between Type I processes, those that are autonomous and do not require working memory, and Type II processes which enable more reflective thinking. Extant conceptualizations of relying on Type 1 processing suggest a strong link to dispositional impulsiveness but the existing research examining this relation has yielded mixed results. The present investigation set out to put the nature of that relation on stronger footing. Across two studies with 540 participants, we found evidence that dispositional impulsiveness is related to CRT performance, but this association is weak and further attenuated when certain cognitive factors are taken into account. In the following, we expand upon and provide broader context for these findings.

### *Trait Impulsiveness and Cognitive Reflection*

Higher impulsiveness scores on both the BIS-11 and the Eysenck $I_7$ were associated with lower CRT scores at the bivariate level. When controlling for numeracy and verbal intelligence, the modest associations between self-reported impulsiveness and CRT diminished further and, when controlling for individuals' cognitive thinking style preferences (i.e., Need for Cognition or Faith in Intuition), these relations became non-significant (though the beta values are not appreciably different). These results are generally consistent with prior research which did not find a significant association between the BIS-11 and CRT performance when controlling for cognitive ability ($\beta = -.06$, $p = .17$; Littrell et al., 2019) and further support the notion that engagement in (and disruption of) reflective processes is a complex and multi-dimensional phenomenon deserving of deeper investigation.

One perspective on the reduction in the correlation between self-reported impulsiveness and CRT when controlling for cognitive ability is that both constructs are related to executive control (Olrati et al., 2016; Necka et al., 2018). While the relation between the latter and measures of verbal intelligence is a point of contention (Ardila, Pineda, & Rosselli, 2000; Necka et al., 2018; Whiteside et al., 2016), if we accept that they do share variance, then the present results would be consistent (indirectly) with the idea that the bivariate relation between impulsiveness and CRT is a product of this overlap. That said, the present research was not designed to test this notion directly and as such it would be useful for future research to examine it, for example, by relating self-reported impulsiveness, CRT, and measures of executive control. More broadly, it should be noted, that impulsiveness, broadly, is a multidimensional construct and some self-report measures might not sufficiently capture certain aspects of impulsiveness (e.g., behavioural) that could be more strongly associated with engagement in cognitive reflection or might be better indexed by other types of impulsiveness measures (e.g., behavioural). Additionally, the CRT is only one purported way to measure cognitive reflection and researchers should take care not to generalize these findings as applying to cognitive reflection more broadly.

Our analyses also revealed the BIS-motor (i.e., motor impulsiveness) to be a consistent, statistically significant negative predictor of CRT scores. This effect, though small, still held after controlling for cognitive ability and cognitive thinking style and is arguably one of our more consistent findings. This suggests that some aspect of dispositional impulsiveness unique to the BIS-motor subscale is able to predict CRT scores and does not overlap with our measures of cognitive thinking style. The fact that so-called "motor impulsiveness" predicts scores on a cognitive measure may seem counter-intuitive but makes sense on closer examination of the subscale items. For instance, the BIS-motor contains items such as:

*I make-up my mind quickly*

*I do things without thinking*

*I act "on impulse"*

*I can only think about one thing at a time*

Though the authors of the BIS-11 consider these items indicative of "motor impulsiveness," the items arguably index aspects of Type I impulsive cognitive responses. For instance, the sense that one “makes up [her] mind quickly” arguably reflects an aspect of *cognitive miserliness.* Stanovich (2018) has argued that "miserly thinking" involves defaulting to cognitive processes that use low computational power insufficient to override Type I responses for certain decisional tasks often leading to lower engagement in reflection. It could be the case that dispositionally impulsive individuals are more averse to engaging in cognitive effort in that when the quick, fluent answer springs to mind, considering a second, alternative idea would require more cognitive effort than the impulsive individual is willing or capable of expending. This idea finds empirical support in the present results given that dispositional impulsiveness (across all scales) was consistently, negatively related to Need for Cognition (i.e., propensity to engage in cognitively effortful tasks), even after controlling for cognitive ability.

One pattern that seems clear in considering predictors of cognitive reflection as measured using the CRT is that generic cognitive ability measures consistently explain a significant amount of variance. Following cognitive ability, there are other dispositional measures that, across studies, appear to capture smaller, but plausibly non-zero, amounts of variance in CRT performance. These include Need for Cognition and Faith in Intuition (Frederick, 2005; Pennycook et al., 2015) and, we would argue, impulsiveness. These constructs, it appears, are also related to one another and the extent to which each explains unique variance in CRT performance remains to be seen. Critically, the strength of the relations between these “second-level” variables and CRT performance are small and as such will be sensitive to vicissitudes of measurement across different studies.

***Interrelations between impulsiveness measures***

It is also worth noting that the association between delay discounting and measures of dispositional impulsiveness in Study 1 was weak, further diminishing and becoming non-significant when controlling for cognitive ability. Neither was delay discounting a significant predictor of CRT scores when cognitive ability was included as a covariate. These effects occurred despite the fact that the association between the dispositional measures of impulsiveness (i.e., BIS-11 and Eysenck $I_7$) was largely unaffected when controlling for cognitive ability.

This has important implications and might be surprising to some, given that delay discounting is often discussed and operationalized specifically as a measure of impulsiveness (Bickel, Odum, & Madden, 1999; Matta, Gonçalves, & Bizarro, 2012; Perry, Larson, German, Madden, & Carroll, 2005). However, the associations of delay discounting with dispositional measures of impulsiveness found throughout the literature tend to be weak, at times arguably underpowered, and generally do not account for cognitive ability (Bickel, Odum, & Madden, 1999; Kirby & Finch, 2010; Kirby, Petry, & Bickel, 1999), calling into question delay discounting's pervasive use as a measure of impulsiveness, broadly. Additionally, the associations between delay discounting and traditional behavioural measures of impulsiveness also range from tenuous to small and non-significant (Reynolds, Ortengren, Richards, & de Wit, 2006) with some researchers suggesting that discounting be considered as distinct from impulsiveness (Holt, Green, & Myerson, 2003). Given this conflict in the literature, as well as our own results presented here, it seems inappropriate to treat impulsiveness and delay discounting as theoretically or empirically isomorphic. Indeed, given the widely recognized multi-dimensionality of impulsiveness (Evenden, 1999), coupled with the inconsistent associations in past studies, future research would benefit from operationalizing measures of impulsiveness and delay discounting as capturing weakly related, yet largely separate, constructs.

**Conclusion**

The present results demonstrate that dispositional impulsiveness is associated with performance on the CRT, but this relation is weak and can disappear when factors such as cognitive ability and thinking style are taken into account. While the relation was modest, the present work supports the general effort to examine dispositional predictors of cognitive reflection in an attempt to understand the processes governing its application.

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