Look Before You Leap: the effects of cognitive impulsiveness and reasoning process on rational decision making

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February 6, 2017

Abstract

Impulsivity may lead to several unfortunate consequences and maladaptive behaviors for clinical and non-clinical people. It has a key role in many forms of psychopatology. Although many studies discuss the negative impact of it, few of them emphasize the relationship between cognitive impulsiveness and decision making in non-clinical subjects. The aim of this study is to investigate the effects of cognitive impulsiveness on decision making and explore the strategies used by non-clinical participants to solve problems. For this purpose, we apply two measures of impulsivity: the self-report Barratt Impulsiveness Scale (BIS-11) and the performance based Cognitive Reflection Test (CRT). This is the first study that compares self-report impulsiveness based on BIS-11 with performance-based reflectivity measured by CRT. Moreover, we evaluate participants' reasoning processes employed to answer CRT questions based on the calculation expressions and data organization they made while answering the CRT, notice that we apply the instruments with pen and paper. These reasoning processes are related to the role of Executive Functions

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for decision making and its relationship with impulsiveness. The sample consists of 191 non-clinical adults, either professionals or undergraduate students from the fields of business, management or accounting. Results show that cognitive impulsiveness may negatively affect decision making, and that who calculate CRT questions on the paper sheet make better decisions. Moreover, there is no difference in strategies used by impulsive and non-impulsive people during a decision making. Finally, people who inhibit their immediate answers also perform better during a decision making.

Keywords: Impulsivity, BIS-11, Reflectivity, CRT, Executive Functions, Dual Process, Reasoning Process, Decision Making.

1 Introduction

How to explain why people from well-known universities or from big companies make mistakes in simple reasoning questions? Did they skip math classes in high school? Although it could be true for some of them, the majority of educated people may make mistakes on simple reasoning tasks because they misuse their own cognitive resources.

Frederick (2005) developed the Cognitive Reflection Test (CRT), a three-item task with simple reasoning problems to measure cognitive reflection ability (reflectivity and impulsivity) presenting the following questions:

(1) "A bat and a ball cost $1.10 in total. The bat costs $1.00 more than the ball. How much does the ball cost?"

(2) "If it takes 5 machines 5 minutes to make 5 widgets, how long would it take 100 machines to make 100 widgets?"

(3) "In a lake, there is a patch of lily pads. Every day, the patch doubles in size. If it takes 48 days for the patch to cover the entire lake, how long would it take for the patch to cover half of the lake?"

Frederick originally applied the test on a sample of students from well-known universities and, surprisingly, found that students from Harvard University (Princeton University) scored only 1.43 (1.63) on average, on a score that ranges from 0 to 3.

What may explain these intriguing results is what researchers call cognitive Dual Process. Literature suggests that people have two types of cognitive processes: System 1 and System 2 (Kahneman and Frederick, 2002; Stanovich and West, 2000; Shafir and LeBoeuf, 2002). While System 1 is related to an impulsive way of thinking, System 2 is a reflective style of decision making (Table 1). That is, even though people know how to answer specific questions and how to make good decisions, they may misjudge if they use the impulsive cognitive system.

[PLEASE, INSERT TABLE 1 HERE.]

Studies on Naturalistic Decision Making suggest that experienced professionals present

great performance using their System 1 cognitive style when solving problems (Klein, 1999). Klein performed a series of studies where he and his research team followed the daily routine of firefighters, pilots, nurses, chess masters and other specialists to investigate how experienced professionals make decisions in real-life settings under fast changing circumstances. One of the stories they witnessed about a firefighter team was the following:

> It is a simple house fire in a one-story house in a residential neighborhood. The fire is in the back, in the kitchen area. The lieutenant leads his hose crew into the building, to the back, to spray water on the fire, but the fire just roars back at them. "Odd", he thinks. The water should have more of an impact. They try dousing it again, and get the same results. They retreat a few steps to regroup. Then, the lieutenant starts to feel as something is not right. He doesn't have any clues; he just doesn't feel right about being in that house, so he orders his men out of the building - a perfectly standard building with nothing out of the ordinary. As soon as his men leave the building, the floor where they had been standing collapses. Had they still been inside, they would have plunged into the fire below (p.32).

As we can see, the decision maker was simply performing an automatically-provided action (Linhares, 2007). The lieutenant was intuitive and not impulsive like Frederick's students. Intuition is also related to non-deliberative thinking. However, it involves pattern matching and recognition of familiar and typical cases (Klein, 1999). Thus, experience plays a key role in successful intuitive decision making. Finally, although students from the best universities in the world may be used to perform reasoning tasks, the CRT was unknown to them. In that way, the use of System 1 cognitive style led to some unexpected low scores among students.

One of the main focus of this study is to explore the mechanisms of cognitive impulsiveness. That is, although it is well known that people may provide correct or incorrect answers due to the use of these different cognitive processes, we are not sure about the strategies that could distinguish when they are using one system or the other. More specifically, we do not know whether people give wrong answers and make bad decisions due to their impulsiveness by using System 1 more frequently or because they do not have the knowledge to give right answers and make better decisions.

In this way, we aim to investigate the effect of impulsivity on rational decision making and explore the strategies people use to solve problems. Although Frederick evaluated the reflectivity of participants providing significant contribution to the literature on cognition and decision making, he and other authors using the same instrument (Alos-Ferrer et al., 2016; Cueva Herrero et al., 2015; Primi et al., 2015; Toplak et al., 2014, 2011) did not investigate whether participants could present impulsive personality traits and neither explained the process of reasoning they used to answer CRT questions. This study intends to fill these gaps.

To achieve this goal, a sample of non-clinical adults was selected, to whom we applied a survey with three questionnaires. The self-report Barratt Impulsiveness Scale (BIS-11) was used to evaluate impulsive traits of personality, the CRT to evaluate reflectivity for decision making, and sociodemographic questions. Aiming to evaluate participants' strategies to answer CRT questions (calculation and data organization), we applied the survey with pen and paper.

Impulsivity has a key role in many forms of psychopatology (Verdejo-García et al., 2007; Malloy-Diniz et al., 2011) and the Barratt's impulsivity model is one of the most widely applied and recognized model (Stanford et al., 2009) to investigate it. According to this model, impulsiveness personality trait is composed of three subtypes: non-planning impulsiveness (orientation toward present and cognitive complexity), motor impulsiveness (act on the spur of the moment), and attentional impulsiveness (lack of attention and concentration) (Patton et al., 1995). However, only two factors (inhibition control and non-planning) were found for BIS-11 adults version in the Brazilian context (Vasconcelos et al., 2012; Malloy-Diniz et al., 2015). The Cognitive Reflection Test, as mentioned before, is a performance-based three-item task which measures reflectivity through simple reasoning questions (Frederick, 2005).

The strategies developed to answer CRT questions are strictly related to the Executive Functions, which are the mental processes required when one needs to concentrate and pay attention to achieve a goal. It allows us to mentally play with ideas, consider responses rather than being impulsive, resist temptations, solve problems, and be creative when meeting unanticipated challenges (Diamond, 2013). Executive Functions act as a manager of our cognitive resources such as planning, decision making, and flexibility, which are used to accomplish an objective.

Regarding psychometric measures of impulsivity, to our knowledge there is no research assessing the relationship between impulsivity and decision making related to logical and abstract reasoning, based on self-report and behavioral measures such as reasoning process and performance. Actually, most studies that use both types of measurements focus on the relationship between impulsivity and mental disorders such as substance abuse (McGue et al., 2001; Tarter et al., 1999; Petry and Casarella, 1999; Dougherty et al., 2009) or obesity (Fields et al., 2013). Studies that also focus on impulsivity in healthy adults investigate the reliability of impulsivity measures in wide dimensions related to personality traits and behaviors(Reynolds et al., 2006). In this perspective, there is no study using both CRT and BIS-11 as measures of impulsivity on non-clinical adults.

Considering the assessment of the impulsivity subtypes following Barratt's model, the present study focuses on non-planning impulsiveness. From a neurobiological perspective, this subtype is analogous to a "cognitive impulsiveness", which in turn is associated with decision making (Bechara et al., 2000). According to Bechara's model, cognitive impulsiveness is related to an inability to delay gratification, which is in line with the

orientation toward present characteristic of the non-planning impulsiveness subtype.

Although there are some differences between the characteristics of cognitive System 1 and non-planning impulsiveness, such as consciousness of actions, there are also similarities that are crucial in leading to mistakes during a decision making process. Planning is the anticipation of events and consequences as well as monitoring of goal attainment. It is most salient in problem-solving activities that call for novel solutions (Krikorian et al., 1994). The use of System 1 during decision making is a result of lack of planning. Abstract reasoning and consequential decision making required to planning are strictly related to characteristics of the System 2 cognitive process. The fast, associative, automatic and experience-based characteristics of System 1 cognitive process may be in line with the lack of planning, which leads to impulsive decision making and, consequently, to disadvantageous choices. Thus, our first hypothesis predicts that high levels of the non-planning impulsiveness trait negatively affect performance on rational decision making. Moreover, the second hypothesis foresees that high levels of the non-planning impulsiveness trait negatively affect manipulation of apparent information needed to solve problems.

This study could provide significant contribution for the development of a tool to measure non-planning impulsiveness. This is an important subtype of impulsivity which is hard to evaluate, at least using self-reported measures (Barratt, 1993). Moreover, it is not proportional to the variety and availability of tools to measure the non-planning impulsiveness comparing to the other subtypes. That is, even though there are several tests to measure motor impulsiveness, for instance, there are few tools to measure non-planning impulsiveness (Malloy-Diniz et al., 2010).

This work could also be valuable for tools that measure Executive Functions. The advantage of using pen and paper to collect data is that it allows us to investigate how participants use their Executive Functions during the reasoning process. For the successful accomplishment of several daily activities, people should clearly identify their final objective, plan a list of goals and use a hierarchical organization that makes its execution feasible (Malloy-Diniz et al., 2014). Nevertheless, people should perform the planned steps constantly evaluating the success of each one, correcting the unsuccessful ones, and adopting new strategies if necessary. Great ability of inhibitory control, working memory and cognitive flexibility are important to plan, pay attention and persist until the end of a task (Diamond, 2013). Thus, our third hypothesis suggests that the more participants manipulate data following a structured reasoning, the better their performance on rational decision making will be.

The benefits of the data collection in the present study admit a different perspective for the evaluation of Executive Functions. Such data emerged from an individual and singular procedure with no explicit instructions, as usually occurs with neuropsychological tasks (Krikorian et al., 1994; Heaton et al., 1993; Bechara et al., 1994). Thus, it presents more spontaneous and ecological data. More specifically, it may be useful for the evaluation

of fluency, decision making, planning and cognitive flexibility. Fluency is the ability to emit verbal and non-verbal behaviors, in sequence, following implicit and explicit pre-settled rules. Decision making is a process that involves the choice of one among several alternatives in situations where there is some level of uncertainty. Planning consists of the ability to create the best way to achieve a defined goal, regarding the rank of steps and the necessary tools to accomplish it (Malloy-Diniz et al., 2014). Finally, cognitive flexibility involves being flexible enough to adjust to changed demands or priorities, to admit we are wrong, and to take advantage of unexpected situations (Diamond, 2013). Therefore, our fourth hypothesis predicts that people who initially succumb to an impulsive answer during decision making, but rethink about it and change their initial answer, present a satisfactory performance when solving problems. That is, cognitive flexibility positively affects rational decision making.

The main results of the present study suggest that people with higher levels of cognitive impulsiveness have lower performance on rational decision making tasks, and that the use of different strategies plays an important role in obtaining better outcomes when solving problems. Based on these results, loss-limiting strategies may be developed, especially for people who present high levels of impulsive personality traits. New tools for a cognitive impulsiveness investigation may be created and applied to more cautious interventions for personal and clinical treatments. Finally, for scholars investigating cognition and intelligence in humans, data about the reasoning process is scarce (Hofstadter, 2008). Thus, the present study could provide valuable contribution and a better understanding about this issue.

In conclusion, some critiques regarding studies on judgment and decision making claim that they focus on performance, leaving aside important dimensions (Bonner, 2008). This study intends to fill this gap presenting important data about intrinsic characteristic, performance and the reasoning process, giving significant contribution to the literature on judgment and decision making.

This work is divided in four sections. Beyond this brief introduction, the second section discusses the method employed. After that, the results are presented in the third part and, finally, the fourth offers a discussion and conclusion.

2 Material & Methods

2.1 Participants

The sample was comprised of 191 non-clinical participants who were professionals (74.8%) and undergraduate students (25.2%) from the fields of business, accounting or management. The sample is composed of 44.3% women, and participant's mean age was 33.9 years (SD=10.23). In total, 191 participants answered the survey, but seven

participants did not inform their monthly income, 11 did not answered some CRT question, and one of them left one BIS-11 question unanswered. Thus, due to missing values, the analyses sample number varies between 183 and 179 in the hypotheses tests.[1] The participants were volunteers recruited from a well-known Brazilian entertainment company, from the public sector administration program at the Getulio Vargas Foundation (FGV), and from accountancy undergraduate program at the State University of Rio de Janeiro (UERJ), both of which are prestigious universities in Brazil. Hence, we assume that all participants were able to read, interpret questions and perform the four basic math operations (add, subtract, multiply, and divide). Inclusion criteria were: ages above 18 years and higher education completed or underway. Participants were excluded from the study otherwise. This study was approved by the Human Subjects Review Committee of FGV-EBAPE (Cod: 18032016-1710).

2.2 Instruments

- Cognitive Reflection Test (CRT) (Frederick, 2005): it is a performance-based three-item task. It is comprised of three reasoning questions that respondents answer, correctly or incorrectly, and scores range from 0 (no correct answer) to 3 (all answers correct). It measures one type of cognitive ability: the tendency to override a premature response that is usually incorrect and to engage in reflective reasoning which usually leads to correct answers. The translation to Portuguese was carried out by researchers themselves. The first question in the CRT was adapted to local Brazilian reality and culture because baseball is not well-known in the country. Thus we replaced "bat" and "ball" for candy (*bala*) and bubble gum (*chiclete*).

- Barratt Impulsiveness Scale (BIS-11) translated version (Malloy-Diniz et al., 2010): this is a self-report Likert scale from 1 to 4 (1 = rarely/never; 4 = almost always/always) consisting of 30 items that evaluate the behavior construct and personality of impulsivity. This scale measures the three subtypes of impulsivity (non–planning impulsiveness, attentional impulsiveness, motor impulsiveness) and the total impulsiveness, which is the sum of the subtypes. Nevertheless, for the Brazilian context, a two-factor division (inhibition control and non-planning impulsiveness), besides the total score, was better adapted (Malloy-Diniz et al., 2015, 2010).

- To evaluate the strategies used by participants we observed how they answered CRT questions on their answer sheet. In this way, we were able to observe three types of CRT answers: those that do not present any externalization or calculation expression

[1] Supplementary Material Table 1 presents the hypotheses tests using variables with no missing values, which shows that results do not change.

or reasoning (*No expression*), answers that show some data organization but with no persistence to the development of calculation (*Organization*) and answers with high manipulation of data, demonstrating a rationale with some structured sequences of reasoning (*Calculation*) as shown in Figure 1.

[PLEASE, INSERT FIGURE 1 HERE.]

Something curious in the CRT answers is that some people answered the question, erased and changed the answer, showing calculation or not (Figure 2). It seems that participants, at first, answered impulsively, but then reconsidered their answers and changed their minds, presenting cognitive flexibility during decision making. This variables was termed as "Erasure".

[PLEASE, INSERT FIGURE 2 HERE.]

2.3 Procedures

Procedures were very simple. Participants answered the survey with pen and paper in a one session of 30 minutes maximum. One part of the respondents answered the survey during an event of a large well-known entertainment company in Brazil, while the other part, composed of undergraduate students and public tender students, answered it in their classrooms, after they returned from a break.

Individually, they answered the CRT, BIS-11 and demographics questions after signing the consent form. Researchers gave directions to answer the questions by themselves without consulting external sources. When in doubt, participants were told to ask the researchers who remained present in the room during procedures for help.

Each CRT questionnaire had a blank space for participants to use for their calculations, if necessary. However, not to influence participants on their decisions of whether or not to use such blank spaces, nothing was said about the possibility of doing calculations in those spaces. At the end, participants returned the protocol with their answers and their consent form. We stored both documents separately, and gave them a code to ensure anonymity.

2.4 Statistical Analyses

Descriptive analysis was used in order to characterize the sample as depicted in Table 2. Age, gender, occupation, and income are the demographic characteristics of the sample. The annual income variable is a categorical variable ranging from US$ 7,536.23 (income0) to over US$ 48,985.50 (income5)[2].

[2]Participants were asked their monthly income in the Brazilian currency (Real, BRL), which was converted into U.S. dollars at the average rate for the period of data collection (i.e., USD 1 = BRL 3.45) then multiplied by 13 (i.e., 12 months plus the thirteenth salary).

Aiming to define which criteria would be used to differentiate the cognitive processes variables (*No* expression, *Organization*, *Calculation* and *Erasure*), two researchers and an assistant analyzed and coded these variables of each questionnaire to reach a consensus about it. Considering the assessments of BIS-11, we analyzed the data using the two-factor structure rather than the original three-factor one (Vasconcelos et al., 2012; Malloy-Diniz et al., 2015), since our sample is comprised of Brazilians. Moreover, BIS-11 is a 30 question Likert scale that ranges from 1 to 4. Thus, it is important to emphasize that there are 11 questions aiming to assess non-planning impulsiveness, and 19 questions to evaluate inhibition control impulsiveness, resulting in a total of 30 questions that evaluate the total impulsiveness measurement in the BIS-11 scale. The minimum score for non-planning is 11 and the maximum is 44; for inhibition control impulsiveness the minimum and maximum scores are 19 and 76; and for total impulsiveness the minimum and maximum scores are 30 and 120. Data were analyzed using Stata version 14.1.

[PLEASE, INSERT TABLE 2 HERE.]

Table 3 presents the correlation analysis applying Pearson Correlation Coefficients. The investigated variables are the total of the two subtypes of impulsivity (inhibition control impulsiveness and non-planning impulsiveness), the total impulsiveness, the sum of the *No expression*, *Erasure*, *Organization*, and *Calculation* variables to answer CRT test, and the sum of correct answers in CRT for each respondent.

[PLEASE, INSERT TABLE 3 HERE.]

An Ordinal Least Square (OLS) and an Ordered Logistic Regression (Ologit) were performed to test the hypotheses. The dependent variables are interval and ordinal. Thus, the results of both methods may be useful to evaluate the robustness in the findings. The OLS presents a simple result, and its coefficient allows a direct interpretation. On the other hand, the Ologit is also appropriate for the analyses since our dependent variables may be ordered from 0 (highest level of impulsive trait), which are the participants who did not present any correct answer or people who did not do any calculation to answer them, to 3 (highest level of reflectivity), participants who answered all three CRT questions correctly or those who did calculations on the sheet of paper to answer all of them. Finally, both methods admit the control of important variables that could influence the outcomes of the dependent variables such as income (Dohmen et al., 2010). Inhibition control impulsiveness was added to the model as control variable for the non-planning impulsiveness effects. Moreover, *Organization* variable is a control variable for the effect of *Calculation*[3].

[3]Supplementary Material Table 2 presents the analyzes of hypotheses tests with no demographic variables in all models.

3 Results

Table 4 presents the results. For the hypotheses tests, results of both regression methods were only different for the first hypothesis regarding p-value. In this way, OLS coefficients are reported because they allow a direct interpretation. The following results do not present standardized coefficients because variables are on the same scale.

[PLEASE, INSERT TABLE 4 HERE.]

Hypothesis 1 predicted that high levels of non-planning impulsiveness would negatively affect performance on decision making (CRT). After entering the demographic variables and controlling for the other impulsivity subtype, the regressions showed that hypothesis 1 was supported ($\beta = -.05, p < .05$). Despite the small coefficient value, this result suggests that people who are usually present-oriented and do not think carefully may make worse choices during a decision making process than people with lower levels of non-planning impulsiveness who are more future-oriented and careful to make decisions.

Hypothesis 2 suggested that higher levels of non-planning impulsiveness would lead people to less frequently manipulate the data performing calculations to answer CRT questions. Results show that this hypothesis was not supported. People with higher levels of non-planning impulsiveness would not necessarily perform less calculation to answer CRT questions. That is, there is no difference between people with high levels of cognitive impulsiveness and people with low levels of cognitive impulsiveness in their strategies to answer CRT questions and making decisions.

Hypothesis 3 stated that higher levels of data manipulation, which means a deeper development of a structured reasoning and calculation to answer CRT questions, would lead participants to perform better on CRT than those who do not engage in calculation. The hypothesis was supported ($\beta = .32, p < .001$). It suggests that the development of a complete thought may lead to better outcomes than only making notes and not expressing the reasoning and calculation.

Finally, the last hypothesis suggested that people who presented erasures to answer CRT questions, that is, people who gave an answer at first but changed their mind presenting another answer showing cognitive flexibility during rational decision making would have better performances on CRT. The hypothesis was supported ($\beta = .43, p < .01$) proposing that those who are able to inhibit and reconsider immediate responses may make better decisions.

Although the present study is not focused on the variables used as controls to test the hypotheses such as gender, age, occupation, and income, their results presented interesting and significant findings. Similarly to previous studies, this study identified that gender has a significant impact on CRT scores ($\beta = -.42, p < .05$); i.e., men score significantly higher than women on CRT (Frederick, 2005; Hoppe, 2011; Oechssler J, 2009). However, an original evidence provided by this study is that gender has no impact on the decision

to engage in calculation. Moreover, senior participants had a lower performance than younger ones during their decision making ($\beta = -.03, p < .01$) and they calculated less to answer CRT ($\beta = -.03, p < .05$). Also, professionals performed less calculation than students to answer CRT ($\beta = -.90, p < .01$), but they did not differ on CRT scores. Lastly, people with higher incomes perform more calculations than their lower income peers ($\beta = 1.39, p < .001$) but income did not have impact on rational decision making. Results related to gender and age are in line with a recent study that uses a larger and similar sample (Barcellos et al., 2016).

4 Discussion and Conclusion

Impulsivity has a key role in many forms of psychopatology (Verdejo-García et al., 2007; Malloy-Diniz et al., 2011). However, few studies investigate the impact of this important construct on logical and abstract reasoning using both self-report and behavioral measures on non-clinical adults. Actually, most studies that use both types of measurements focus on the relationship between impulsivity and mental disorders such as substance abuse (McGue et al., 2001; Tarter et al., 1999; Petry and Casarella, 1999; Dougherty et al., 2009) or obesity (Fields et al., 2013). Studies that investigate impulsivity in healthy adults are focused at most on the reliability of impulsivity measures (Reynolds et al., 2006). Aiming to fill this gap, the goal of this study is to investigate the effect of impulsiveness on decision making and explore the strategies people use to solve problems. For this purpose, we applied two measures of impulsivity: Barrat Impulsiveness Scale (BIS-11) (Patton et al., 1995) and Cognitive Reflection Test (CRT) (Frederick, 2005) in a sample of 191 non-clinical adults that are professionals or undergraduate students from the field of business, accounting, or management. BIS-11 is a self-report scale based on a model in which impulsivity is composed by three subtypes: motor impulsiveness, attentional impulsiveness, and non-planning impulsiveness, but we used the two-factors version validated in Brazil (Malloy-Diniz et al., 2010, 2015) because our sample is comprised of Brazilians. The CRT is a performance-based three-item task that aims to measure cognitive reflection ability. Pen and paper were used to answer the questionnaires, therefore it was possible to evaluate which strategies participants used to answer the questions, which were coded as *No expression*, *Erasure*, *Organization*, and *Calculation*. *Calculation* was considered the strategy with the highest data manipulation compared to the other strategies, and the one closest related to the best employment of Executive Functions. *Organization* was treated as the beginning of a logical reasoning organization of information and data. *Erasure* was the act of rethinking an answer, and *No expression* was the act of presenting an answer with no externalization of reasoning processes. Table 5 summarizes the evidences collected in this study from all tested hypotheses.

[PLEASE, INSERT TABLE 5 HERE.]

Results show some interesting findings. The first hypothesis outcome suggests that higher levels of non-planning impulsiveness lead to worse performance on CRT. In our daily lives it may appear in the form of frustration and stress. Non-planning impulsiveness may lead people to make disadvantageous choices since there may not be a logical reasoning for the choices made when logic is required. In unusual situations planning has a key role in finding satisfactory solutions for a problem (Krikorian et al., 1994). Thus, whether people do not have much previous experience in a given situation, it takes them more time and more cognitive effort to develop a hierarchical plan and follow it successfully. When they act without these concerns, they make mistakes that lead them to frustration and to incapable thoughts that limit their capability of reaching a positive solution. The problem may lie in the way they are dealing with the situation rather than who they think they are.

There are common situations in our lives where planning and structured reasoning are required for making successful choices. Some examples are: sitting for a school exam; buying a new cellphone, computer, apartment or car. In business, lack of planning and logical reasoning may lead to unfavorable choices being made when strategic decisions need to be performed but better strategy design is not implemented due to impulsive decision making.

Another finding is that maybe there is no difference between the strategies used by people with high levels of non-planning impulsiveness and non-impulsive people to answer CRT questions. This may be explained due to compensatory behaviors (Anderson and Bulik, 2004), that is, impulsive people that are aware about their impulsive features may aim to mitigate their impulsiveness by organizing data and performing calculations (if applicable). When making decisions it may be true that impulsive people put extra effort into it because they know they are impulsive and that their impulsiveness could lead to impairments on their decision making processes. However, considering that the first hypothesis is supported, this second finding suggests that some people presented wrong logical sequence of reasoning and gave wrong answers, which is possible to confirm by checking the questionnaires. Thus, participants with high and low levels of non-planning impulsiveness might have presented a logical reasoning sequence while manipulating data to answer CRT questions, but this logical sequence was wrong. This finding is interesting considering that one of the sample inclusion criteria was higher education completed or underway, which implies knowledge of basic math calculations.

The third hypothesis is supported. Performing calculations positively affects CRT outcome. It suggests that when people persist in doing what they had planned their outcomes are better, assuming their plan was effective. This result seems to be intuitive but it is important to highlight the relevance of an adequate employment of Executive Functions. Calculating requires a plan of the necessary procedures to manipulate the given information and following-up with such plan and to change the plan when relevant

circumstances have changed. Thus, it represents an adequate proxy for a successful implementation of important Executive Functions such as planning, inhibitory control and the appropriate use of working memory during rational decision making.

The last hypothesis suggests that people who reevaluate their answers may perform better when making decisions. Even though some participants presented wrong answers due to impulsive reasoning, if they had changed their mind they could have had better results. Thus, cognitive flexibility may play an important role in achieving the best results possible on rational decision making. In this study, participants could think again about their choices and change their minds without having any negative consequences; however, this may not always be possible in their daily lives. Therefore, it is important to inhibit prompted thoughts particularly in new situations, evaluating options carefully and then making the best possible choice. However, if good choices are not implemented, it is valuable to have the ability to find more appropriate solutions depending on the context. Finally, this finding could contribute to the literature on reasoning process conflicts, which investigates the dynamic between Type 1 and Type 2 and the factors that lead to Type 2 engagement (Pennycook et al., 2015). The action of reevaluating the given answer may represent the process of Type 2 monitoring the Type 1 output.

Considering the findings related to gender, income, age and occupation, there is a higher impact of these variables on the reasoning process than on the performance of rational decision making. That is, people present a greater difference of their reasoning structure compared to the choice they make depending on the control variables investigated. Only gender had an impact on decision making but not on the reasoning structure according to results. These findings are in line with data of previous studies about differences between men and women during decision making. Literature suggests that women are more risk averse than men on uncertain decision making (Jain, 2015; Francis et al., 2015). Moreover, Frederick (2005) also found that women had lower performance on CRT than men. Women presented more impulsive answers for each question on CRT (10, 100, and 24), while men presented more diverse wrong answers for these questions (20, 500, and 1). According to the author, this finding suggests that men are more reflective than women. However, in the present study we did not find any differences in the reasoning structure between men and women. That is, considering that performing calculations is an important process related to the act of reflection and making choices, this is an interesting finding that raises a question about the concepts of reflection and reflective thinking used in the literature on decision making and cognitive ability. Moreover, studies on risk behaviour and gender are inquiring about the role of social learning in the difference between men and women to make decisions (Booth and Nolen, 2012; Booth et al., 2014) and the type of test used to evaluate risk preferences (Filippin and Crosetto, 2016) rather than inherent gender traits.

The main contributions of this study include a methodological advancement in literature on decision making and impulsiveness. Differently from studies on decision making that

usually give emphasis only on people's performance, this study complements such evidences adding data about intrinsic characteristics, reasoning process and performance. It also contributes to the literature on impulsivity by presenting evidence using BIS-11, based on the second order sub-scale outcomes, which are different from the usual studies that present evidence based only on the total score. Finally, to our knowledge, this is the first study that uses BIS-11 and CRT as measures of cognitive impulsiveness. Indeed, this is the first research that conducts this type of analysis on non-clinical adults.

This study presents a few limitations, such as the fact that some people may not have performed calculation or other reasoning expressions by hand on paper but they may have done it mentally or using other resources such as the surface of a table or their own palm, for instance. Another limitation is that the sample is restricted to specific fields of study and professionals who have similar specialities.

Moreover, we cannot observe the relationship between *Calculation* and *Erasure* when participants present both on their CRT answers. That is, we do not know the sequence performed by participants, if they first answered with no calculation, then rethought, performed the calculation and then changed their answer (*Erasure*), or if they first performed the calculations and answered the questions, thought about it and performed more calculations then changed the answer (*Erasure*) as shown in Figure 3. Finally, data collection was not performed in a standardized way since some of the data was collected during a company event and some was collected in classrooms.

[PLEASE, INSERT FIGURE 3 HERE.]

Future research could further investigate the performance of reasoning tasks related to neuropsychological tools that evaluate inhibitory control, decision making, attention, and non-verbal fluency. Furthermore, it would be fruitful to evaluate one's cognitive effort and awareness of self-impulsiveness more deeply. Thus, it would be possible to investigate the issue of compensatory behavior and whether participants are presenting higher cognitive effort compared to the presence or absence of calculations in their answers.

Regarding sample analyses, the replication of this study with different participants would be valuable. That is, it would be interesting to investigate the performance on CRT, cognitive processes and impulsiveness traits with students from different fields and professionals with others specialities. Another suggestion is to measure the time a participant takes to answer each CRT question in order to investigate the relationship between time and impulsive decision making, and to collect information about the processes of reasoning for more detailed analyses. Osman (2013) has a point when she suggests that there are few studies measuring response time in tasks that measure dual processes. Time measurement could contribute to the reliability of the differences between Type 1 and Type 2 processes of reasoning. Moreover, assessment of emotions and somatic markers could bring important insights about reasoning processes, and the investigation of the cognitive overload effects on CRT performances may also contribute to research.

Another interesting future research possibility is the exploration of recent findings about a System 3 together with System 1 and System 2 reasoning processes (Noël et al., 2013). Noel and colleagues suggest that a third neural system is responsible for craving sensations and, consequently for addictions such as gambling and drug addiction. This third system is an insula dependent system which is responsible for the reception of interoceptive signals and their translation into feeling states, presenting significant influence in decision making and impulse control related to risk, reward and uncertainty. Thus, a study that tests and explores this theory using CRT, BIS-11 and other useful tools to measure the association between insula, impulse control and decision making would be a great contribution to both literature and field. Finally, physiological measures such as brain activation using Functional Magnetic Response Image (FMRI) or electroencephalogram (EEG) could be used to assess the coherence between neurophysiological activation, behavior, and feelings.

Disclosure/Conflict-of-Interest Statement

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Author Contributions

APGJ: Had a substantial contribution to the conception and design of the work, conducted survey and statistical analysis, and wrote the manuscript. RLC: Had a substantial contribution to the conception and design of the work, conducted the recruitment of participants, contributed to the statistical analysis and wrote the manuscript. AL: Revised it critically for important intellectual content and had an organizational role.

Acknowledgments

The authors thank all the volunteer participants and acknowledge the Controller of the Brazilian entertainment company who evaluated and approved the research project and invited its professionals to participate in this research. We also would like to thank Leonardo P. Barcellos for his help in insightful discussions and survey conception, Rodrigo O. Leite and Layla Mendes for their help with statistical methodology, Felipe A. P. Fernandes for his support in coding reasoning processes variables and Fernanda Concatto for her help in the data collection. We also thanks Michele M. Bento, who reviewed the manuscript.

Funding During the research the authors received funds from the National Research Council of Brazil (CNPq—www.cnpq.br): 308038/2013-4 (RLC), 308964/2013-6 (AL),

470341/2009-2, Higher Personnel Advancement Coordination (CAPES—www.capes. gov.br): 153174003 (APGJ), Rio de Janeiro State Research Foundation (FAPERJ—www.faperj.br): E-26/102.246/2013 (RLC), E-26/110.790/2009 (AL). The above mentioned institutions do not have any responsibility of data collection and estimation. The research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest. The views expressed in this article represent the authors' point of view, and not from any institution.

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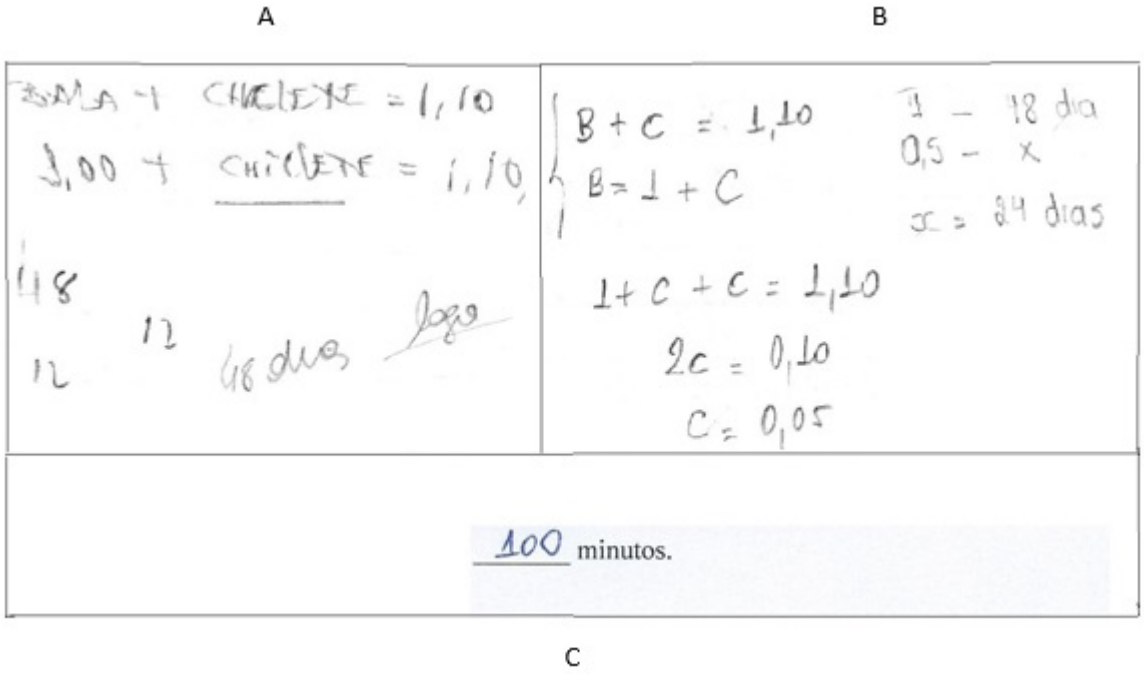
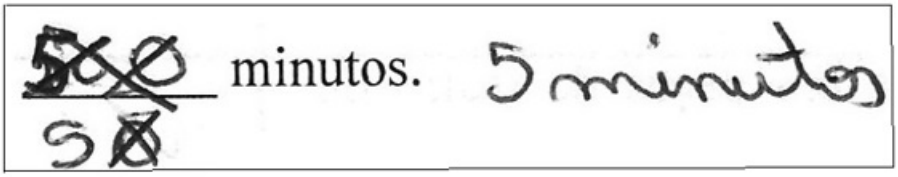
Figures

Figure 1: Illustration of Reasoning Strategies



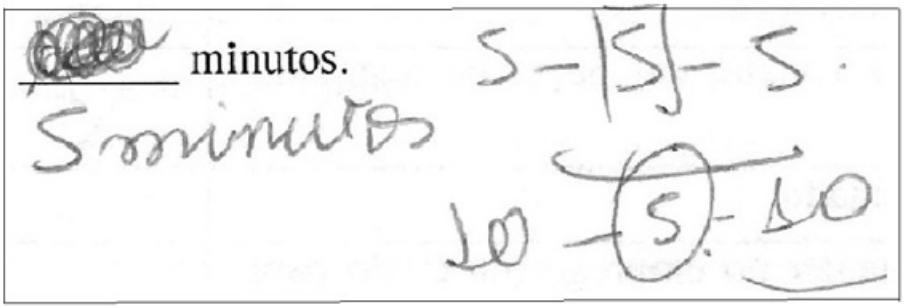
Note: (A) *Organization*: some organization but with no persistence for calculation; (B) *Calculation*: high manipulation of data, demonstrating a rationale with some structured sequences of reasoning; (C) *No expression*: no externalization or expression of calculation or reasoning.

Figure 2: Erasure Variable



Note: *Erasure*: it seems that participants, at first, answered impulsively, reconsidered their answers, and changed their minds.

Figure 3: Erasure and Calculation



Tables

Table 1: Cluster of Attributes Usually Associated to the Models of Dual System and Dual Process Theories Related to Decision Making, adapted from Evans and Stanovich (2013).

Type 1 process (impulsive)	Type 2 process (reflective)
Defining features	
Does not require working memory	*Requires working memory*
Autonomous	*Cognitive decoupling: mental simulation*
Typical correlates	
Fast	Slow
High capacity	Capacity limited
Parallel	Serial
Nonconscious	Conscious
Biased response	Normative responses
Contextualized	Abstract
Automatic	Controlled
Associative	Rule based
Experience-based decision making	Consequential decision making
Independent of cognitive ability	Correlated with cognitive ability

Table 2: Summary Statistics

Variable	**Mean (SD)**	**Min**	**Max**	**N**
CRT	1.21 (1.12)	0	3	187
Non-planning	23.38 (4.42)	13	35	191
Inhibition control	35.78 (6.13)	24	67	191
Total Impulsiveness	59.16 (9.23)	37	87	191
Organization	0.14 (0.41)	0	2	191
Calculation	0.49 (0.89)	0	3	191
Erasure	0.18 (0.45)	0	3	191
No Expression	2.37 (1.01)	0	3	191
Gender (1=female)	0.44 (0.5)	0	1	185
Age	33.9 (10.24)	18	61	185
Occupation (1=professional)	0.74 (0.43)	0	1	191
income0 (up to US$7.536,23)	0.21 (0.41)	0	1	184
income1 (US$7,536.23 to US$13,188.40)	0.07 (0.25)	0	1	184
income2 (US$13,188.00 to US$18,840.57)	0.13 (0.34)	0	1	184
income3 (US$18,840.57 to US$30,144.92)	0.18 (0.39)	0	1	184
income4 (US$30,144.92 to US$48,985.50)	0.21 (0.41)	0	1	184
income5 (above US$48,985.50)	0.2 (0.4)	0	1	184

CRT = sum of correct answers on CRT; Non-planning = total non-planning impulsiveness;
Inhibition control = total inhibition control impulsiveness; Organization = sum of *Organizations*;
Calculation = sum of *C*alculations; Erasure = sum of *Erasures*; No expression = sum of *No expressions*

Table 3: Cross-correlation table

Variables	1	2	3	4	5	6	7	8
1-CRT	1.000							
2-Non-planning	-0.214	1.000						
3-Inhibition control	-0.039	0.517	1.000					
4-Total impulsiveness	-0.129	0.822	0.912	1.000				
5-Organization	0.061	0.008	0.110	0.077	1.000			
6-Calculation	0.300	-0.081	-0.003	-0.041	0.098	1.000		
7-Erasure	0.221	0.038	0.105	0.088	-0.082	0.004	1.000	
8-No expression	-0.288	0.068	-0.041	0.005	-0.487	-0.917	0.030	1.000

CRT = sum of correct answers on CRT; Non-planning = total non-planning impulsiveness;
Inhibition control = total inhibition control impulsiveness; Organization = sum of *O*rganizations;
Calculation = Sum of *Calculations*; Erasure = Sum of *Erasures*; No expression = sum of *No expressions*

Table 5: Summary of Results

Hypotheses	**Supported?**	**P-value**	**Coefficient**	**95% CI**
H1: High levels of the non-planning impulsiveness trait negatively affect performance on rational decision making.	Yes	.02	-.05	[-.09, -.01]
H2: High levels of the non-planning impulsiveness trait negatively affect manipulation of apparent information to solve problems.	No	.52	-.01	[-.04, .02]
H3: The more participants manipulate data following a structured reasoning, the better their performance on rational decision making will be.	Yes	$< .01$	.32	[.17, .47]
H4: Cognitive flexibility positively affects rational decision making.	Yes	$< .01$	.43	[.12, .74]

Table 4: Hypotheses Tests

	Ordinal Least Square (OLS)		Ordered Logistic Regression (Ologit)	
	CRT	Calculation	CRT	Calculation
Non-planning	-0.05*	-0.01	-0.11**	-0.02
	(0.02)	(0.02)	(0.04)	(0.05)
Inhibition control	0.01	0.01	0.02	0.04
	(0.02)	(0.02)	(0.03)	(0.04)
Organization	0.15		0.33	
	(0.15)		(0.33)	
Calculation	0.32***		0.65***	
	(0.08)		(0.17)	
Erasure	0.43**		0.89**	
	(0.16)		(0.34)	
Gender (1=female)	-0.42*	-0.14	-0.86**	-0.27
	(0.17)	(0.14)	(0.32)	(0.35)
Age	-0.03**	-0.03*	-0.07**	-0.07*
	(0.01)	(0.01)	(0.02)	(0.03)
Occupation (1=professional)	0.60	-0.90**	1.20	-2.94**
	(0.40)	(0.31)	(0.72)	(0.89)
income 1	0.44	0.44	0.92	0.68
	(0.37)	(0.27)	(0.75)	(0.80)
income 2	0.39	1.04**	0.68	2.81**
	(0.49)	(0.39)	(0.84)	(1.06)
income 3	0.38	1.25***	0.61	3.66**
	(0.51)	(0.36)	(0.90)	(1.12)
income 4	0.31	1.25**	0.61	3.75***
	(0.50)	(0.38)	(0.88)	(1.12)
income 5	0.54	1.39***	0.80	4.05***
	(0.52)	(0.40)	(0.92)	(1.14)
N	179	183	179	183
R^2	0.293	0.106		
Adjusted R^2	0.237	0.054		
Pseudo R^2			0.129	0.066
F/χ^2	9.93	2.30	61.84	21.54

Standard errors in parentheses
* $p<0.05$, ** $p<0.01$, *** $p<0.001$
Inhibition control is a control variable for the effect of Non-planning.
Organization is a control variable for the effect of Calculation.
CRT = sum of right answers on CRT; Non-planning = total non-planning impulsiveness;
Inhibition control = total inhibition control impulsiveness; Organization = sum of *Organizations*;
Calculation = sum of *Calculations*; Erasure = sum of *E*rasures
income1 = (US$7,536.23 to US$13,188.40)
income2 = (US$13,188.00 to US$ 18.840.57)
income3 = (US$18,840.57 to US$30,144.92)
income4 = (US$30,144.92 to US$48,985.50)
income5 = (above US$48,985.50)