



# Cognitive Reflection and Decision Making

---

Final Thesis

**Taimoor Naseer Waraich**

**4/10/2016**

Thesis Supervisor: Dr Azam Chaudhry

## **Abstract**

We conduct a study which tests the impact of Cognitive Reflection on decision making theories of time and risk preferences. Decision theorists have suggested that people make lottery decisions according to the expected maximum value assigned to the lottery and they also claim that people generally discount the future more. We test these theories using the Cognitive Reflection Test (CRT). We use an extension of the original CRT which was a 3 item test based on the dual system theory and was used to divide people into different cognitive groups according to their scores. Originally the test was developed by Fredrick (2005) and then worked on by Primi et al (2013); they extended it to a 7 version item of the test which has greater predictive powers as compared to the original one. We also conduct an additional behavioral experiment which measures time and risk preferences but with real monetary rewards to see whether the decisions of the respondents change when presented with real life choices. The aim is to see the impact on both risk and time preferences using the instruments initially used by Fredrick (2005) and our additional experiment. We find a significant difference between decision making of respondents divided into two groups of low and high CRT scores. We also find that that new version of CRT has a stronger correlation with time and risk preferences. Our results show that the relation persists when we switch from hypothetical to real choices.

## Contents

Abstract.....	2
I. Introduction .....	4
II. Literature Review .....	6
A. Cognitive Reflection Test (CRT).....	7
B. Cognitive Reflection and Time Preferences.....	8
C. Cognitive Reflection and Risk.....	9
III. Methodology and Theoretical Framework .....	10
A. Cognitive Reflection Test .....	10
B. CRT and Time Preferences .....	13
C. CRT and Risk Preferences.....	14
D. Experiment for Risk Preferences and Time Preferences .....	15
E. Sample.....	17
F. Hypotheses .....	17
IV. Results.....	18
A. CRT .....	18
B. CRT and Time Preferences .....	21
C. CRT and Risk Preferences.....	25
D. Behavioral Experiments .....	28
Experiment A.....	28
Experiment B.....	28
Analysis .....	29
V. Conclusions .....	29
References .....	31
Appendix 1 .....	35

## **I. Introduction**

Decision theory in economics is mostly associated with identifying the uncertainties, values and all other relevant issues when it comes to decision making. Its main concern is the rationality and the resulting optimal decision. Most decision making theories are normative in nature. Its main concern is to identify the best possible decision assuming he is an ideal decision maker who has all the relevant information needed and has the required set of skills to make the decision at hand. The biggest assumption with this is that decision maker is rational in nature. The practical approach of this decision making process is known as decision analysis. Since people tend to not behave in the fixed rules assumed by this theory which often leads to violations of assumptions (rationality) there is a related area of study for this which is known as descriptive decision making theory. Under this field we can assume that the assumptions of perfect information do not hold true. Also the assumptions regarding rationality are relaxed which helps in more accurate predictions about behavior. Over the last decade there is increasing interest in “behavioral decision making” and this has forced a review of what rational decision making requires (Anand, 1993).

People falling in different groups of cognitive skills differ from each other in many impactful ways. Research has shown that generally they tend to earn more, have a longer life span, improved reaction times and have larger cognitive working memories (Jensen 1998). Fredrick (2005) attempted to see how this diversity of cognitive skills impacts decision making and choices of individuals. Previously a lot of literature on time preference, endowment effects, anchoring, and risk preferences ignored the possibility of individual cognitive abilities having an impact on them.

Decision researchers may neglect cognitive skills because they believe the individual effect averages out however as an ignored aspect will not cease to exist just because it is ignored. Fredrick (2005) made it clear that there is no good reason for not investigating the hypothesis that different traits of cognitive skills can be an important causal determinant in behavioral decision making.

Fredrick (2005) introduced his Cognitive Reflection Test (CRT) test to check whether such a relation exists. He found out that people who were grouped in high scoring groups generally showed a tendency to be more patient when given hypothetical intertemporal choices. He also

found out that people in high CRT group were more inclined towards gambling in the domain of gains regardless of the expected value. However they would rather face certain losses rather than gambling in the domain of losses. After Fredrick a number of researchers followed his example and used his CRT test to not only further its impact on time preferences and risk but also on other areas like behavioral biases, performance on heuristic tasks and social preferences (Oechssler, Roider & Schmitz (2009); Albaity, Rehman and Shahidul(2014); Toplak, West & Stanovich, 2011; Campotelli & Labollita, 2010; Chen et al, 2012).

Since this test was developed in 2005 it has become relatively known and hence would not be as effective as it was ten years ago since the respondents might be familiar with the questions. In this thesis, we use an extension of the CRT test developed by Primiet al(2014). This version of the CRT has five additional items which measure the same characteristics which the original three represented but measure it on a larger scale.

The findings of this paper could be potentially relevant for economic models that consider cognitive reflection and time or risk preferences as important variables. Generally Structural models allow for dependency that might be potentially identified by our results except for Heckman et al (2006). He allows for a two way relation between cognitive skills and discount rate in a model that explains behavioral outcomes. Since their method of measuring discount rate is not direct, hence, they cannot identify the relation of cognitive skills and time preferences alone. Our potential findings might provide more insight on the nature of relation of cognitive skills with time and risk preferences.

Reduced form models earlier have included measures of cognitive skills however they have not included variables like risk aversion and/or impatience as independent variables. Resulting outcomes which include wages or education may be affected by impatience and risk aversion and hence the findings of this paper may potentially point towards omitted variable bias in the estimations of these models. Literature has explored the possibility that cognitive skills are passed on from parents to children. We may be able to shed more light on socioeconomic status

and intergenerational transmission of preferences. Dohmen et al (2006) showed attitudes towards risk were strongly correlated between parents and children. Literature also shows strong intergenerational correlations between risk or patience and wealth, occupation, education and income. Our findings might show how cognitive skills effects impatience and risk aversion and the passing on of cognitive skills could be one important factor in explaining why the outcomes concerned with risk aversion and impatience are similar for parents and children. This will have several policy implications. One example would be that interventions could be used to improve cognitive skills at a young age.

Findings could also contribute towards inequality in economic outcomes. For example if people who fall in the higher cognitive skills group tend to make more patient choices, hence, they also invest more. Since they are less risk averse they would earn a risk premium. These two factors would provide a positive correlation between high cognitive skills and income inequality. Hence, they could play an important role in reducing the magnitude of the relation between economic outcomes and income inequality.

## **II. Literature Review**

The literature review will consist of three sections. We are going to first explore how the CRT is based on the dual system theory. Then we will discuss how the CRT has been mostly successful by reviewing the literature on this test. Our main focus will be Fredrick (2005) in which he not only explains the theory behind the CRT but also gives valuable proof of how using CRT is the best option for researchers. Moving on to the next section we will be discussing the literature on cognitive reflection and time preferences. Here we will explore the relation in general by reviewing the literature and also review how the CRT has fared so far in explaining this relation. The last section of the literature review will be on cognitive reflection and risk preferences. Here

again we discuss the relation in general but also talk about how CRT has been used in the past to shed light on this relation.

### **A. Cognitive Reflection Test (CRT)**

Over the past few decades several researchers have stressed upon the distinction of two separate cognitive processes and are referred to as dual system theories. The basic premise of these theories is to provide a difference between two types of thinking processes. The first one is rapid and innate while the other is measured and thought through. Dual processing theories of cognition have been developed in many different areas which include reasoning (Evans, 2003), social cognition (Chaiken and Trope, 1999), attention (Schneider & Shiffrin, 1997), and decision making (Kahneman & Frederick, 2002).

Early on such distinctions about the dual system theories were made by many authors but most of them ignored the writing of others (Frankish & Evans, 2009). Although these theories originated in the 1970s but they have become popular with time as many researchers have developed their own version of the dual process theories (Evans & Over, 1996; Kahneman & Frederick, 2002; Stanovich & West, 2000). However recently there have been attempts to connect these theories in a broader perspective which will aim to link a wide range of different attributes to a single two system theory called them System 1 and System 2 processes.

There are considerable amount of similarities between the theories. Processes that are slow, controlled and sequential (System 2) are compared with those which are fast, natural and automatic (System 1). Many theorists have based their theories on these two different types of cognitive processes (Epstein, 1994; Evans, 1989; Chen & Chaiken, 1999; Evans & Over, 1996; Sloman, 1996; Stanovich, 1999). However our test of cognitive reflection will be based on the Dual System developed by Stanovich and West (2000). The three item test called the Cognitive Reflection Test (CRT) developed by Frederick (2005) checks whether the respondent uses System 1 and makes the hidden intuitive mistake or uses System 2 processes and arrives at the correct answer.

Over the last decade the CRT has been used by many researchers as a measure which accurately differentiates between people based on a cognitive trait. Frederick (2005) used the CRT test and

found out that people who score higher on the test make more patient choices. He also found out that people who scored less in the CRT were showing a higher willingness to gamble in the domain of losses.

Hoppe and Kusterer(2011) tested Behavioral Biases against the CRT. He tested base rate fallacy, conservatism bias and other behavioral biases. After analyzing the results it showed that subjects who exhibited base rate fallacy had on average lower CRT scores as compared to people who did not exhibit base rate fallacy. The same trend was apparent in conservatism bias where people who on average scored higher on CRT were closer to the correct answer. Similar results were observed by Oechssler, Roeder & Schmitz (2009) and Albaity, Rehman and Shahidul(2014) when they tested for behavioral biases.

CRT has also been used to check the impact on performance on heuristic tasks and social preferences (Toplak , West & Stanovich, 2011; Campotelli & Labollita, 2010 ; Chen et al, 2012). All showed positive and encouraging results with the CRT.

### **B. Cognitive Reflection and Time Preferences**

The idea that people with higher cognitive skills tend to “discount” rewards received in the future when compared to people with lower cognitive skills. In the book “New Principles of Political Economy” (Rae, 1834, pp. 57) it was suggested that more rational people promote reasoning and attaching greater value to future.

Over the last few decades the cognitive skills has been tested against patience. The relation has been put under test in many studies using different methods. Funder and Block (1989) ran an experiment consisting of six sessions. In this experiment he paid 14 year olds an amount of \$4 in the first 5 sessions or gave them an option to forego the amount as an investment and receive \$4.8 in the 6<sup>th</sup> sessions of the experiment. The conclusion from his results was that people with a relatively higher score were generally choosing to invest more of their money. Melikan(1959) asked children between the age group of five and twelve years and then offered them a choice between an immediate small amount or promissory note for a larger amount that they would receive two days later in exchange for the picture they drew. Children who chose the promissory

note generally scored higher on a scoring test which was based on the drawing. In another paper (Shoda et al, 1990) found out that respondents who had resisted longer the impulse to receive an immediate inferior reward had higher SAT scores ten years later. Since this link between patience and cognitive skills has been established in the literature, Jones and Podemaska (2010) showed while growth theory predicts that more patient countries will save more.

CRT has been used by several researchers to test the relation between test scores on CRT and time preferences. Fredrick (2005) was the first one to test the relation. The tests showed that people who made more patient choices had scored higher on the CRT. This showed that people with higher CRT scores considered lower discount rates. For choices which were based over short term horizons people with higher scores were generally choosing the larger reward which is supposed to be received later. However there was no significant relation for choices over long horizons. Similar results were also achieved by Oechssler, Roeder & Schmitz (2009) in their article "Cognitive Abilities and behavioral biases" which was an extension on Fredrick's original work but also tested for time preferences. Similar results were also observed by Toplak, West & Stanovich (2011); Albaity, Rehman & Shahidul (2010) & Hoppe & Kusterer (2011).

### **C. Cognitive Reflection and Risk**

There hasn't been much research in the area of Risk Preferences hence there is no clear presumption about the relation between cognitive skills of any kind and how it impacts their decisions regarding risk. One research paper showed that respondents with higher levels of education showed more tolerance to risk in hypothetical gambles (Donkers et al, 2001).

In the last decade CRT has been used to check if there is difference in risk taking among people in different CRT groups. Fredrick (2005) included several survey questions to measure risk. He introduced choices between certain gains and losses. In some choices the lottery maximized output and in some the safe option. The low CRT group showed a higher willingness to gamble in domains of losses rather than gains however no apparent trend is shown in the higher CRT group. Toplak, West & Stanovich (2011); Albaity, Rehman & Shahidul (2010) and Hoppe & Kusterer (2011) all used CRT to test risk preferences and there was a degree of similarity in the results.

### **III. Methodology and Theoretical Framework**

For this thesis, we conducted a survey followed by a behavioral experiment. The survey consists of three sections. The first section contains a modified version of the CRT. The second section consists of hypothetical choices which are supposed to reveal if respondents value payments made at a later time period more. The final section of the survey consists of hypothetical gambles both in the domain of gains and losses. It will reveal if a certain respondent is risk loving or risk averse. Followed by the survey the respondents were provided with a behavioral experiment however in this case the payoff are not going to be hypothetical and the choices they make will dictate their pay off. Again the choices presented to them would reflect on their patience and risk taking. This section of the paper will explain the above mentioned survey and behavioral experiment. It sheds light on the theoretical reasoning behind the process and how we are going to use the obtained data to calculate results.

#### **A. Cognitive Reflection Test**

We used the Cognitive Reflection Test (CRT) by Fredrick (2005). It is a simple 3 item test and past literature has shown a favorable relation between the test scores and observed behavior when compared to other more detailed and complex tests. The main idea on which the CRT test is based on is that it differentiates between the people who make more compulsive decisions as compared to people who make more reflective decisions. Hence all 3 questions in the CRT are designed in such a way that they have a intuitive answer which comes to mind as soon as we look at the question but that answer is actually wrong. The solution to the three items in the cognitive reflection test is easily understood when explained to the respondents. However to reach the correct answer for each problem one has to ignore the incorrect answer that comes impulsively. Fredricks(2005 claim that these problems mostly either generate the correct or the intuitively wrong answers can be supported by several facts. His study shows that over 90 percent of the respondents either give the correct answer or the intuitively wrong one for all the three problems. This finding is consistent with the findings of (Hoppe &Kusterer, 2010; Campitelli&Labollita 2010; Toplack,West &Stanovich 2011).

It was also reported that a fair majority of the people who answered the question correctly had first considered the wrong answer. This was deduced through analyzing the filled questionnaires as well as verbal reports. Moreover he also found out that people who had incorrectly answered an item on the test overestimated the percentage of respondents who answered that item correctly (92% in the bat and ball problem).

On the other hand those who answered this problem correctly only estimated that 62% of the respondents will answer them correctly. This shows that people who answered it correctly knew that not everyone would not catch the trick hence they gave a lower estimate on the other hand people who answered it wrong gave a higher estimate as they thought the problem was easy and no one would get it wrong.

One last finding that supports this argument is that the respondents performed much better in problems that require more computation. He gave the example of "*A banana and a bagel cost 37 cents. The banana costs 13 cents more than the bagel. How much does the bagel cost?*" Respondents performed much better on this problem as compared to bat and ball problem.

Since the test is based on the dual System theory of System 1 and System 2 processes, Fredrick proposed that the CRT measures "cognitive reflection" which was explained as the ability or temperament to ignore the first response that we come across. We will be limiting our definition of Cognitive Reflection strictly to the one provided by Fredrick (2005).

Although all three problems of the CRT seem to be arithmetic there is sufficient evidence to suggest that the CRT is much more than that. Fredrick along with his CRT test also collected data from the same respondents on Wonderlic Performance Test, Need for Cognition Scale, ACT and SAT scores. He then ran correlations between the different measures of cognitive skills. The table below shows that CRT has a positive and significant correlation with all the above stated measures. For example it shows that although CRT has a positive correlation with mathematical portions of SAT scores it also positively correlated with WPT and NFC which have no arithmetic portions. This shows that CRT measures a series of different traits rather than just arithmetic ability.

It can be argued that although these tests are designed to measure different traits of cognitive skills there may be many like sources of shared variance. This would suggest that all these tests would predict time and risk preferences. To test if this indeed holds Fredrick (2005) constructed composite indices and correlated them with scores for all these different measures of cognition. The results are shown in the table below. They show that CRT is the only test that has the right hypothesized sign for all the indices and is significant. Moreover it also shows that CRT is either the best or the second best predictor for all the indices.

Considering that CRT is limited to three items and can be conducted relatively easily as compared to other tests which may take up to several hours and its predictive validity which exceeds or equals other measures it is an attractive test to divide people into cognitive groups.

Since the original Cognitive Reflection Test was developed in 2005 it was possible that the original three item test may have been becoming common and hence they would already know the questions and would be aware of the trick. The problems have started appearing in books and magazines. Another problem with the test is that in some samples the test scores were floored. Fredrick (2005) reported that the mean of scores for students from some institutions were very low which suggested the scores for those colleges and schools might be problematic in terms of floor effects. Hence there is a need for extensive version of the CRT test which deals with these issues. Toplack, West & Stanovich (2011) developed a seven item version of the CRT. It included the original three items, two were provided by Fredrick in personal correspondence, one was used from Dominowski and the last item was developed by author. All the new problems were based on the premise of the dual system theory. Results showed that the problem of flooring did exist in the sample as there were less than half a problem was correctly answered questions from the original three problems. Out of the four new problems this average went up to one. Also the new items had a positive and significant correlation with the original three survey items. Results also showed that these four new items on their own had lower predictive powers than the original problems. However results showed that combining the problems into one seven item test was quite substantial. The seven item score was a better predictor than both the three and four item score. Hence their results showed that the four items do add to the predictive power of the original test.

Another problem with the original CRT was that its psychometric properties were never tested. Primi et al (2014) tested the psychometric properties of the original three item test and additional five items to develop a suitable longer version of the test. They applied the Item Response Theory (IRT) to check the psychometric properties. The aim of their study was to develop new items for the test with similar characteristics to original problems. Since Fredrick (2005) did not report on the psychometric properties of the original problems the authors applied IRT models which provided them with parameters on evaluation of how well an item measures the underlying construct. IRT also provides them with a measure of precision which is derived from the Test Information Function (TIF). This function give us an evaluation of the how accurate the test is using a scale that measures varying levels of the measured construct. The results showed that the new items added measured the same underlying construct as the original three problems. It also showed that the new test problems had a broader base in terms of difficulty of the test lower the chances of floor effects. All the items were verified in their ability to differentiate between the respondents with different levels of the measured trait. Also when the TIFs of both the CRT (original) and CRT (L) were compared it showed that CRT (L) had higher values associated with a larger range of the measured construct. This means that the longer version of the test was able to differentiate from low-to-medium to medium-to-high levels of the latent trait. To conclude the authors confirmed the reliability of the original questions in measuring cognitive reflection and also showed that the new eight question test has a higher precision in measuring cognitive reflection as compared to the old test.

Hence we will be using the extended version of the CRT and the complete test is provided in the appendix 1 section B.

### **B. CRT and Time Preferences**

The aim of this section is to investigate how people who fall in different CRT groups make different decisions under the intertemporal decision making theories. This area of theory is concerned with where different choices lead to different outcomes realized at different points in time. For example if someone wins a lottery they could spend it on an expensive holiday which would only yield him immediate rewards or they could choose to invest it and reap greater rewards in the future. The question is what is the optimal thing to do? The answer to that depends on different factors like expected inflation, life expectancy, interest rates etc. However

even after accounting for those factors human behavior can deviate greatly from expected outcomes of decision theory.

Literature has shown that a relation between cognitive reflection and time preferences exists. However why it has an impact and what types of decisions are influenced by cognitive reflection is not yet clear. So in this paper we are going to examine the relation between cognitive reflection and various responses which are designed to measure the varied aspects of “time preference”. The different question asked to measure time preferences are adapted from Fredrick (2005). These will include choices where they will chose between an instant payment and a relatively larger delayed payment (a to e), an instant payment and series of delayed payments (f to h), a smaller immediate loss or a relatively larger one at a delayed time period. Respondents will also be asked about their maximum willingness to pay for an item received immediately as compared to receiving it in two weeks. Also included in this section are a series of choices which are aimed to get the minimum amount of money they would want in four days to instead of a larger amount in two months. There are also questions where the respondents are expected to comment in their impulsivity, preoccupation with their future and Procrastination. They are also asked to comment on how worried they are about inflation on an eleven point scale ranging from -5 (extremely low as compared to an average person taking the survey today) to + 5 (extremely high as compared to an average person taking this survey today). For this section we to get the variable for inter-temporal choices we summed up the number of patient choices made by the respondents. The above mentioned items are in appendix 1 section C.

### **C. CRT and Risk Preferences**

This section of the paper is based on Expected Value Theory. The main idea of this is when you are presented with different number of choices and each of this choice has a different outcome associated with them. All of these outcomes have probabilities attached to them. The rational way to arrive at the right outcome would be to first identify all outcomes and then determine the expected value of all outcomes whether it be positive or negative. The action chosen should be one that has the highest expected value. However, prospect theory of Danial Kahneman and Amos Tversky (1979) argues that economic behavior doesn't always rely on rationality they found out that in actual decision making people focus more on changes in their relative utilities as compared to absolute utilities.

Reviewing the very little literature on this domain showed that there is no established relation between cognitive skills and risk preferences. To find out whether such a relation exists we have included a separate section on risk preferences in the questionnaire. This section includes choices between guaranteed gain (and loss) and then a chance of a comparatively bigger gain (or loss). Value maximization for these questions was with the game in some cases and in some cases with the certain amount. Questions d and o along with h and r are reflection of one another in the domain which is concerned with gains and losses. As explained the prospect theory states that the tendency of risk taking is higher in losses as compared to gains. To get the variables for risk preferences we divide it in three categories. First of many categories of choices which represent risk are those where the maximum expected value is attached to the gamble as compared to the certain choice. Second category is where the maximum expected value is achieved by choosing the certain option. The first two categories fall in the domain of net gains. Finally the third category is where the expected value is maximized by choosing the certain option but in this case it is in the domain of losses. Proportion of risky choices made was used to form variables for all three categories. The above mentioned items are in appendix 1 section D

#### **D. Experiment for Risk Preferences and Time Preferences**

One of the problems faced by researchers using hypothetical gambles and time preference choices is that they do not fully reveal the true preference of a respondent. To correct for this problem we add a paid experiment to measure the impatience and willingness to take risks. Subjects were randomly chosen to come participate in the lottery and intertemporal choice experiment. The complete instructions manual is provided in the appendix.

In both experiments the subjects were provided with a choice table. They were explained the type of choices they can make and also how the payment would work. They were then presented with several choices; one choice will be represented in each row on the provided table and one out of these choices will be selected randomly and played out. They were also be informed that one of every seven respondents will actually receive their pay off and those respondents will be selected randomly. The aim of this procedure was to ensure that the respondents reveal their true preference there is incentive compatible. Once the experiment was explained then the respondents were asked if they want to participate in the experiment after which all relevant questions were answered and the experiment was begin.

Willingness of taking risk was measured by providing choices between a number of different paid lotteries and a guaranteed certain amount. Respondents were expected to make a choice between a safe option that guarantees a certain amount and a lottery in all twenty rows. The safe option amount went up from row to row however the lottery remained the same each with a fifty percent probability to win Rs 500 amount.

If the subjects only chose the lottery up to a certain point and then switch to choosing the safe option they will have monotonic preferences. The switching point in this experiment reveals the subjects willingness to take risks. As we are aware that the expected maximum value of the lottery has been fixed at Rs 250 amount, people who prefer the safe amount that is smaller or less than Rs 250 are said to be risk averse and theoretically only the risk loving respondents should prefer the lottery when the certain amount is above Rs 250.

To measure a respondents time preferences we gave them a table of choices in which they have to choose between different payments that they can receive at different time periods. Similar to the lottery experiment they were provided a table and will be asked to select between the choices provided for every row. The choice for this experiment will always be between a fixed Rs 300 amount today and larger  $(300+Y)$  amount that would be received 1 week from now. The value of  $Y$  initially gave a return of 3.33 % compounded semiannually and it kept increasing by 3.33% in all the subsequent rows. This experiment was used to determine a index of patience.

Subjects were asked about their decision one row at a time and were informed that one row will be randomly selected and played out which would decide their pay off. Respondents were also informed that all payments would be sent by post which consisted of cheques that could be cashed “today” or 1 week from today depending on the choices they made.

A problem that researchers generally face when we try to measure impatience is that the subjects could be skeptical about receiving the promised payments after 1 week and hence place a premium on the patient choice which will result them in being more impatient than they actually are. We designed the experiment in such a way that it reduces this premium to nearly zero. The subjects were informed that they will not receive payments immediately but rather the payment will be sent after a short period through mail. Adding this to the design of the experiment ensures that people do not place an extra premium on payments received now and also makes payments

for both the options credible. This helps in mitigating the problem of overestimation of impatience.

### **E. Sample**

For our sample we took 7 universities across Lahore. We randomized different universities across different days of the week through a draw. Two separate boxes were made one with university names and the other with days of the week. The draws were made for 3 visits to each campus on a different day of the week. Respondents were recruited on the spot while visiting the universities. The survey was conducted in a maximum group of 5 respondents and a minimum of 1 respondent. The survey was conducted during September 2015 over a period of 30 days. Due to the limitations of our resources we restricted our sample to 200 students. The target was to have a diversified student sample from different universities of different ages. We took in both undergraduate and post graduate students for this survey and experiment.

### **F. Hypotheses**

1.

*H<sub>0</sub>: Respondents in the high CRT group are not significantly more impatient than respondents in the low CRT group.*

*H<sub>A</sub>: Respondents in the high CRT group are significantly more impatient than respondents in the low CRT group*

2.

*H<sub>0</sub>: Respondents in the high CRT group are not significantly more risk loving than respondents in the low CRT group*

*H\_A: Respondents in the high CRT group are significantly risk loving than respondents in the low CRT group*

3.

*H\_0: There is a significant change in decision making when we switch hypothetical choices to real ones.*

*H\_A: There is no significant change in decision making when we switch from hypothetical choices to real ones.*

#### **IV. Results**

##### **A. CRT**

The cognitive reflection test was administered to 200 students. A majority of the respondents were undergraduates from different universities across Lahore. The first row of Table 1 shows the number of respondents from each institution. As you can see the sample is evenly spread out across the institution from all over Lahore hence giving us a diversified and representative sample. The second row of Table 1 shows number of respondents who fall the High CRT group from each university. The third row is showing the percentage of respondents falling in the High CRT group for each university. High CRT group are the respondents who scored 3 or more on the CRT.

The table shows the percentage of respondents in the High CRT group for all universities. This confirms the fact that CRT measures a trait that is consistent across all universities and doesn't favor a certain field.

Table 1

	Univ1	Univ2	Univ3	Univ4	Univ5	Univ6	Univ7
Total Sample	30	30	30	30	15	30	35
High CRT	9	7	9	8	4	11	11
High CRT (%)	30%	23%	30%	26%	26%	36%	31%

The first row shows the number of respondents from each institution. The second row shows total number of people that fall in the high CRT group for each institution. The third row shows the percentage of people who fall in the high CRT group for each institution

The first row of Table 2 shows the percentage answering the 6 CRT questions correctly. As we can see only 15% of respondents answered the “bat and ball” question correctly which is the lowest for all 6 questions in the CRT which was considerably lower than the average number of respondents answering a question correctly. On the other hand 60% of the respondents answered the “workers” question correctly which was considerably higher than the average number of respondents answering the question correctly. If we had used the original CRT there would have been a smaller amount of respondents who would fall in the high CRT group and hence our results would have been understated. Another interesting fact that can be drawn from Table 2 second row is that for every wrongly answered question in the CRT over 80% of the respondents gave the impulsive wrong answer. This further backs our notion that the CRT measures “the ability to ignore the first impulsive response”.

Table 2

	Cognitive Reflection Test					
	Q1	Q2	Q3	Q4	Q5	Q6
Correct Answer	15%	30%	27%	60%	24%	27%
Intuitively Wrong Answer	81%	84%	80%	84%	82%	80%

The first row shows the percentage of correctly answered questions for each question in the CRT. The second row shows the percentage of respondents who answered the CRT question wrong but gave the intuitive wrong answer.

We also calculated correlations between CRT scores with CGPA, Primary school results and Secondary school results. As we can see in Table 3 CRT doesn’t have a significant correlation with any of these measures. It has a weak positive correlation with primary and secondary school results and weak negative one with CGPA. Although the CGPA, Primary school results and Secondary school results are intended to measure conceptually distinguishable traits, there are many likely sources of shared variance however in our case the correlations are weak and insignificant hence cannot be used for interpretation.

Table 3

	CRT	CGPA	Result(1)	Result(2)
CRT	1			
CGPA	-0.0308 0.6719	1		
Result(1)	0.0658 0.3965	-0.1853 0.0186	1	
Result(2)	0.1163 0.1334	-0.1785 0.0235	0.5008 0.000***	1

The above table shows correlations of CRT scores, CGPA , Secondary Result and Primary Result with each other.

We would also like to check if any of these measures of cognition have strong predictive power in predicting decision making behavior and then compare it with CRT. As we can see in Table 4 CRT has not only has a strong significant correlation with all our measures of decision making but also the right direction when compared with other measures of cognition which had weak correlation in cases of CGPA and Primary Result. Although Secondary Result also showed significant correlation with patience and risk indexes CRT had higher predictive power.

Table 4

	Exp A	Exp B	Patient	Risky
CRT	0.2141 0.0023***	-0.4251 0.0000***	0.4250 0.0000***	0.4528 0.0000***
CGPA	0.0986 0.1736	0.1140 0.1153	-0.0585 0.4206	-0.0225 0.7571
Result(1)	-0.0719 0.4298	-0.0364 0.7182	0.1153 0.1874	0.1723 0.0367
Result(2)	-0.2116 0.0034***	-0.0567 0.4654	0.1879 0.0147**	0.2513 0.0010***

The table above is showing correlations. The first row shows the correlation of CRT with variables derived from ExpA ,Exp B , Patience and Risk. The second row shows the correlation of CGPA with variables derived from ExpA ,Exp B , Patience and Risk. The third row shows the correlation of Result(1) with variables derived from Exp A , Exp B , Patience and Risk. The fourth row shows the correlation of Result(2) with variables derived from Exp A , Exp B , Patience and Risk.

There were 112 men and 82 women in the sample. On average men scored slightly higher than women. As Table 5 show men on average scored 1.9 on the CRT and women scored 1.7. The P-

value shows this difference is insignificant it is in line with Fredrick (2005) who also found that men slightly scored higher than women on the CRT.

Table 5

	Obs	CRTScore	P-Value
Male	118	1.9	0.4164
Female	82	1.7	

The table above shows the average CRT scores for males and females. The first column shows the number of male and female observations. The second column shows the average CRT scores .

### **B. CRT and Time Preferences**

Table 6 shows the responses for both the High and Low CRT groups for each of the 17 items in section C of the survey. The values in the table are either the percentage choosing the patient option for dichotomous responses or the mean response in the continuous items. There are 4 columns in the table. The 2<sup>nd</sup>, 3<sup>rd</sup> and 4<sup>th</sup> columns show the percentage of patience choices made by High CRT group, Low CRT group and the total sample. The 5<sup>th</sup> and last column reports the level of significance of group differences.

Those who scored higher on the CRT were on average more patient as the results suggest. This implies that they considered lower discount rates while making their decisions. 6 of the 17 items in the table were choices involving short horizons (1 year or less). 5 of these items were significant at less than 5%. The only item that is not significant at 5% was “Rs 20000 this month or Rs 24000 next month” still there was a significant difference between the high and low CRT group for this item and it was significant at less than 10%. Another interesting result was for “Tooth pulled today or tooth pulled in 2 weeks” here the high CRT group preferred getting their tooth taken out in 2 weeks delaying the pain inducing process. Also the high CRT group preferred a higher amount on average when they were asked to forego Rs2500 in 2 months. For choices involving long horizons (more than 1 year) the results were generally significant at the 10% level. For items involving self-evaluation the High CRT group considered themselves less impulsive , tend to procrastinate less , thought more about their future , worried more about inflation and worried more about getting a job as compared to the Low CRT group.

Fredrick (2005) showed a positive relation between patience and CRT scores. This implies higher the CRT score higher the number of patient choices made by respondents. He also states that those who were more patient might be considering lower discount rates when making their choices. High CRT group chose the larger later reward for short term choices however the relation was weak for the long term choices. In case of measures of pure time preferences the relation was nonexistent. Respondents were also asked to report several personality characteristics that seemed relevant to intertemporal choice. The high CRT group considered themselves to be more worried about inflation, less concerned about their future, relatively less impulsive. Oechssler ,Roider and W.Schmitz (2009) also found that respondents falling in the low CRT groups are less patient than the respondents who fall under the high CRT group. They also gave their respondents a choice between receiving the payment for their experiment now or 1 month later with a 10% additional amount. As compared to Fredrick (2005) their sample was much more patient. Albaity ,Rehman and Shahidul (2014) also showed that High CRT group was more patient as compared to the Low CRT group however their results were insignificant. Campitelli and Labollita (2010) also found that the relation between inter temporal choices and CRT was not significant but one of the possible reasons he gave for this were the high inflation rates in previous years in Argentina which might have caused respondents to consider a higher discount rate.

Comparing our findings with the previous results we can see that the general relation between patience and CRT holds true. However the results are much more significant in our sample. The difference between High and Low CRT group was significant across items of long and short horizons unlike Fredrick (2005) findings which showed an insignificant relation in items which were concerned with long horizons. Also items which measured pure time preferences yielded significant results unlike the previous papers. Items of self-evaluation which are relevant for time preferences also provided results which were in line with Fredrick (2005).

One reason for this could be the use of the new CRT which as explained earlier measures “Cognitive Reflection” along a wider scale and hence the results in the previous findings could have been understated. A theoretical explanation for these results could be that thoughtful respondents could be discounting future monetary outcomes at rates less than the prevailing

interest rates meaning they would value money received in the future more. The respondents could consider that interest rates could decrease (unlikely in Pakistan) or one might be predictably less wealthy in the future. Collectively these reasons could explain choosing the later larger rewards over the immediate smaller ones.

Thus, despite the diverse nature of the items we have included to help resolve this issue, there is still a need for items which measure more different type of psychological characteristics which are related to cognitive reflection. The inflation result where the high CRT group was considerably more concerned about inflation as compared to the low CRT is line with the concept that people who fall in the higher scoring group consider background factors when making their respective choices of time preferences. However there is a lot of ambiguity in the interpretation of these results wince future conditions are considered.

Table 6

	High CRT	Low CRT	Total	P-Value
Number of people	59	141	200	
1)Rs 20000 this month or Rs 24000 next month	49%	35%	39.50%	0.0700*
2)Rs 100 now or Rs 2000 next year	43%	13%	19.50%	0.0000***
3)Rs 1000 now or Rs 15000 in 10 years	51%	16%	24%	0.0000***
4)Rs 500 now or Rs 25000 in 10 years	59%	35%	42%	0.0100***
5)Rs 500 immediately or Rs 25000 in 10 years	53%	32%	38%	0.0600*
6)Rs 10000 now or Rs 2000 every year for 7 years	53%	39%	43%	0.0780*
7)Rs 40000 now or Rs 10000 every year for 25 years	66%	51%	56%	0.0500**
8)30 min massage in 2 weeks or 45 min massage in 1 month	49%	24%	32%	0.0100***
9)Lose Rs 5000 this year or lose Rs 10000 next year	47%	25%	32%	0.0200**
10)Tooth pulled today or tooth pulled in 2 weeks	51%	26%	34%	0.0100***

11)Smallest amount in 4 days preferred to Rs 2500 in 2 months	1344	830	981	0.0000***
12) How impulsive are you?	0.76	2.34	1.88	0.0000***
13) How much do you tend to procrastinate?	1.101	1.87	1.645	0.0324**
14) How much do you think of your future?	3.406	2.517	2.78	0.0186**
15) How much do you worry about inflation?	1.983	1.17	1.41	0.0374**
16) How much do you worry about getting a job?	3.05	1.943	2.27	0.0051***
17) Pick a number from 1-100. With that number representing your best guess of two-thirds of the average number chosen in survey of 200?	38.13	41.12	40.245	0.4095

The table above shows responses for both High and Low CRT groups for each of the 17 items asked in section C of the questionnaire. The first column shows the questions asked in the questionnaire. The second column shows the percentage of people in the High CRT group who made the risky choice. The third column shows the percentage of people in the Low CRT group who made the risky choice. The third column shows the percentage of people in the sample who made the risky choice. The last column shows the P-Value of significance of group differences for each item in the questionnaire.

### **C. CRT and Risk Preferences**

The results for this section are shown in Table 7. The table is divided into 3 panels. The items in the first panel fall in domain of gains. Here the expected value of the risky option is more than the safe payment. The items in the second panel still fall in the domain of gains but here the expected value of gamble is less than the safe payment. Items in the third and last panel fall in the domain of losses. Here the choice was between taking a sure loss or taking a riskier option for a higher loss. The expected value of the risky options here was higher than certain losses.

The first panel contains 8 items. In the domain of certain gains vs higher expected value gambles, the high CRT group was more willing to take the riskier option as compared to the low CRT group. The difference was significant at the 5% level for seven out of the eight items in this section of the table. The second panel contains 5 items. For all these items the expected value of the risky choice was less than the safe option. The trend that was apparent when the riskier option had higher expected value but this trend was still present when the expected value was not higher. There are 5 items in the second panel and P-Values of group differences for all 5 items are significant at the 5% level. The High CRT group is taking the riskier option relatively more than the Low CRT group in the second panel as well. For items involving losses (3rd panel), the high CRT group was again more risk loving then the low CRT group. Group differences for four of the five items in this panel are significant at the 5% level. Which means the High CRT group is willing to take the chance of a larger loss significantly more than the Low CRT group.

The above is confirmed by Fredrick (2005) whose research shows that individuals falling in the high CRT group exhibit a higher willingness to gamble irrespective of whether their gamble yields a higher expected value or not. However, the high CRT group is observed to be less willing to gamble in scenarios involving losses, i.e., they more willingly accept a sure loss rather than investing in a gamble that yields a lower expected value (Fredrick, 2005). Oechssler, Roeder, and Schmitz (2009) use the same methods as Fredrick (2005) but report a much smaller incidence for risk aversion than him. Oechssler, Roeder, and Schmitz (2009) show that rather than avoiding risky items, the high CRT group is significantly more likely to choose gambles that are risk neutral with 7.7 percent of individuals in the low CRT group, and 2.9 percent of

individuals in the high CRT group select the sure payment alternative in the domain of gains, and the lottery alternative in the domain of losses (Oechssler, Roider, and Schmitz (2009)). Albaity, Rehman and Shahidul(2014) build on Fredrick (2005) and Oechssler, Roider, and Schmitz (2009) findings to show that CRT scores are positively related the level of risk one is willing undertake when the expected value of the gamble exceeds the value of the safe option (Albaity, Rehman and Shahidul(2014). This research also finds that those with low CRT scores are less prone to accept losses versus counterparts with high CRT scores. This is confirmed by highlighting that individuals in the low CRT group partake significantly more than high CRT scorers in gambles that yield lower expected values versus the expected return of the safe option.

Our results for the first panel where the expected value of the gamble is higher than the safe option is line with the results in the literature as Table 4 shows that the High CRT group takes the riskier option significantly more than the low CRT group. Our results are also show that even when the expected value of the gamble is less than the safe option the High CRT group takes the riskier option significantly more than the low CRT group.

If aggregate the percentage of risky choices made in both panels we can see that both High and Low CRT groups are way less risk seeking where the expected value of gamble is less than the safe payment. The aggregate for first panel is 60% for High CRT group and 38% for Low CRT group. The aggregate for the second panel is 34% for High CRT group and 15% for Low CRT group. Hence showing although the risk seeking behavior is persistent in both panels but both groups are far less risk seeking when the expected value of the risky option is less than the safe option. These results are again in line with previous literature. This suggests that the correlation between cognitive reflection and risk taking in gains might not be due solely to a greater disposition to compute expected value but still is an important factor.

When we switch from gains to losses the High and Low CRT groups are *even more* risk seeking; also High CRT group were more willing to gamble rather than taking a sure loss in contrast to what was reported by Fredrick (2005), we learn that upon switching from gains to losses high CRT scorers are significantly more willing to undertake gambles than accept a sure loss versus those individuals who feature in the low CRT group. These results are compatible with Kahneman and Tversky's (1979) prospect theory that augers that people will exhibit a higher

willingness to undertake risky gambles in order to avoid losses than to secure wins. This expectation holds true for both High and Low CRT scorers.

Table 7

	High CRT	Low CRT	Total	P-Value
Number of People	59	141	200	
Certain Gains vs Higher Expected Value Gambles				
Rs 10,000 for sure or a 90% chance of Rs 50,000	88.1	60.2	68.5	0.0000***
Rs 1000 for sure or a 90% chance of Rs 5000	80	51.77	60	0.0000***
Rs 10,000 for sure or a 75% chance of Rs 40,000	67.8	40.4	48.5	0.0000***
Rs 1000 for sure or a 75% chance of Rs 2000	59.3	28.3	37.5	0.0000***
Rs 1000 for sure or a 75% chance of Rs 1500	40.6	24.8	29.5	0.0250**
Rs 1000 for sure or a 50% chance of Rs 3000	44.06	23.4	29.5	0.0030***
Rs 5000 for sure or a 15% chance of Rs 1,000,000	57.6	51.06	53	0.3960
Rs 1000 for sure or a 3% chance of Rs 70,000	40.6	23.4	28.5	0.0140**
Certain Gains vs Lower Expected Value Gambles				
Rs1000 for sure or a 25% chance of Rs 2000	40.6	12.05	20.5	0.0000***
Rs1000 for sure or a 25% chance of Rs 3000	33.89	17.02	22	0.0090***
Rs 100 for sure or a 4% chance of Rs 800	32.2	16.3	21	0.0120**
Rs 100 for sure or a 1% chance of Rs 800	28.81	12.05	17	0.0040***
Rs 600 for sure or a 1% chance of Rs 5000	33.89	19.14	23.5	0.0250**
Certain Losses vs Lower Expected Value Gambles				
Lose Rs 100 for sure or a 90% chance to lose Rs 250	45.7	24.11	43.88	0.0020***
Lose Rs 100 for sure or a 75% chance to lose Rs 150	59.32	26.9	36.5	0.0000***
Lose Rs 1000 for sure or a 50% chance to lose Rs 2000	52.5	27.6	35	0.0010***
Lose Rs 150 for sure or a 10% chance to lose Rs 800	66.1	37.5	46	0.0000***

Lose Rs 1000 for sure or a 3% chance to lose Rs 7000	62.7	35.4	43.5	0.0000***
	%	%	%	

The table above shows responses for both High and Low CRT groups for each of the 18 items asked in section D of the questionnaire. The table is divided into 3 panels. The first panel shows items where the expected value of gambles is greater than the certain gain. The second panel shows the items where the expected value of gambles is less than the certain gain. The third column shows items where the expected value of gambles is less than the certain loss. The first column shows the questions asked in the questionnaire. The second column shows the percentage of people in the High CRT group who made the patient choice. The third column shows the percentage of people in the Low CRT group who made the patient choice. The third column shows the percentage of people in the sample who made the patient choice. The last column shows the P-Value of significance of group differences for each item in the questionnaire.

#### **D. Behavioral Experiments**

The behavioral experiment was added to check whether decision change if we switch from hypothetical to real life choices. There were two separate experiments. Experiment A was used to measure risk preferences while Experiment B was used to measure patience.

##### **Experiment A**

Results from experiment A (Table 8) showed that on average respondents in the high CRT group were more risky as they switched from the gamble to say payment at the 13<sup>th</sup> point (safe payment of Rs 325). Respondents in the low CRT group were generally risk averse as they switched to safe payment at the 9<sup>th</sup> point (safe payment for Rs225). The P-value for the group differences is significant.

##### **Experiment B**

Results from experiment B (Table 8) showed that on average respondents in the high CRT group were more patient as they switched from the payment now to payment 1 week from now at the 8<sup>th</sup> point (Rs380 1 week from now). Respondents in the low CRT group were generally impatient

as they switched to payment 1 week from now at the 13<sup>th</sup> point (Rs430 1 week from now). The P-value for the group differences is significant.

Table 8

	High CRT	Low CRT	Total	P-Value
Number of People	49	141	200	
Experiment A	12.96	9.7	10.67	0.0000***
Experiment B	8.35	13.04	11.66	0.0000***

The table above shows responses for both High and Low CRT groups for Experiment A and Experiment B in section D of the questionnaire. The second column shows the average switching point of people in the High CRT group from gamble to safe option for Experiment A and from payment now to 1 week from now for Experiment B. The third column shows the average switching point of people in the Low CRT group from gamble to safe option and from payment now to 1 week from now for Experiment B. The third column shows the average switching point of people from gamble to safe option and payment now to 1 week from now for Experiment B. The last column shows the P-Value of significance of group differences for Experiment A and Experiment B.

### Analysis

The results for both behavioral experiments confirm the results of our hypothetical sections in the survey. Although the magnitude of these results cannot be compared since the experiment has a totally different design but the relationship between CRT and risk and time preferences is same for both instances.

An interesting finding from the experiment A was that if we look at the complete sample on average the group seems risk neutral as the average switching point is 10<sup>th</sup>(Rs250 = Expected value of gamble). However if we divide the sample into high and low CRT group we can see that the high CRT group is risk pro and the low CRT group is risk averse.

### V. Conclusions

Research has shown that CRT correlated significantly with normative patience and risky choices. Fredrick (2005) showed that the relation between risk and CRT is also extended to preference for risk and is not only related normative choices. The findings of our study confirms this fact as

CRT is positively correlated with both time and risk preferences. We also showed that if we switch from hypothetical to real choices the correlation of CRT with time and risk preferences still remains strong. The question that remains unanswered is that whether one response is correct or one is wrong.

In most studies of decision making the respondents are assured that is no correct or wrong answer. If we truly believe this the implications of this statement would be that we would consider choices made as primitive like choosing between apples and oranges which don't require or permit further investigation.

Nevertheless measures of risk and time preferences are often strongly related to cognitive reflection and the notion that one preference is better than the other and that cognitive reflection is a possible indicator of the better preferences is not new. Savage (1954) talked about how the frequency of the "normative response" would be increased if increase the understanding behind the response which basically means that a preference that is not in line with a normative principle might not survive through discussion. Stanovich and West (2000) also argued that if the smarter respondents had a higher frequency of chronically correct responses then indeed the responses might not be equally good. However not everyone agrees with this school of thought Sternberg(1999) argues that for example people with high SAT scores might have certain type of cognitive abilities but this doesn't necessarily mean that they have any monopoly on quality of thinking.

The importance placed on opinions of those with higher cognitive reflection depends solely on the type of decision in question. If we were to decide between a fixed and variable interest mortgage then using the opinion of someone with higher cognitive reflections seems like the right choice but if one were to decide between an apple and an orange Einstein's preference for apples over oranges would definitely be irrelevant. To conclude you cannot determine a correct response for any particular individual through the relation between cognitive reflection and preference as two individuals with different cognitive reflection may feel differently about certain outcomes which may explain different choices.

## References

- Albaity, M., Rahman, M., Shahidul, I., 2014. Cognitive reflection test and behavioral biases in Malaysia Judgment and Decision Making, Vol. 9, No. 2, March 2014, pp. 149–151
- Anand, P., 1993. The Philosophy of Intransitive Preference. *Economic Journal* 103 (417), 337–346
- Campitelli, G., & Labollita, M., 2010. Correlations of cognitive reflection with judgments and choices. *Judgment and Decision Making*, 5, 182–191.
- Chaiken, S. and Trope, Y., 1999. *Dual-Process Theories in Social Psychology*. New York: Guilford Press
- Chen et al, 2012. *Clin Infect Disease*. 55:194–200)
- Chen, S. & Chaiken, S., 1999. The heuristic-systematic model in its broader context. In S. Chaiken & Y. Trope (Eds.), *Dual-process theories in social psychology* ( New York: The Guildford Press.
- Donkers, Bas, Bertrand Melenberg and Arthur van Soest. 2001. Estimating Risk Attitudes Using Lotteries: A Large Sample Approach. *Journal of Risk and Uncertainty*. 22:2, pp. 165–95.
- Epstein, S., 1994. Integration of the Cognitive and Psychodynamic Unconscious. *American Psychologist*. 49:8, pp. 709–24.
- Evans, J. St. B. T., 1984. Heuristic and analytic processes in reasoning. *British Journal of Psychology*, 75, 451–468.

Evans, J. St. B. T., 2003. In two minds: Dual-process accounts of reasoning. *Trends in Cognitive Sciences*, 7, 454–459.

Evans, J. St. B. T., & Over, D. E., 1996. *Rationality and reasoning*. Hove: Psychology Press.

Frankish, K., & Evans, J. St. B. T., 2009. The duality of mind: An historical perspective. In J. St. B. T. Evans & K. Frankish (Eds.), *In two minds: Dual processes and beyond* (pp. 1– 30). Oxford, England: Oxford University Press.

Frederick, S., 2005. Cognitive reflection and decisionmaking. *Journal of Economic Perspectives*, 19, 25–42.

Funder, David C. and Jack Block. 1989. The Role of Ego-Control, Ego-Resiliency, and IQ in Delay of Gratification in Adolescence. *Journal of Personality and Social Psychology*. 57:6, pp. 1041– 050.

Hoppe, E. I., & Kusterer, D. J., 2011. Behavioral biases and cognitive reflection. *Economics Letters*, 110, 97–100.

Jensen, E., 1998. *Teaching with the brain in mind*. Alexandria, VA: Association for Supervision and Curriculum Development. Science Teachers Association

Jones, G., & Podemaska, M., 2010. IQ in the utility function: Cognitive skills, time preference, and cross country differences in savings rates. Retrieved 17 Dec. 2010 from [mason.gmu.edu/~gjonesb/IQsavings.pdf](http://mason.gmu.edu/~gjonesb/IQsavings.pdf)

Kahneman, D. and Frederick, S., 2002. “Representativeness Revisited: Attribute Substitution in Intuitive Judgment,” in *Heuristics and Biases: The Psychology of Intuitive Judgment*. T. Gilovich, D. Griffin and D. Kahneman, eds. New York: Cambridge University Press, pp. 49–81.

Kahneman, D. and Tversky, A.,1979. "Prospect Theory: An Analysis of Decision Under Risk." *Econometrica*. 47:2, pp. 263–91.

Melikian, L.,1959. "Preference for Delayed Reinforcement: An Experimental Study among Palestinian Arab Refugee Children." *Journal of Social Psychology*. 50, pp. 81–86.

Oechssler, J.,Roider, A., & Schmitz, P. W., 2009.Cognitive abilities and behavioural biases.*Journal of Economic Behavior & Organization*, 72, 147–152.

Primi et al, 2014. Item Response Theory analysis of the Cognitive Reflection Test: Testing the psychometric properties of the original scale and a newly developed 8-item version.  
<https://mindmodeling.org/cogsci2014/papers/484/paper484.pdf>.

Reber, A. S., 1993. *Implicit learning and tacit knowledge: an essay on the cognitive unconscious*. Oxford: Oxford University Press

Shiffrin, R. M., & Schneider W., 1977.Controlled and automatic human information processing. II. Perceptual learning, automatic attending and a general theory. *Psychological Review*, 84, 127-190.

Sloman, Steven A.,1996. The Empirical Case for Two Systems of Reasoning.*Psychological Bulletin*. 119:1, pp. 3–22.

Stanovich, K. E., 1999. *Who is rational? Studies of individual differences in reasoning*. Mahwah: Erlbaum.

Stanovich, K. and West, R., 2000. Individual Differences in Reasoning: Implications for the Rationality Debate?*Behavioral and Brain Sciences*. 22:5, pp. 645–726.

Sternberg, R. J., 1999. The theory of successful intelligence. *Review of General Psychology*, 3, 292–316.

Toplak, M. E., West, R. F., & Stanovich, K. E., 2011. The Cognitive Reflection Test as a predictor of performance on heuristics-and-biases tasks. *Memory & Cognition*, 39(7), 1275–1289.

## **Appendix 1**

### **Information Letter to Participants**

#### Title of the Project:

Cognitive Reflection and Decision Making

#### Researchers Contact Details:

Chief Investigator: TaimoorNaseer Waraich-03105933393

Primary Supervisor: DrAzamChaudhry

This research project is being undertaken as part of the requirements of aMphil Thesis at Lahore School of Economics.

#### Sources of funding:

All funding for the research will be provided by the Lahore School of Economics.

#### Description of the Research Project:

This research offers a quantitative design to explore the potential of cognitive reflection as predictors of an individual's time and risk preferences. You have been invited to voluntarily participate in this social experiment.

You will be asked to complete all questions in 4 section booklet which will be provided at the time of the survey. You will be required to finish the survey in 30 minutes. Along with the survey you will be asked to participate in a social experiment which will include real payoffs. You will be provided a detailed explanation of the experiment by the supervisor.

As your involvement is voluntary, if you choose not to participate please indicate so to the test supervisor. Similarly, if you experience any discomfort or inconvenience at any time please indicate to this effect.

If you choose to participate please read and sign the accompanying consent form and listen to the directions from the testing supervisor.

### Confidentiality

The information you supply will be collected and analyzed in line with the above outcomes. On completion of the tests, they will be collected, de-personalized and recoded into raw data with no connection to the participant. Analysis will occur after the completion of the Selection Course. The Chief Investigator will at no stage be able to make any personal connection between candidates and their results.

### Results:

Upon completion of the study all information will be published in a report and be available by application. No names of participants or any personal reference to individuals will be included.

### Voluntary Participation:

Participation is voluntary. Upon commencing the testing, it at any time you reconsider participation, you are free to withdraw. However you will only be eligible for the pay off if you complete the survey.

If you have any questions or require any further information about the research project, please contact one of the above Researchers.

The following testing has been approved by the Lahore School of Economics.

Thank you for the time.

## **Consent Form**

The following series of tests are for research purposes only and are designed to test their utility in recognizing individual decision making. As such, the researcher asks that you attempt all questions openly and honestly.

It is important that you understand that no element of any results of this testing will be used in any other way other than research. Upon completion the data will be de-identified and recoded for analysis purposes, without reference to you personally.

Please complete the following test within the 45 minutes allowed. Once you are satisfied that you have answered all of the questions please hand it to the supervisor.

1. I have been provided with information explaining the research project and I understand its intent.
2. I have been given the opportunity to ask questions and all my questions have been answered satisfactorily.
3. I am aware that I can contact the researcher or their supervisor if I have any further queries, or if I have concerns or complaints. I have been given their contact details in the Information Letter.
4. I understand that participating in this project will involve completing a written test of approximately 80 questions.
5. I understand that the researcher will not be able to identify me and that all the information I give will be de-identified, recoded and kept confidential and will be accessed only by the researcher and his/her supervisor.

6. I understand that I will not be identified in any report, thesis, or presentation of the results of this research.
7. I understand that I can withdraw from the research at any time without penalty.
8. I understand that I will not be formally de-briefed on the result of this testing; however, I will be able to access the written report relating to this study upon completion.
9. I freely agree to participate in this project.

NAME: \_\_\_\_\_ SIGNATURE: \_\_\_\_\_

DATE: \_\_\_\_\_

## **Instructions**

1. The survey consists of a 4 sections. You are expected to complete the survey in 30 minutes.
2. Section A consists of questions regarding general information. You are required to tick the boxes in the relevant questions.
3. Section B consists of 6 open ended questions. You are required to provide the answers in the blank space provided. You will be provided an extra sheet for your rough work if required.
4. Section C consists of 16 questions. You are required to make a choice between the provided alternatives for question 1 to 11 where you have been given a choice between two alternatives. 11 to 15 are supposed to be answered on scale of 1 to 5 with 1 being the smallest amount. Question 16 is an open ended question. You are required to tick or circle the choice you make.
5. Section D consists of 18 questions where you have been a choice between two alternatives. You are required to tick or the circle the choice you make.
6. Please tick the relevant tick box when asked in the survey.
7. You are expected to provide answers for all the questions.
8. If there are any questions you can ask the supervisor before you start with the survey. You will be given 5 minutes to review the survey.

**Section A**

Age: \_\_\_\_

Gender: \_\_\_\_\_

Email: \_\_\_\_\_

Phone Number: \_\_\_\_\_

University: \_\_\_\_\_

City: \_\_\_\_\_

Number of siblings: \_\_\_\_

CGPA: \_\_\_\_

Fathers Occupation: \_\_\_\_\_

Institute(s) for Secondary Education and Degree Studied

- 1. \_\_\_\_\_
- 2. \_\_\_\_\_
- 3. \_\_\_\_\_

Test Scores

SAT(out of 2400): \_\_\_\_\_

GAT(out of 100): \_\_\_\_\_

GRE(out of 340): \_\_\_\_\_

GMAT(out of 800): \_\_\_\_\_

Other(Please state name and total marks of the test): \_\_\_\_\_

Currently Enrolled (tick the appropriate choice)

- Undergraduate
- Post Graduate

Secondary Education and Results (tick the appropriate choices and specify results in the given space):

- Metric \_\_\_\_\_
- FSC \_\_\_\_\_
- & A levels \_\_\_\_\_
- High School \_\_\_\_\_

Other (Please specify): \_\_\_\_\_

**Please state the answers in the space provided in front of every question**

**Section B**

1. A bat and a ball cost Rs1.10 in total. The bat costs Rs1.00 more than the ball. How much does the ball cost? \_\_\_\_ Paisas
2. If it takes 5 machines 5 min to make 5 widgets, how long would it take 100 machines to make 100 widgets? \_\_\_\_ Minutes
3. In a lake, there is a patch of flowers. Every day, the patch doubles in size. If it takes 48 days for the patch to cover the entire lake, how long would it take for the patch to cover half of the lake? \_\_\_\_ Days
4. If 3 workers can wrap 3 toys in 1 hour, how many workers are needed to wrap 6 toys in 2 hours? \_\_\_\_ Workers
5. Jerry received both the 15th highest and the 15th lowest mark in the class. How many students are there in the class? \_\_\_\_ Students
6. In an athletics team tall members are three times as likely to win a medal as short members. This year the team has won 60 medals so far. How many of these have been won by short athletes? \_\_\_\_ Medals

**Please circle or tick the option of your choice.**

**Section C**

1. Rs 20000 this month or Rs 24000 next month
2. Rs 1000 now or Rs 2000 next year
3. Rs 1000 now or Rs 15000 in 10 years
4. Rs 500 now or Rs 25000 in 10 years
5. Rs 500 immediately or Rs 25000 in 10 years
6. Rs 10000 now or Rs 2000 every year for 7 years
7. Rs 40000 now or Rs 10000 every year for 25 years
8. 30 min massage in 2 weeks or 45 min massage in 1 month
9. Lose Rs 5000 this year or lose Rs 10000 next year
10. Tooth pulled today or tooth pulled in 2 weeks
11. Smallest amount in 4 days preferred to Rs 2500 in 2 months
12. How impulsive are you?
13. How much do you tend to procrastinate?
14. How much do you think of your future?
15. How much do you worry about inflation?
16. How many do you worry about getting a job?
17. What are your plans after you complete your current education?
18. Pick a number from 0-100. With that number representing your best guess of two-thirds of the average numbers chosen in the survey?

**Please circle or tick the option of your choice.**

**Section D**

1. Rs 10,000 for sure or a 90% chance of Rs 50,000
2. Rs 1000 for sure or a 90% chance of Rs 5000
3. Rs 10,000 for sure or a 75% chance of Rs 40,000
4. Rs 1000 for sure or a 75% chance of Rs 2000
5. Rs 1000 for sure or a 75% chance of Rs 1500
6. Rs 1000 for sure or a 50% chance of Rs 3000
7. Rs 5000 for sure or a 15% chance of Rs 1,000,000
8. Rs 1000 for sure or a 3% chance of Rs 70,000
9. Rs 1000 for sure or a 25% chance of Rs 2000
10. Rs 1000 for sure or a 25% chance of Rs 3000
11. Rs 100 for sure or a 4% chance of Rs 800.
12. Rs 100 for sure or a 1% chance of Rs 800
13. Rs 600 for sure or a 1% chance of Rs 5000
14. Lose Rs 100 for sure or a 90% chance to lose Rs 250
15. Lose Rs 100 for sure or a 75% chance to lose Rs 150
16. Lose Rs 1000 for sure or a 50% chance to lose Rs 2000
17. Lose Rs 150 for sure or a 10% chance to lose Rs 800
18. Lose Rs 1000 for sure or a 3% chance to lose Rs 7000

## Experiment

Now that the questionnaire is complete we invite you to participate in a behavioral experiment, which is important for economic science. The experiment involves financial decisions, which you can make in any way you want to. The questions are similar to those asked in the questionnaire with the exception that THIS TIME YOU CAN EARN REAL MONEY!

I will first explain the decision problem to you. Then you will make your decisions. A chance move will then determine whether you actually earn money.

Every 4<sup>th</sup> participant wins!

**HOW MUCH MONEY YOU WILL EARN AND AT WHICH POINT IN TIME WILL DEPEND ON YOUR DECISIONS IN THE EXPERIMENT.**

If you are among the winners, your amount will be paid by check. In this case the check will be sent to you by post.

The instructions for the Risk Lottery Experiment are as follows:

In each row of the given table A (on the next page) you see two alternatives. You can choose between

- A fixed amount that you get “for sure”
- An “all or nothing” lottery, where with 50 percent probability you can win Rs 500 Rs and with 50 percent probability you win nothing.

You start with row 1 and then you go down from row to row. In each row you decide between a safe payment (column A) and the lottery (column B). The lottery is the same in all rows. Only the amount on the safe payment (left) increases from row to row.

The instructions for the Intertemporal Choice Experiment are as follows:

In each row you see two alternatives. You can choose between

- A fixed amount of Rs300 (column A “today”)
- A somewhat higher amount, which will be paid to you only in “1 week” (column B).

Payment “today” means that the check you get can be cashed immediately. Payment “in 1 week” means that the check you get can be cashed only in 1 week.

You start with row 1 and then you go down from row to row. In each row you decide between Rs 300 today (column A) and a higher amount (column B); please always keep the timing of the payments in mind. The amount on the left side always remains the same, only the amount on the right side increases from row to row.

Which row on one of the tables will be relevant for your earnings will be determined by a random device later.

## Choices in Risk Preference Experiment

	Safe Payment	Lottery
1	Rs 0	50% chance of winning Rs 500 and 50% chance of winning Rs 0
2	Rs 25	50% chance of winning Rs 500 and 50% chance of winning Rs 0
3	Rs 50	50% chance of winning Rs 500 and 50% chance of winning Rs 0
4	Rs 75	50% chance of winning Rs 500 and 50% chance of winning Rs 0
5	Rs 100	50% chance of winning Rs 500 and 50% chance of winning Rs 0
6	Rs 125	50% chance of winning Rs 500 and 50% chance of winning Rs 0
7	Rs 150	50% chance of winning Rs 500 and 50% chance of winning Rs 0
8	Rs 175	50% chance of winning Rs 500 and 50% chance of winning Rs 0
9	Rs 200	50% chance of winning Rs 500 and 50% chance of winning Rs 0
10	Rs 225	50% chance of winning Rs 500 and 50% chance of winning Rs 0
11	Rs 250	50% chance of winning Rs 500 and 50% chance of winning Rs 0
12	Rs 275	50% chance of winning Rs 500 and 50% chance of winning Rs 0
13	Rs 300	50% chance of winning Rs 500 and 50% chance of winning Rs 0
14	Rs 325	50% chance of winning Rs 500 and 50% chance of winning Rs 0
15	Rs 350	50% chance of winning Rs 500 and 50% chance of winning Rs 0
16	Rs 375	50% chance of winning Rs 500 and 50% chance of winning Rs 0
17	Rs 400	50% chance of winning Rs 500 and 50% chance of winning Rs 0
18	Rs 425	50% chance of winning Rs 500 and 50% chance of winning Rs 0
19	Rs 450	50% chance of winning Rs 500 and 50% chance of winning Rs 0
20	Rs 475	50% chance of winning Rs 500 and 50% chance of winning Rs 0

### Choices in Intertemporal Choice Experiment

	Column A(Today)	Column B(1 Week from now)
1	Rs 300	Rs 310
2	Rs 300	Rs 320
3	Rs 300	Rs 330
4	Rs 300	Rs 340
5	Rs 300	Rs 350
6	Rs 300	Rs 360
7	Rs 300	Rs 370
8	Rs 300	Rs 380
9	Rs 300	Rs 390
10	Rs 300	Rs 400
11	Rs 300	Rs 410
12	Rs 300	Rs 420
13	Rs 300	Rs 430
14	Rs 300	Rs 440
15	Rs 300	Rs 450
16	Rs 300	Rs 460
17	Rs 300	Rs 470
18	Rs 300	Rs 480
19	Rs 300	Rs 490
20	Rs 300	Rs 500

