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Cognitive reflection and the disposition effect: A lab experiment

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ABSTRACT

This research investigates the connection between cognitive reflection and the disposition effect, a well-known bias in the behavioral finance literature. Utilizing the Cognitive Reflection Test (CRT) developed by Frederick (2005), we measured cognitive abilities in a laboratory-based experiment comprising 55 students. The main goal was to investigate the extent to which these cognitive resources might modulate the disposition effect. The study was conceptualized within the framework of the dichotomy between a deliberative long-term self and an impulsive short-term self, as detailed in Kahneman's 2011 two-systems theory. The findings indicate a significant negative correlation between cognitive abilities and the disposition effect, providing extra empirical support for Kahneman's theory. This study presents new empirical evidence of the association between cognitive reflection and behavioral biases associated with decision-making under conditions of risky, thus providing a basis for possible interventions to mitigate these biases. The implications of this study are not limited to academia, but may provide information for the development of future financial education programs to enhance the decision-making process of individuals, whether in public or private companies.

Keywords: disposition effect, cognitive reflection test (CRT), behavioral biases, lab experiment

1. INTRODUCTION

The disposition effect (Shefrin and Statman, 1985) refers to the tendency of investors to sell winning stocks more often than losing ones. This behavioral bias has been observed across various trading environments, including options exercise (Heath, Huddart, and Lang, 1999), futures market operators (Locke and Mann, 2005; Coval and Shumway, 2005), equity investment fund shareholders (Chiu et al., 2004), and real estate sales (Genovese and Myer, 2001).

One of the main reasons why this effect is studied so much in finance is that individuals who suffer from the disposition effect, in general, underperform in the management of their investments compared with individuals who do not present this bias (Odean, 1998; Dhar and Zhu, 2006; Prates et al., 2019).

In general, it has been found that the more sophisticated and savvy an investor is, the less prone to the disposition effect and other cognitive anomalies he will be (Da Costa Jr. et al., 2013; Oechssler et al., 2009; Noori, 2016; Prates et al., 2019).

Several studies demonstrate a link between cognitive ability and economic behavior (Frederick, 2005; Benjamin et al., 2013; Oechssler et al., 2009; Noori, 2016; Janssen et al., 2020). Frederick (2005) introduced the Cognitive Reflection Test (CRT), which comprises math problems with intuitive yet deceptive answers. Highly cognitively-abled individuals tend to exhibit less risk aversion in winning bets and display increased patience.

The results obtained by Frederick (2005) suggest that the human mind processes information in a dual way. Currently, according to Kahneman (2011), several authors agree that these processes can be unconscious, fast, automatic, and high capacity (System 1), or conscious, slow and deliberative (System 2).

In this study, we conducted a lab experiment to investigate the relationship between the disposition effect and individuals' cognitive abilities. The hypothesis is that high (low) CRT scores are associated with low (high) levels of the disposition effect. We simulated an exogenous stock market to capture the effect and assessed cognitive abilities using a questionnaire and CRT scores.

To be useful, a test of cognitive skills must be short and simple. The cognitive reflection test first proposed by

Frederick (2005) is a 3-item test that can be performed in less than five minutes and is a good predictor of cognitive skills, particularly with regard to mathematical skills.

Recent studies have already verified the relationship between behavioral biases and cognitive abilities (Oechssler et al., 2009; Benjamin et al., 2013; Deck and Jahedi, 2015; Noori, 2016; Blaywais and Rosenboim, 2019; Maloney and Retanal, 2020).

The only study, so far, that has analyzed the relationship between the disposition effect, emotions, and Systems 1 and 2 was that of Richards et al. (2018), which focused on real investors in the United Kingdom, but used a different approach from ours. As the present research was conducted in an experimental setting it has the potential to reduce the presence of noise that could directly interfere with investor behavior and thus can add a new dimension to the study of this effect.

In this way, we contribute to the literature by analyzing the relationship between the disposition effect and cognitive abilities via CRT scores in a lab environment. Real market tests of the disposition effect are inconclusive due to uncontrollable investor decisions and the interference of confounding variables. Laboratory experiments can be an important tool in finance research because they allow more control over the variables, allowing researchers to isolate specific factors and observe their impact on financial decision-making.

The remainder of this article is organized as follows. Section 2 describes the design of the experiment, Section 3 presents the results, and Section 4 concludes the work.

2. EXPERIMENTAL DESIGN

The procedure adopted here is characterized by a study in a laboratory environment with a hypothetical simulation design of investments through a specific software, with monetary incentives for participants throughout the experiment . The total number of participants was n=55.

The experiment design was similar to that of Weber and Camerer (1998) and Fischbacher et al. (2017). The simulation begins with all assets having the same price and participants receiving an initial endowment of 10.000 monetary units (= 10 BRL) and can trade six different stocks labeled 1 to 6. As in Weber and Camerer (1998) and Fischbacher et al. (2017), the game consists of 34 rounds, beginning in Round –3 and ending in Round 30. In Rounds –3 to –1, the participants cannot trade but observe the price changes for the six stocks. In Rounds 0 to 30 participants can trade the six stocks.

In each period, the price can go up by 6% or down by 5%. The probability of the increase varies between stocks but is constant throughout the periods for each one. Participants know the size of the possible price increase or decrease, and they also know that the probabilities of price change vary from one asset to another, but are constant in all rounds and independent of their trading activities. Furthermore, in accordance with Fischbacher et al. (2017), we implemented the following six price increase probabilities for the six stocks: 40%, 45%, 50%, 55%, and 60%. However, these probabilities were unknown to the participants. Figure 1 shows the decision-making interface where participants make their decisions to buy or sell stocks.

During the simulation, the participant can follow his results at any time. They are updated at the end of each of the 30 periods. The average time it took the 55 participants to complete the experiment was 56 minutes.

Figure 1: "Bem Nos Investimentos" software – decision-making interface

The cognitive reflection test (CRT), introduced by Frederick (2005), has proved to be one of the most useful measures in the study of individual differences in thinking, judgments, and decisions (Baron et al., 2015).

CRT differentiates between more impulsive and more reflective decision makers. To do so, each of the three CRT questions has an apparently intuitive (but incorrect) answer that quickly comes to mind. CRT questions are not difficult in the sense that the correct solutions are easily understood when explained to participants.

Frederick (2005) applied the CRT to measure the cognitive reflection capability (reflexivity x impulsivity) of undergraduate students at renowned universities. He found that Harvard students averaged only 1.43, while Princeton University students averaged 1.63 (on a score ranging from 0 to 3).

These intriguing results can be explained based on what researchers call the dual cognitive process (Epstein, 1994; Evans, 2003). The literature suggests that people use two types of cognitive processes: System 1 and System 2 (Stanovich and West 2000; Kahneman and Frederick, 2002; Kahneman, 2011). Thus, System 1 operates automatically and quickly, with little or no effort and no perception of voluntary control. In System 2, cognitive operations are performed from a logical judgment with predefined rules that require a high cognitive effort. While System 1 is related to an impulsive way of thinking, System 2 is a reflective and slower style of decision making. Thus, even when people know how to answer specific questions and how to make good decisions, they can misjudge if they resort to impulsive thinking.

The test consists of answering three questions (FREDERICK, 2005):

1) A bat and a ball together cost 110 cents. The bat costs 100 cents more than the ball. How much does the ball cost? (Impulsive response: 10 cents; correct answer: 5 cents).

2) In a lake, there's a patch of lily pads. Each 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? (impulsive response: 24 days; correct response: 47 days).
3) If it takes 5 machines 5 minutes to make 5 widgets, how long would it take 100 machines to make 100 widgets (in minutes)? (Impulsive response: 100 minutes; correct answer: 5 minutes).

The test is used to separate people into those who tend to use System 1 and those who tend to use System 2. Studies indicate that individuals with a higher score for CRT questions tend to be less risk averse in gains (FREDERICK, 2005). Noori (2016) found in his sample that individuals with lower scores in CRT are significantly more likely to exhibit conjunction fallacy, illusion of control, overconfidence, base rate fallacy and conservatism biases.

As already pointed out, in this study the interest lies in identifying whether the score in the CRT (S1 and S2) is associated with the level of the disposition effect.

The average number of correct CRT responses in our sample was 1.75 questions. Of our subjects, 25.5% answered all three questions correctly, 41.8% answered two questions correctly, 16.4% answered one question correctly, and the remaining 16.4% answered none of the questions correctly. As in Frederick (2005), male subjects received a higher average score (2.03 questions) than female subjects (1.25 questions), which is a significant difference ($p < 0.004$, Mann-Whitney U test).

2.1 The Disposition Coefficient (DC)

As defined previously, the disposition effect is the tendency to realize gains before losses. The term was coined by Shefrin and Statman (1985).

Detecting the disposition effect on market data is a difficult task because once detected there is always an additional plausible hypothesis to explain it, such as the tendency of investors to believe in the mean reversion phenomenon, portfolio rebalancing, taxes, etc. Thus, the use of data collected in controlled laboratory experiments can help to explain this and many other phenomena.

The disposition effect of each participant in the experiment can be estimated, based on Odean (1998), by the disposition coefficient (DC):

$$PRG=RG/(RG+PG) \quad (1)$$
$$PRL=RL/(RL+PL) \quad (2)$$

where PRG (PRL) is the proportion of realized gains (losses); RG (RL) is the number of trades of an investor/participant with a realized gain (loss); PG (PL) is the amount of the paper gain (loss) of the investor/participant. Each stock that is in the investor's/participant's portfolio at the beginning of each simulation period, but is not sold, is considered a paper gain or a paper loss (not realized).

The disposition coefficient (DC) of the investor/participant is then

$$DC=PRG-PRL \quad (3)$$

2.2 Recruiting and Payment

Fifty-nine students were randomly selected from several classes in the Business and Accounting undergraduate courses at a private Brazilian university Four participants were excluded due to prior CRT knowledge, resulting in a sample of 20 females and 35 males. The majority (81%) were below 25 years old. Data was collected during two experimental sessions in the computer lab on March 15 and 18, 2019.

As an incentive for the participants, an award system was included. Thus, each participant was given a number that was used to identify him/her. Twenty participants from the 55 who carried out the experiment were randomly selected. There were three levels of awards: the participant with a final balance up to 10,000.00 monetary units received R$5.00; final balance from 10,001.00 to 20,000.00 received R$10.00; and those who achieved a final balance above 20,001.00 received R$15.00. This information was available at the beginning of the experiment. The exchange rate on March 29, 2019, was 1 USD=3.89 BRL.

3. FINDINGS AND DISCUSSIONS

In Table 1 we observe that 80% (44 individuals) of the sample presented DC greater than zero, a result like other experiments (Weber and Camerer, 1998; Da Costa Jr. et al., 2013). It is also observed that the average assets held in portfolio per period and per participant was 3.54 (maximum would be 6).

Table 1: Descriptive statistics of the participants in the experiment

	Students	Random trades
Sample (n)	55	55
Average Portfolio Returns (%)	16%	11.4%
Average transactions per period	33	37
Average assets in portfolio per period	3.54	4.33
Subjects with DC > 0 (%)	80%	56%

The BNI software's calibration for calculating disposition coefficients was tested using random asset transactions in an Excel spreadsheet. The null hypothesis, that the coefficient is

Table 2: Descriptive statistics of the participants and random trades

	Disposition Coefficients					
	DC	PRG	PRL	DC Random	PRG	PRL
n	55			55		
Mean	0.058	0.169	0.110	0.001	0.171	0.171
Median	0.057	0.173	0.100	0.007	0.156	0.167
Max.	0.397	0.398	0.550	0.260	0.406	0.438
Min.	-0.288	0.000	0.000	-0.180	0.063	0.000
Standard Dev.	0.118	0.092	0.113	0.083	0.068	0.090
Kolmogorov-Smirnov (D)	0.131			0.091		
t stat (mean=0)	3.63***			0.07		
Wilcoxon test	1214.5***			-0.084		

Note:
* p < 0.10; ** p < 0.05; *** p<0.01

Table 3 displays CRT score statistics for 55 students, with an average score of 1.75 correct questions. Students were split into "high" (2-3 correct answers; 36 students) and "low" (0-1 correct answers; 19 students) groups, reflecting their decision-making styles. Women scored significantly lower than men ($p < 0.004$), indicating greater reliance on intuition. Another fact to note is that participants with positive DCs achieved a lower score than those with negative CDs, but the difference was not significant ($p < 0.139$).

Table 3: Descriptive statistics for the CRT score

	CRT	CRT Low	CRT High	CRT Male	CRT Female	CRT (CD<0)	CRT (CD>0)
N	55	19	36	20	35	11	44
Mean	1.75	0.52	2.39	2.03	1.25	2.18	1.64

Note:
(1) "CRT low" is the group that answered 0 or 1 question correctly, and "CRT high" is the group that answered 2 or 3 questions correctly.

3.1 Regression Analysis

Next, in Table 4, we present a series of regressions to provide more details regarding the association between DC and CRT, along with five control variables, namely: sex, transactions, overconfidence, average number of assets in portfolio and profitability (portfolio's final return).

A robust regression (via Stata) was used to check how much the variables interfere with or relate to one another. Robust regression is able to correct patterns of nonnormality in the residual regression. Its objective is to reduce the influence of discrepant points that affect the quality of the estimation of the regression model parameters.

It can be seen in Table 4 that the control variables, in general, showed no great explanatory power for DC variations. Only the CRT variable was (negatively) significant across all regressions, and the overconfidence variable at a lower significant level.

Table 4: Robust regression between DC and six independent variables

DC	Intercept	CRT	Sex	Transactions	Overconf.	Assets	Return
Model1	.1080***	–.0283**					
.0595**	(.0262)	(.0136)					
.1157							
Model 2	.0914***	–.0381**	.0533				
.1004*	(.0279)	(.0162)	(.0378)				
.1142							
Model 3	.0853**	–.0392**	.0539	.0002			
.1020*	(.0384)	(.0171)	(.0389)	(.0009)			
.1152							
Model 4	.0654	–.0337**	.0462	–1.9e-06	.0862*		
.1462	(.0412)	(.0166)	(.0362)	(.0008)	(.0515)		
.1135							
Model 5	.0613	–.0339**	.0462	.00001	.0868*	.0011	
.1463	0,072	(.0165)	(.0364)	(.0008)	(.0524)	(.0143)	
.1146							
Model 6	.0641	–.0331*	.0482	.00007	.0850	.0008	–.0378
.1482	(.0734)	(.0169)	(.0365)	(.0010)	(.0528)	(.0144)	(.1013)
.1157							

Notes:
(1) This table presents the regression coefficients and, in parentheses, the robust standard error; in bold, the R-sq, and below the R-sq the RMSE, both estimated via Stata.
(2) $DC_i = \alpha + \beta_1 X_{1i} + \beta_2 X_{2i} + \beta_3 X_{3i} + \beta_4 X_{4i} + \beta_5 X_{5i} + \beta_6 X_{6i} + u_i$
Where DC_i is the disposition coefficient; X1 is the CRT test used to measure the participants' attention level, whether they were in a more intuitive or rational mode; X2 is the sex of the participants; X3 is the average number of transactions carried out by each participant during the simulation; X4 is the level of confidence in participants' decision-making identified by means of a questionnaire; X5 is the average number of assets in portfolio in each period per participant; X6 is the profitability achieved by each participant (loss or profit).
(3) Sample size n=55 participants.
(4) To build a confidence index, which was used as a proxy to measure the participants' overconfidence, a questionnaire like that used by Busenitz and Barney (1997) was applied.
(5) * p < 0.10; ** p < 0.05; *** p < 0.01

4. CONCLUSIONS

Our study found participants' disposition effect significantly different from zero at a 1% level, consistent with past research on the subject in both lab experiments and archival data (Shefrin & Statman, 1985; Odean, 1998; Weber & Camerer, 1998; Genovese & Myer, 2001; Locke & Mann, 2005; Dhar & Zhu, 2006; da Costa Jr. et al., 2013).

However, new in terms of a lab experiment, we showed that the disposition effect is lower among students with higher measured cognitive ability. To the extent that the cognitive ability test (CRT) proposed by Frederick (2005) can be taken as a proxy for available cognitive resources, our results are consistent with the two systems theories (Kahneman, 2011), which postulate that when a subject decides (shows his preferences) he usually faces a conflict between a deliberative, long-term self and an impulsive, short-term self.

Despite the popularity of the CRT, one challenge hinders its interpretation: the numerical characteristic of the CRT may cause reflection skills to be confounded with mathematical skills (Sirota el al. 2021). However, our findings align with studies showing a negative correlation between cognitive abilities and biases (Frederick, 2005; Benjamin et al., 2013; Oechssler et al., 2009; Noori, 2016; Richards et al., 2018; Blaywais & Rosenboim, 2019; Maloney & Retanal, 2020).

Last, the experiment was conducted in 2019 using the traditional CRT, however, currently the questions of this test are already well known among students, and it would be recommended to apply a more updated version of it, such as CRT-7, among others (Toplak et al., 2014; Primi et al., 2016, Sirota et al., 2021). However, self-reported prior exposure does not affect the test's predictive validity (Sirota, 2021).

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Data Sharing Statement
The data that support the findings of this study are openly available in figshare at https://doi.org/10.6084/m9.figshare.19727380.v1

REFERENCES

Baron, J., Scott, S., Fincher, K., and Metz, S. (2015) "Why does the cognitive reflection test (sometimes) predict utilitarian moral judgment (and other things)?" Journal of Applied Research in Memory and Cognition 4 (3), 265-284.

Benjamin, D., Brown, S., and Shapiro, J. (2013) "Who is 'behavioral'? Cognitive ability and anomalous preferences." Journal of the European Economic Association 11 (6), 1231-1255.

Blaywais, R., and Rosenboim, M. (2019) "The effect of cognitive load on economic decisions." Managerial and Decision Economics 40 (8), 993-999.

Brañas-Garza, P., Kujal, P., and Lenkei, B. (2019) "Cognitive Reflection Test: Whom, how, when. " Journal of Behavioral and Experimental Economics 82 (10), 14-55.

Busenitz, L., and Barney, J. (1997) "Differences between entrepreneurs and managers in large organizations: Biases and heuristics in strategic decision-making." Journal of Business Venturing 12 (1), 9-30.

Chiu, S., Chen, H., Yeh, Y., and Shu, P. (2004) "Does year end sweep ameliorate the disposition effect of mutual fund investors?" Working Paper, National Taiwan University.

Coval, J., and Shumway, T. (2005) "Do behavioral biases affect prices?" Journal of Finance 60 (1), 1-34.

Dhar, R., and Zhu, N. (2006) "Up close and personal: investor sophistication and the disposition effect." Management Science 52, 726–740.

Da Costa Jr., N., Goulart, M., Cupertino, C., Macedo Jr., J., and Da Silva, S. (2013) "The disposition effect and investor experience. " Journal of Banking & Finance 37, 1669–1675.

Deck, C., and Jahedi, S. (2015) "The effect of cognitive load on economic decision making: A survey and new experiments" European Economic Review 78, 97-119.

Epstein, S. (1994) "Integration of the cognitive and the psychodynamic unconscious." American Psychologist 49 (8), 709-724.

Evans, J. (2003) "In two minds: Dual-process accounts of reasoning."Trends in Cognitive Sciences 7 (10), 454-459.

Frederick S. (2005) "Cognitive reflection and decision making." Journal of Economic Perspectives 19 (4), 25–42.

Fischbacher, U., Hoffmann, G., and Schudy, S. (2017) "The causal effect of stop-loss and take-gain orders on the disposition effect." Review of Financial Studies 30 (6), 2110–2129.

Genovese, D., and Myer, C. (2001) "Loss aversion and seller behavior: Evidence from the housing market." Quarterly Journal of Economics 116 (4), 1233-1260.

Goulart, M., Da Costa Jr., N., Santos, A., Takase, E., and Da Silva, S. (2013) "Psychophysiological correlates of the disposition effect." Plos One 8, e54542.

Heath, C., Huddart, S., and Lang, M. (1999) "Psychological factors and stock option exercise." Quarterly Journal of Economics 114 (2), 601-627.

Janssen, E., Raoelison, M., and De Neys, W. (2020) ""You're wrong!": The impact of accuracy feedback on the bat-and-ball problem."Acta Psychologica 206,e103042.

Kahneman, D. (2011) Thinking, Fast and Slow. Farrar, Straus and Giroux.

Kahneman, D., and Frederick, S. (2002) "Representativeness revisited: Attribute substitution in intuitive judgment." In Heuristics and biases: The psychology of intuitive judgment, 49–81.

Locke, P., and Mann, S. (2005) "Professional trader discipline and trade disposition." Journal of Financial Economics 76, 401–444.

Maloney, E. A.; Retanal, F. (2020). "Higher math anxious people have a lower need for cognition and are less reflective in their thinking." Acta Psychologica, 202, 102939.

Noori, M. (2016) "Cognitive reflection as a predictor of susceptibility to behavioral anomalies." Judgment and Decision Making 11 (1), 114–120.

Odean, T. (1998) "Are investors reluctant to realize their losses?" Journal of Finance 53 (5), 1775-1798.

Oechssler, J., Andreas, R., and Schmitz, P. (2009) "Cognitive abilities and behavioral biases." Journal of Economic Behavior & Organization 72 (1), 147-152.

Prates, W., Da Costa Jr., N., and Santos, A. (2019) "Efeito disposição: Propensão à venda de investidores individuais e institucionais. (The disposition effect: Propensity to sell of individual and institutional investors.)" Revista Brasileira de Economia 73 (1), 97-119.

Primi, C., Morsanyi, K., Chiesi, F., Donati, M. A., and Hamilton, J. (2016). "The development and testing of a new version of the cognitive reflection test applying item response theory (IRT)". Journal of Behavioral Decision Making, 29, 453–469.

Richards, D., Fenton-O'Creevy, M., Rutterford, J., and Kodwani, D. (2018) "Is the disposition effect related to investors' reliance on System 1 and System 2 processes or their strategy of emotion regulation?" Journal of Economic Psychology 66, 79-92.

Shefrin, H., and Statman, M. (1985) "The disposition to sell winners too early and ride losers too long: theory and evidence." Journal of Finance 40 (3), 777-790.

Sirota, M., Dewberry, C., Juanchich, M., Valuš, L., and Marshall, A.C. (2021) "Measuring cognitive reflection without maths: Development and validation of the verbal cognitive reflection test". Journal of Behavioral Decision Making, 34, 322–343.

Stanovich, K., and West, R. (2000) "Individual differences in reasoning: Implications for the rationality debate?" Behavioral and Brain Sciences 23 (5), 645-665.

Fischbacher, U., Hoffmann, G., and Schudy, S. (2017) "The causal effect of stop-loss and take-gain orders on the disposition effect. " Review of Financial Studies 30 (6), 2110–2129.

Toplak, M.E., West, R.F., and Stanovich, K.E. (2014). "Assessing miserly information processing: An expansion of the cognitive reflection test".Thinking & Reasoning, 20, 147–168.

Weber, M., and Camerer, C. (1998) "The disposition effect in securities trading: An experimental analysis." Journal of Economic Behavior & Organization, 33 (2), 167-184.