

## 1.5 Cognitive Behaviour Studies

Chair: Georgios Melios (LSE) & Ploutarchos Kourtidis (LSE)

<b>Chouzouris Michail</b> University of Piraeus	Is Economic Rationality a Learned Behaviour? A Joint Investigation of Cognitive Abilities and Behavioural Biases
<b>Ioannidis Nikandros</b> Pompeu Fabra University	Observed (in)Congruence: the effect of voter-party distance on quasi-electoral behaviour

# **Is economic rationality learned behavior? A joint investigation of cognitive abilities and behavioral biases.**

**Michail Chouzouris<sup>1,2</sup> and Platon Tinios<sup>1</sup>**

<sup>1</sup>University of Piraeus

<sup>2</sup>University of Western Macedonia

## **Abstract**

This work employs experimental methods to explore the extent to which individuals deviate from choices consistent with the concept of "Rational Economic Man". It aims to investigate whether such departures are linked to financial and numeric literacy, as well as impulsive or analytical thinking. The study specifically focuses on a group of Greek undergraduate students who were enrolled in a course heavy on statistics and probability. The Cognitive Reflection Test (CRT), along with other financial and numeric literacy tools, was used to understand how irrational choices are made. The results indicate that individuals with lower CRT scores are more prone to behavioral biases, even when controlling for numeracy and financial literacy. Furthermore, gender was found to be a significant factor, both independently and through the mediation of CRT. These findings suggest that cognitive reflection is essential in avoiding behavioral biases, and impulsive thinking can lead to irrational decision-making. Also, it is the first study to examine these effects using a sample of Greek students. This is of importance to behavioral economics; it adds a data point from a cultural milieu which less exposed to discussion on behavioral biases. It may also enlighten discussion of public policies and reforms in Greece.

**Keywords:** behavioral economics; biases; rationality; numeric literacy; financial literacy; gender; Greece

## Introduction

Homo Economicus—Rational Economic Man REM—forms the foundation of orthodox economic analysis. This has been contested by theories of bounded rationality (Simon 1990) which developed into a more thoroughgoing critique by behavioural economics (Kahneman 2003), who proposed an alternative theoretical construct. However, rationality is not jettisoned. REM remains in use as a point of reference, perhaps as characteristic of behaviour at a limit point, while still providing the dominant focus in normative economics. Thus, non-orthodox approaches do not present themselves as fully-fledged alternatives, but purport to offer more realistic descriptions of actual decision making. REM is not replaced—but remains as reference, or an ideal. This ideal can be approached in certain conditions or is one that, with practice, could be emulated or encouraged using suitable ‘nudges’ (Sunstein 2014). In consequence, the behaviour of a REM is not treated as an ontological, essentialist, issue but simply as a matter for empirical hypothesis. Individuals may approach—to a greater or a lesser degree—how a REM could behave; they may also approach such behaviour depending on the issue at hand or even the prevailing market conditions (Fama 1998). Another way of putting it is that rational behaviour is encouraged by contexts, most notably that of scarcity; indeed, experiments have showed animals when placed in situations of scarcity exhibit behaviour consistent with main-stream economics. Coyle (2021, p118) interprets such findings to imply that environmental and social context affect learning, cautioning against placing all emphasis on cognition.

In other words, it is not the case that an individual is or is not ‘really’ an REM. REM is a situation that can be learned; it is a cognitive issue, not innate but acquired (Bikhchandani et al. 1998). Implicit in this view that closeness to REM is a matter of degree, which could be measured; that individuals could be closer to REM in some areas than in others; and that is likely to be subject to cognitive issues related to learning.

Behavioural economics contends that matters—such as REM—which taken as given can instead be objects of empirical investigation, most often through conducting a series of experiments. Most of these have, with time, become well established with an accepted series of well-understood tests and measures. Thus, there exists a set of questions testing how far individuals are from the ideal of REM through questions probing the understanding of uncertainty, time or consistency of decisions. This in some sense shadows tests designed to benchmark learning or cognition. Some measure numeracy (the Berlin numeracy test), financial literacy, while decision making processes are probed by test of cognitive reflection (CRT). These tests have been conducted at a wide variety of contexts, populations, while a corpus of findings is emerging on how these processes are related to co-factors such as gender. Several studies report the effect of education on rational choices; Ates et al (2016) found that individuals with higher education are less liable to exhibit biases; Seru et al (2010) examining the learning process made a distinction between experience and abilities, emphasizing the importance of the latter.

This paper builds on this empirical approach by attempting four tasks. First, it conducts a barrage of different tests in a range of behavioural areas for the same subjects: Economic literacy questions, examine how closely individuals correspond to REM; this coexists with tests of financial literacy and numeracy, as well as cognitive reflection. Second, the fact that all tests are conducted for the same individuals allows us to probe relationships between the various kinds of biases. Moreover, by positing that there exists a hierarchy of effects, where higher level departures from rationality are caused by more fundamental cognitive features, we approach the issue of how far causal mechanisms can be inferred. An individual thus would start from the bedrock of cognitive reflection and would extend through numeracy and financial

literacy before ‘becoming’ REM. That is, we treat the status of REM as a stance that is the product of learning whose origin is cognitive reflection. Third, our paper probes with greater detail how gender enters such processes – the vexed question of and why extent do women come closer or not from Homo Economicus. Fourth, it does so for a sample of Greek undergraduate students, who, by virtue of following a course heavy on probability and statistics, can be expected not to be subject to numeracy problems, and hence better disposed to be closer to REM. In this purposely biased sample, the probability of individuals conforming to the model of rationality and of REM ought to be magnified; hence findings of systematic cognitive biases should be accorded greater weight.

The paper is structured as follows. A section surveying theory and concepts is followed by an exposition of the experimental design. A short description of the key findings for each departure motivates the definition of numerical scores summarizing essentially how close each individual is to the ideal of fully rational, numerate REM. These scores can be related to each other and can form the basis of an econometric analysis which attempts to explain being REM as a learned behaviour, where the most basic influence is that of cognitive reflection. The paper concludes by discussing the findings, benchmarking against previous studies.

## **Theory and concepts**

An accumulation of theoretical literature has highlighted the importance of a link between cognitive abilities and behaviour – with an especial focus on how individuals react to risk: would they behave as expected utility maximisers or are they closer to prospect theory? At the heart of the discussion is the distinction between system 1 decision making which lies behind automatic decisions, and system 2, which is characterised by slow, controlled, high effort and low capacity processes. (Morewedge and Kahneman 2010). The mechanism of dual –system theory (intuitively thinking vs analytical) and the incorrect intuitions of system 1 can explain the occurrence of irrational choices. In this way, people who learn how to control their intuitions should appear as less biased decision makers. This learning process has been well documented. Sutton & Barton (1998) show that shifts between choices can be explained by theories of learning and valuation that incorporate prediction error mechanisms. Friedman (1998) showed that individuals can learn the decision-making process and how the task interacts with their basic underlying values; once this learning has taken place, choices converge on expected utility maximization.

The classical approach proceeds from the maximization of expected utility on the part of a fully informed, rational individual with unlimited knowledge, who only faces a budget constrain. Kahneman and Tversky (1979) proposed a fully specified alternative to the utility model- prospect theory. Their critique is particularly relevant in the presence of risk and uncertainty. They suggest that individuals’ decisions are evaluated using a reference point - setting the scene to define risk attitudes focusing on gains and losses rather than on absolute amounts of resources. Additionally, the authors proposed an S-shaped probability function to weight probabilities. This reflected the finding that decision makers either ignore or overestimate small probabilities. Zhang and Maloney (2012) used prospect theory to find that experience and problem solving affect the perception of probabilities, including notably better estimation of probabilities.

This learning behaviour, apart from cognition, can, as behavioral economics suggests, be significantly affected by cognitive and psychological factors (Camerer 1998). Unlike consumer theory, which proceeds from an environment of certainty, behavioural economics lays emphasis on risk and uncertainty. For example, Nyger et al. (2019) state that a key element in decision making is the perception of risk on the basis of the consequences, expressed as the

balancing of expected pay-offs (the sum of benefits and loss). Factors such as past experiences, social or demographic characteristics operate as predictors of risk perception, to the extent that they help individuals familiarize themselves with the recognition, categorization and alleviation of risk. Psychological factors can drive individuals to irrational decisions through the occurrence of cognitive biases in an environment of uncertainty (Kahneman and Tversky 2013).

An association between cognitive abilities and behavior can be explained in three different, but not mutually exclusive, ways. First, dual process theory, suggests that decision makers with lower cognitive abilities are heavily influenced by past experiences, and are more liable to use system 1 thinking. In contrast, high cognitive ability individuals employ system 2 and, so, are more likely to arrive at rational choices through an intellectual process (De Neys 2021; Shulman et al. 2016). Rabin & Thaler (2001) state that high cognitive capacity- an attribute of high cognitive capacity individuals- enables people to recognize the irrationality of risk aversion over small stakes. Furthermore, people who summon system 2 for analyzing data and decision taking can distinguish with ease any intuitively (wrong) answer from the correct ones, and hence exhibit fewer behavioral biases.

A second plausible suggested explanation for a link to cognitive capacity reverses causality, positing that risk preferences affect, directly and indirectly, cognitive ability. A low cognitive capacity individual would prefer safer environments with fewer risky choices (Deck and Jahedi 2015). In a similar fashion, the risk attitude profile may affect choices in education which, in turn, has been shown to increase cognitive abilities. In this way, risk attitude would be related to cognitive abilities by way of the intermediary mechanism of education. A final, third possibility, is based on people's facility to place decisions in an appropriate frame. When facing a decision problem, individuals with high cognitive abilities can pay more attention to the features of the particular choices available and hence exhibit a smaller framing effect. This allows them to reframe the options and hence to narrow them down (Simon et al. 2004), moving closer towards REM.

These theoretical expectations have been subjected to empirical testing by way of measuring the cognitive abilities and testing its predictive power in uncertain situations where individuals are forced to make a decision – i.e., treating cognitive abilities as a causal mechanism leading to different behaviour. Some authors have used experimental tools to measure the association of cognitive performance with different cognitive biases and heuristics in consumers goods markets (Lukas and Nöth 2019), or in strategic behavior (Branas-Garza et al. 2012).

## **Literature Review**

Many empirical studies probe the link between cognitive abilities and behavioral biases. Specifically, Oechssler et al. (2009) examined five biases and found a significant influence of cognitive abilities on behavioral biases, especially in the case of the conjunction fallacy, conservatism, time preference and risk preferences. Noori (2016) building on previous studies, increased the number of examined biases to nine using a sample of university students. His results underline that cognitive reflection can predict the occurrence of behavioral anomalies. Skagerlund et al. (2018) focus their research on the effect of cognitive factors, alongside emotional and demographic cofactors, as well as on financial literacy. Using a representative sample of Swedish adults, they conclude that cognitive factors have significantly predictive power on financial literacy, while the most note-worthy contribution was that of numeracy. Our work applies a similar empirical strategy to a Greek sample; however, we focus on a purposely biased sample of young numerate undergraduates. This group is homogeneous and familiar

with mathematical techniques, a feature which allows us to concentrate on the relationship between the various kinds of departure, rather than the influence of cofactors.

Our experimental design and empirical strategy thus share much with the approach of Skagerlund et al. (2018), who conducted a similar series of tests on a random sample of the population in Sweden and then proceeded to estimate a series of econometric models relating departures from rationality to each other as well as to socio-economic cofactors. Our approach roughly reproduces their approach but uses a focused, purposely biased sample of young undergraduates of both genders; concentrating on a more homogeneous group allows us to clarify the relationship between the various kinds of departure.

An issue that has received considerable attention in the literature is how gender relates to these matters, and in particular the extent to which the very concept of REM is gendered (Eckel and Grossman 2008). Gender differences have been studied in experimental settings, where a common finding is that males consistently perform better on CRT tasks than females (Holt et al. 2015), among other differences. While gender difference is a common finding, the literature has not extensively studied the causes of this difference (Ring et al. 2016). For example, Croson and Gneezy (2009) found that males are more confident and competitive than females while Camerer and Lovallo (1999) attribute these differences on beliefs about one's self and the others.

Apart from the existence or origin of gender differences, an extended literature has developed examining the salience of gender differences in preferences and behavior, that is their practical importance. The central tenet of this paper – that economic rationality is learned – is consistent with the view that differences are socially shaped. However, even if differences were “fundamental or categorical”, according to Nelson (2012), these statements appear to be rooted more in confirmation bias than reality. In practical terms, Hyde (2005) points that the differences in an average score between men and women are considerably smaller than the differences among women and among men.

This turns the spotlight beyond measures of central tendency, such as mean scores, towards dispersion. It is dispersion which determines the degree of overlap of statistical distributions. If there is extensive overlap, as is often the case, then the simple presence of gender differences, even if statistically significant, is of limited economic importance. The reason is plain: Out of all pairwise comparisons between men and women, there will a large number where the aggregate relationship would be reversed. If that is so, statements based on average differences, would not generalize to individuals: stereotypes will mislead. Nelson (2015) makes this point forcefully in a meta-analysis of attitudes to risk. She suggests using ‘Cohen's d’, average difference as a percentage of dispersion. Small values of Cohen's d indicate large overlap and make using stereotypes that much more unwarranted.

Finally, behavioral economics in Greece is still in its infancy. Behavioural insights have been used to study discrimination, notably in the labour and rental housing markets (Drydakis 2009). The importance of economic literacy is stressed by Philippas and Avdoulas (2020) among others. Despite the dearth of research, the importance of designing incentives appropriately is stressed in the literature advocating structural economic reforms during the decade-long financial crisis. For example, Panageas and Tinios (2017) stresses that, for pension reform to succeed, it should be preceded by ‘a major investment in financial literacy, so that... individuals are in a position to take advantage of (new) freedoms’, (p483)

## **Materials and Methods**

A total of 222 third- and fourth-year undergraduate students (mean age= 23; SD=6.75; 116 male and 104 female) took part in the study (Table 1). The students are following a

university course heavy on probability theory and statistical methods and can hence be expected to be above the mean regarding arithmetic and financial numeracy.

Table 1. Descriptive statistics of participants

	<b>N</b>	<b>Mean</b>	<b>S.D</b>	<b>Min</b>	<b>Max</b>
<b>Age</b>	222	23	6.75	18	58
<b>Time to complete</b>	222	24.6	2.38	19	30
	<b>N</b>	<b>Percent of total sample</b>			
<b>Gender (Female)</b>	104	47.3%			
<b>Year of study ( 3<sup>d</sup> year)</b>	120	54.5%			

The participants are all Greek speakers who had not been exposed to the particular tests before. They were recruited at the university. They completed all the tasks in a single 30 minutes session. The tasks were presented on a computer using Google Forms and were divided into five main categories including Cognitive Reflection Test, behavioral biases, numeracy tests, economic literacy assessment and demographics. Each test result was summarized by means of a score, which was then normalized to a 100; higher values signify closer conformity to ‘ideal rationality’ or REM. This allows us to relate performance on cognition to evidence of departures from rationality, as well as to check for possible independent impacts of gender. The study protocol received ethical approval from the scientific board of the Department of Statistics and Insurance Science of Piraeus University. At the onset of the electronic form, we included information for the participant and an option to proceed to the questionnaire after checking an online consent form. The questionnaire was anonymous and did not elicit sensitive personal information, such as grades, social background, or other cofactors. The tests are examined starting from what orthodox economics usually assumes – REM – going towards more basic cognitive functions – financial literacy, numeracy, CRT.

#### *Economic rationality- REM*

In order to tackle our questions, we use 10 well known questions designed to test behavioral biases and heuristics (Table A1). These tasks can be categorized in three main groups with respect to the different aspect of economic rationality they examine. The first group measures the perception of uncertainty and risk including three questions (risk attitude, status quo) related to risky choices and loss aversion (prospect theory). The second group examine people’s tendency to evaluate rewards ignoring general information and focusing on information only pertaining to a specific case; specified by Kahneman (2000) as extension neglect. This group includes four questions (time preference, hyperbolic discounting, conjunction fallacy, base rate fallacy). The last group of three questions (illusion of control, overconfidence, conservatism) evaluate individuals’ tendency to rely too heavily on one's own perspective having a higher opinion of oneself than reality (Ross and Sicoly 1979). This categorization essentially applies prospect theory and is in line with Benson and Manoogian (2016).

An alternative categorization would link departures to the type or content of the decisions involved: uncertainty (risk preference, conservatism, overconfidence), time (time preference, hyperbolic discounting), or consistency under certainty (status quo, conjunction

fallacy, base rate fallacy, illusion of control). Implicitly such an approach would accord greater importance to context than to innate qualities. (Coyle 2021)

Each task has a correct answer. We score the number of correct answers out of the maximum number of rights (10 in REM, smaller in other tests) before normalizing them to 100. Thus, we compute the distance between the REM (=100) and individual stance. Cronbach's alpha, which measures the internal consistency and the extent to which all the items in a test measure the same concept, this in the case of REM was calculated showing a reliability coefficient equal to 0.59, indicating that is quite reliable (Hair et al. 2019).

### *Financial literacy score*

According to Huston (2010) financial literacy is the ability to use knowledge and skills to manage resources effectively for a lifetime of financial well-being. Lusardi and Mitchell (2011) devised a tool on financial literacy. Their 5-question tool aims to identify the economic concepts that people should understand and be able to use to handle financial decisions. These questions cover topics such as interest rates, bond pricing, inflation, and risk diversification (Table A2). The total score of these questions is related to financial engagement and planning. Empirical evidence is that more financially literate people are more likely to save, plan for retirement and use more complicated methods in allocating their assets (Anderson et al. 2015). Cronbach's alpha was calculated at 0.59.

### *Numeracy*

The Berlin numeracy test is a psychometric tool that quickly assesses individuals' level of statistical numeracy and risk literacy, in the sense that it measures the ability to interpret risks and rewards and hence to act on the information gained using statistical and probabilistic computations. According to Cokely et al. (2012), the Berlin numeracy test is the strongest predictor of comprehension of everyday risks, doubling the predictive power of other numeracy instruments and accounting for unique variance beyond other cognitive tests. Furthermore, it is concise, flexible, and easily applicable to diverse samples, while it is readily translatable into different languages without affecting its high construct validity (Lindskog et al. 2015). This instrument is based on four questions using a 3-level categorization tree (Table A3). Cronbach's alpha was calculated at 0.51.

### *Measure of cognitive reflection*

To measure cognitive ability, we use the three-item cognitive reflection test introduced by Frederick (2005). All questions are designed such that the wrong answer comes to mind immediately, while the correct answer is easily understandable when explained, after reflection. In that sense, the test aims to measure a person's ability to force his cognitive abilities to resist the intuitive answer by choosing the correct alternative (see Table A4). The three questions are well-known, though not so among Greek speakers. The number of correct answers was used as an index to cognitive abilities. Cronbach's alpha was calculated at 0.60.

## **Results**

One of the main questions of our study is whether individuals with high cognitive capacity are less likely to make irrational choices in economic decisions – that is how close



they appear to REM. If REM is learned, it is likely to be related to cognitive capacity and numeracy and financial literacy.

Our interest also focuses on gender differences (Table A5-A6). First, we report participants' performance on each question, reporting differences among gender and CRT groups. Second, we examine which of the biases and heuristics are correlated with cognitive capacity. Finally, we compute an index for the overall performance of the respondents based on their answers and the deviation from the classical economic behavior. Assuming that homo economicus operates within the framework of rational choice theory it is able to measure respondents' deviation from the "ideal" economic man. Individuals exhibit rational behavior acting inconsistently with utility function. Thus, all the tasks have the same ground for comparison.

For each bias, we present the percent of correct answers, both for the total but also with respect to CRT group (Table 2). The mean total scores is 46.5 while the mean performance in each of the three components vary from 33.1 in perception of uncertainty and risk to 43.6 to evaluate rewards. Subjects depended on their CRT score were divided into two groups; the "low" group consists of individuals who correctly answered one question or didn't manage to answer correctly to any of the three tasks (107 subjects), while the "high" group consists of those who gave the correct answer, at least in 2 questions (115 subjects). The "low" group is characterized by impulsiveness and intuitive answers while the "high" group can be described as more analytical decision takers. The table also reports how total scores are related to gender and CRT.

Table 2. Conformity to REM (Heuristic and bias tasks) by CRT group and Gender (% of correct answers)

Task	Total sample	High	Low	Difference (in p.p)	Male	Female	Difference (in p.p)
<b>Categorization by type of departure from rationality</b>							
<b>Perception of risk</b>	<b>33.1</b>	<b>36.5</b>	<b>29.4</b>	<b>7.1</b>	<b>38.9</b>	<b>26.7</b>	<b>12.2***</b>
<i>Risk Preference I</i>	38.3%	47.0%	29.0%	18.0***	49.6%	25.7%	23.9***
<i>Risk Preference II</i>	8.6%	6.1%	12.2%	-6.1	8.6%	9.5%	-0.9
<i>Status quo</i>	19.4%	79.8%	81.3%	-1.5	79.3%	81.9%	-2.6
<b>Evaluate rewards</b>	<b>43.6</b>	<b>48.3</b>	<b>38.6</b>	<b>9.7***</b>	<b>47.6</b>	<b>39.0</b>	<b>8.6***</b>
<i>Conjunction Fallacy</i>	31.1%	38.3%	23.4%	14.9**	35.0%	26.7%	8.3
<i>Time preference</i>	56.8%	69.6%	43.9%	25.7***	61.5%	52.4%	9.1*
<i>Base rate fallacy<sup>†</sup></i>	34%	28%	38%	-10.0**	33.8%	34.2%	-0.4
<i>Hyperbolic discount</i>	66.7%	70.4%	62.6%	7.8	76.1%	56.2%	19.9***
<b>Own perspective</b>	<b>36.9</b>	<b>46.4</b>	<b>26.8</b>	<b>19.6***</b>	<b>41.0</b>	<b>32.3</b>	<b>8.7***</b>
<i>Illusion of control</i>	30.6%	38.3%	22.4%	15.9***	35.0%	25.7%	9.3*
<i>Conservatism</i>	40.5%	37.4%	43.9%	-6.5	44.4%	36.2%	8.2
<i>Overconfidence</i>	42.1%	71.6%	14.0%	57.6***	45.1%	38.5%	6.6
<b>Total Score</b>	<b>46.5</b>	<b>54.4</b>	<b>37.9</b>	<b>16.5***</b>	<b>51.6</b>	<b>40.8</b>	<b>10.8***</b>
<b>Categorization by context of decision<sup>1</sup></b>							

<b>Uncertainty</b>	<b>33.2</b>	<b>41.3</b>	<b>24.5</b>	<b>16.8***</b>	<b>37.2</b>	<b>28.8</b>	<b>8.4***</b>
<b>Time</b>	<b>61.7</b>	<b>69.6</b>	<b>53.3</b>	<b>16.3***</b>	<b>68.8</b>	<b>53.8</b>	<b>15.0***</b>
<b>Consistency</b>	<b>34.1</b>	<b>38.7</b>	<b>29.0</b>	<b>9.7***</b>	<b>36.5</b>	<b>31.1</b>	<b>5.4***</b>

To test the relationship between CRT group and biases Fisher's exact test is used. For base rate fallacy the Man Whitney test is used.

1. By context – Uncertainty (1,2,9,10), Time (5,7), Consistency (3,4,6,8)

\*p<0.1, \*\*p<0.05, \*\*\*p<0.01; †average probability

Participants with lower CRT are more likely to be susceptible to behavioral biases. Examined biases are statistically significant in six of the ten cases. In those cases where we have found strong evidence that this is the case for most of the examined biases, the susceptibility to the overconfidence, the hyperbolic discount does not vary with the cognitive performance. Moreover, males tend to have a better performance in a series of biases and heuristics. For example, females are more likely to believe they can control or influence outcomes (illusion of control) or tend to evaluate rewards in accordance with their immediacy and not only in absolute rates and amounts (hyperbolic discount). Also, the biggest difference between males and females can be noticed in time questions while the smallest in questions related to consistency under certainty. Using the decomposition technique analyzed by Huettner and Sunder (2012) we quantify the effect of each category on the total score. For the first categorization, the 'evaluate reward' counts for 44.2%, the 'own perspective' for 37.8% and the remaining 18.0% is for 'perception of risk'. Using the alternative categorization, the consistency under certainty counts for 35.9%, the uncertainty for 35.7% and the time for the remaining 28.4%.

The examination of behavioral biases, under the scope of rational economic man, sheds light on the existing difference between high and low cognitive capacity and among genders. Participants with low cognitive score are more susceptible to act irrationally; the same pattern can be noticed comparing females with males. Nonetheless, the effect of gender and cognitive score are examined separately without accounting for the joint effect on REM. Table 3 illustrates the joint effect of gender and cognitive score. Males with high CRT have significantly better performance in "perception of risk" and "own perspective" task compared to males with low cognitive performance (p-value<0.05). The two distributions overlap: high cognitive females perform better in "own perspective" and "evaluate rewards" tasks (p-value<0.05). Overall, the recorded differences are statistically different. Following Nelson (2015), we compute Cohen's d, average difference as a percentage of dispersion, equal to 0.285. This small value indicates large overlap and make using stereotypes that much more unwarranted.

Table 3. REM groups by CRT group and Gender (mean score)

	<b>High male</b>	<b>High female</b>	<b>Low male</b>	<b>Low female</b>
<b>Perception of risk</b>	48.3	43.5	30.5	23.7
<b>Evaluate rewards</b>	50.7	44.6	43.2	34.7
<b>Own perspective</b>	48.3	43.5	30.6	23.7
<b>Uncertainty</b>	44.2	36.9	27.1	22.4
<b>Time</b>	73.2	64.1	62.5	45.8
<b>Consistency</b>	39.9	36.9	31.8	26.8

As shown in Figure 1 the distribution of the total score is close to the standardized normal distribution ( $p$ -value $<0.05$ ). The mean score is 46.5 which correspond to approximately 4 correct answers out of 10. The 60% of participants did not answer correctly more than 4 questions and only 10% dealt successfully with more than 7 questions. Males have an average total score significantly higher than female; 4.6 and 3.7 respectively. ( $p$ -value $<0.05$ ).

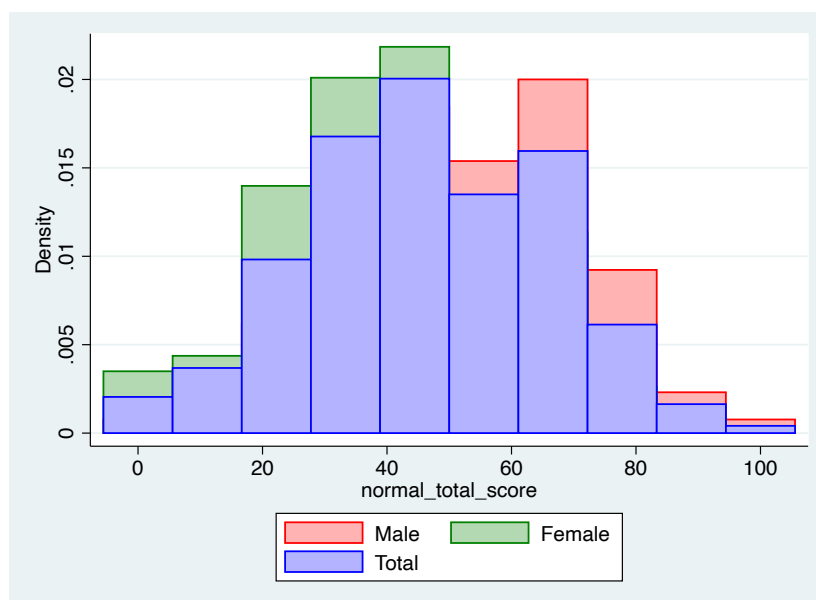


Figure 1. Total score distribution

To have an overview of participants performance on the examined tasks we present the average performance in each task which measures departures from full rationality: Economic rationality, Cognitive reflection, Financial literacy and numeracy abilities. Individuals record the higher score in cognitive reflection task (53.9) following by the economic rationality task (46.5). These scores correspond to an average number of 4 out of 10 correct answers for economic rationality and 1.6 out of 3 for cognitive reflection task. The lowest performance recorded in numeracy abilities, scoring on average 31.3. (Table 4).

Table 4. Summary score for all the tests

Test	Number of questions	Mean score in units (SD)	Normalized Mean (SD)
Economic rationality	10	4.2 (1.8)	46.5 (19.9)
Cognitive reflection	3	1.6 (1.2)	53.9 (39.9)
Financial literacy	5	2.1 (1.2)	42.4 (23.9)
Numeracy	4	1.3 (1.1)	31.3 (27.6)

### *The econometric model*

Can this information explain how one learns how to be an REM? In other words, can we explain the score on REM test by the performance in the more basic tests and ultimately on cognition? Does gender exert an independent influence? Our approach is similar to Skagerlund et al 2018.

The regression analysis starts with a baseline model, controlling for covariates. In our purposely homogeneous sample these are gender and age, which is collinear with stage in the course.

$$TotalScore_i = \beta_0 + \beta_1 age_i + \beta_2 gender_i + u_i \quad (1)$$

The bibliography has shown that women are more likely to exhibit behavioral biases compared to men; thus, we expect a negative coefficient. Next, we focus on the relationship between the cognitive performance and the behavioral and heuristic biases as described by the variable “total score”. We also control for financial literacy and the numerical abilities. CRT enters independently, but also through its effect on numerical and financial literacy.

The estimating equation is:

$$TotalScore_i = \beta_0 + \beta_1 age_i + \beta_2 gender_i + \beta_3 numerical\_abilities_i + \beta_4 financial\_literacy_i + \beta_5 CRT_i + u_i \quad (2)$$

The dependent variable is the total score, and the independent variables includes personal characteristics and the performance in numeracy abilities and financial literacy. In Table 5 we summarize the mean and the standard deviation for all the measures that will be included in the regression. Also included is the correlation among the variables. The total score is positively correlated with the numeracy abilities and financial literacy while it is also correlated with the cognitive performance. Also, cognitive performance is highly correlated with economic rationality while it is negatively correlated with gender. It can be noticed that gender is negatively correlated with participants’ performance, highlighting the effect of gender on the behavioral biases.

In order to ensure that all the assumptions hold we tested for multicollinearity issues finding the variance inflation factor (VIF) equals to 1.18 and the tolerance above 0.80 flagging that no issue was detected. Also, the heteroscedasticity tested using the Bruschi-Pagan test (p-value >0.05) indicate that we have not violated the assumption.

Table 5. Descriptive statistics and correlation

<b>Task</b>	<b>M (SD)</b>	<b>Age</b>	<b>Gender</b>	<b>Numeracy abilities</b>	<b>Financial literacy</b>	<b>CRT score</b>
Age	23.1(6.8)					
Gender	-	-0.06				
Numeracy abilities	1.3(1.1)	0.24**	-0.09			
Financial literacy	2.1(1.2)	0.21**	-0.16*	0.34**		
CRT score	1.6(1.2)	0.21**	-0.16*	0.40**	0.14	
Total score	4.2(1.8)	0.07	-0.27**	0.39**	0.24**	0.44**

\*p<0.05; \*\*p<0.01

Table 6 summarizes the results of the analysis. The first model (Model 1), uses only cofactors, including gender and age and explains only 8% of the total variation. Model 2 includes the cognitive reflection task driving up R<sup>2</sup>=0.23; this almost trebles the explanatory power of the model. The next model adds information about numeracy increasing the overall explanatory

power by 0.05. The final model (Model 4) also captures the effect of financial literacy, slightly increasing  $R^2=0.29$ . The model confirm that women tend to have lower performance in total score, exhibiting behavioral biases more often. Also, the effect of cognitive score seems to be positive; a unit increase in cognitive performance causes a positive effect of 5.55 points to the total score. The effect of numeracy and financial literacy is also positive, each additional increase in the Berlin test performance is associated with a 3.66 points increase while the financial literacy add a 1.83 to the dependent variable. The halving of the CRT coefficient once numeracy and financial literacy are allowed for, confirms that cognitive reflection operates both independently and through numeracy. These findings support evidence that individuals with lower cognitive performance are more likely to be susceptible to behavioral biases; as they might be more likely to have a poor performance in numeracy and literacy task.

To investigate further if the effect of cognitive reflection on the behavioral biases depends on the gender, we include an interaction term in the regression equation (Model 5) to see if it has a significant effect on the dependent variable. The model showed significant interaction ( $p<0.05$ ) suggesting that the effect of cognitive performance on biases is notably lower among women.

Table 6. Regression model for Total score

Variables	Model 1	Model 2	Model 3	Model 4	Model 5	Standardized beta
Gender (1=Female)	-10.7*** (2.6)	-8.62 *** (2.4)	-8.36*** (2.34)	-7.64*** (2.48)	-5.45* (0.43)	-0.13
Age	-0.11 (0.2)	-0.27 (0.2)	-0.33* (0.17)	-0.32* (0.19)	-0.33 (0.19)	-0.10
CRTScore	-	6.76*** (0.13)	5.29*** (1.06)	5.55*** (1.14)	6.17*** (1.48)	0.36
Berlin Numeracy Test	-	-	4.29*** (1.15)	3.66*** (1.24)	3.74*** (1.25)	0.20
Financial literacy	-	-	-	1.83 * (1.08)	1.83 * (1.09)	0.11
CRTScore x Gender					-1.37* (2.10)	
Constant	54.2*** (4.8)	45.74*** (4.59)	43.95*** (4.48)	40.11*** (5.19)	38.93*** (5.51)	
N	218	218	218	201	201	201
R-square	0.08	0.23	0.28	0.29	0.30	0.30
BIC	872.501	837.3947	829.0081	769.7057	756.5804	

\*  $p<0.1$ , \*\*  $p<0.05$ , \*\*\*  $p<0.01$

Note: Standard error in parenthesis

Standardized coefficients are included to facilitate comparison of the magnitude of effects of explanatory variables. These coefficients adjust standard deviations in such a way that all variables have equal standard deviations. So, the last column of Table 2 shows that cognitive score contributes the most to total score ( $\beta=0.36$ ) followed by numerical abilities ( $\beta=0.20$ ) and financial literacy ( $\beta=0.11$ ). Interestingly, cognitive performance is three times as important as financial literacy in predicting behavioral biases.

To summarize, the final model suggests a strong impact of cognitive abilities on the prediction of behavioral performance in 10 well-known tasks linked to how close someone comes to

REM. The higher the cognitive performance the closer you approximate the legendary rational economic individual. Also, the numerical performance as well as the financial literacy positively affect the chance of exhibiting smaller biases and getting a higher score. Gender has also a big impact, suggesting that women are less likely to avoid the biases examined. Concerning its effect on cognitive performance we include an interaction term. This evidence depicts a different performance based on gender and cognitive capacity. The marginal effect will allow us to examine the partial effect of CRT on the behavioral biases controlling for gender for some representative cases. Using the first order derivative of the regression equation we get:

$$E[y|x] = \beta_0 + \beta_1 x \tag{3}$$

$$\frac{\partial E[y|x]}{\partial x} = \beta_1$$

Controlling for covariates (CRTscore and gender) we get the average marginal effect as the average first order derivative:

$$AME = \frac{1}{N} \sum_{i=1}^N \frac{\partial E[y|x, w]}{\partial x} \beta_k \tag{4}$$

Figure 2 illustrates the computed marginal effects on the prediction of exhibiting behavioral biases, using model 5. As the cognitive score increases the effect on behavioral biases score also increases, but at a different rate by gender. In the lowest cognitive group, the difference is small (9% difference) while it is getting bigger as the cognitive score increases. For example, if the cognitive score is 3 the estimation for males is 4.8 while for females 3.7. Interestingly, in the model a high CRT woman is 27% closer to REM than a low CRT male - indicating possibly that gender differences are not innate. Also, in can be noticed the difference in estimations for each group grows as the cognitive score increases; in the lowest group the difference is.

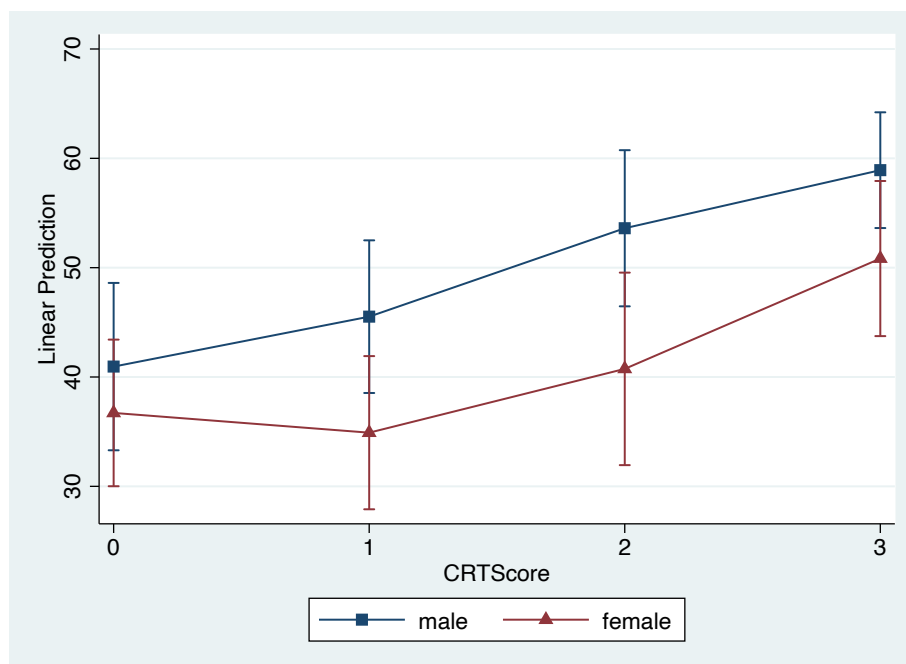


Figure 2. Predictive values for Total score controlling for CRT score and gender.

## Discussion

Our findings highlight the connection between behavioral biases and individuals' capacity to make rational choices of the type associated with Homo Economicus. They also, ponder the influence of gender on the relationship between cognitive ability and behavioral biases. Previous studies uncovered the relation between cognitive abilities and behavioral biases using laboratory experiments. For example, Hoppe (2011) using university students from different fields of study, investigated whether the cognitive reflection score is related to behavioral biases, focusing on the base rate fallacy, the conservatism bias, the overconfidence and the endowment effect. They conclude that CRT is a good predictor for biases where there exists a correct solution and where analytical skills help to derive it (base rate fallacy, conservatism bias). Also, Albaity et al (2014) summoned undergraduate and postgraduate students to explore the correlation between behavioral biases and CRT. Their findings suggest that a lower cognitive score is correlated with conservatism (0.11) and impatience in time preference judgements (0.13). They also found that males score higher in the cognitive reflection test, confirming Oechssler et al. (2009) and Hoppe (2011). Noori' approach (2016) is similar, using university students to examine nine biases (Table 7). His results underline that cognitive reflection can predict the occurrence of behavioral anomalies. He also found that illusion of control and the self-serving bias are correlated with gender. In contrast to the above studies which focused on students, Oechssler et al. (2009) and Skagerlund et al. (2018) used representative samples from the general population and confirmed that biases are significantly more pronounced for people with low cognitive scores. Specifically, they found that risk aversion in the domain of gains, conjunction fallacy and conservatism are more pronounced among such individuals.

Our own work found a statistically significant between CRT and six of the ten examined heuristics and biases. Individuals with lower cognitive performance significantly underestimate the correct probability and are less patient. Moreover, they are susceptible to illusion of control behaving as if they have control over an uncontrollable event.

Our work focused on a purposely biased samples of young undergraduates. As no population registry exists in Greece, drawing a sample purporting to be representative is an ambitious undertaking. As the premise of the paper is that rationality is not innate but learned, a sampling frame composed of individuals with proven numeracy skills, tilts the probabilities towards confirming the null hypothesis of REM; should tests reject this, the (unknown) 'true' power of the test would be greater than if the sample was random. However, it may be, a feature of behavioral economics is that most evidence comes from Anglo-Saxon or (to a lesser extent) Western European contexts. Adding a data point derived from the European southern rim, culturally and linguistically distinct, would possibly carry greater weight. This observation is compounded by the fact that behavioral economics and the specific cognitive tests are relatively unknown in Greece, with the probability of familiarity correspondingly smaller.

Table 6. Principal results of selected studies

	<u>Oechssler et al. (2009)</u>	<u>Hoppe (2011)</u>	<u>Albaity et al. (2014)</u>	<u>Noori (2016)</u>	<u>Our study</u>
Number of heuristics in the study	5	4	4	9	10
Mean CRT score	2.05	1.84	0.88	1.89	1.6

Gender difference in CRT score	males perform better				
Correlation between CRT and heuristics	conjunction fallacy, conservatism, time preference, risk preferences	base rate fallacy, conservatism bias	time preference, conservatism bias	conjunction fallacy, illusion of control, overconfidence, base rate fallacy, conservatism	risk preference, conjunction fallacy, illusion of control, time preference and overconfidence
Gender difference in heuristics and biases	-	-	-	illusion of control, self-serving bias	risk preference, hyperbolic discounting

Our work used a broader number of examined heuristics and biases; in doing so, it largely confirmed previous findings. The novelty of our approach is three-fold. First, it examined the effect of cognitive abilities on the level of statistical numeracy and risk literacy and found that subjects in the low group score lower in the numeracy test. Second, it tested the relationship between financial literacy and cognitive performance showing that “high” CRT group have a better performance on the task compared to “low”. Third, it is the first study to examine these effects using a sample of Greek students. This is of importance to behavioral economics; it adds a data point from a cultural milieu which less exposed to discussion on behavioral biases. It may also enlighten discussion of public policies and reforms in Greece.

## Conclusions

In this study we set out to test the effect of cognitive performance on selected behavioral anomalies. We utilized a barrage of tests on the same subjects, which allowed us to relate performance between the tasks: the cognitive reflection test, the Berlin numeracy test and the financial literacy task. In our sample of numerate Greek university students, we found a strong correlation between the performance on cognitive tasks and several other biases (risk preference, conjunction fallacy, illusion of control, time preference, overconfidence). Despite the sample being predisposed to display ‘rationality’ this was far from the case – Greek undergraduates were no closer to REM than (say) the representative Swedes of Skagerlund (2018). Our premise was that there is potential to correct this, through reflection and learning; even so, this potential was hardly taken up.

What is the significance of this for Greece? When these tests were taken the country was gripped by a deep economic and financial crisis necessitating deep structural reforms. Most reforms, especially in the labour and social fields were in the direction of limiting the State’s paternalistic role (Meghir et al.2017). Given that choice is taken away from the State and handed over to individuals, a valid issue is how efficiently such choice would be exercised (Tinios 2020). In this sense, our results of widespread departures from rationality are not encouraging: if young students supposedly taught to handle complex concepts depart from rationality, what hope is there for their older counterparts, who are accustomed to defer decisions to the State? However, if traits can be learned, there may be a silver lining: reflection leads to tangible results – even in the simplistic world of the instruments used in our tests. However, it may be, our results underline the importance of ‘educating’ economic agents as an important component of reform programmes. It is not enough to construct new structures; people should be ‘to make use of them.



These remarks are especially important in the case of gender. Low female labour market participation in Greece (at 56%) is far below that of its peers in the EU and constitutes the major untapped ‘growth potential (Lyberaki 2017, Lyberaki et al 2017). Our results are in line with other behavioural economics findings but are especially poignant as they highlight the size of the work in hand. Public nudges for economic literacy urgently need a gender dimension.

Our study provided another data point in the accumulating evidence that homo economicus is not born but made. Further research could focus on the mechanics, process, and content of learning. Conducting such research in the protected environment of academia, apart from providing easy answers to sampling issues, could profitably exploit the link between academic and experiential learning, relating (for example) cognitive tests to academic scores in different disciplines (using them as instrumental variables). Should students be followed into the labour market could result in panel data which could combine cognitive scores with labour market outcomes.

## Appendix

Table A1. Heuristic and behavioral biases questions

Task	Question
Risk Preference I	You have the choice between two alternatives. Alternative 1: You receive 10€. Alternative 2: You receive a lottery ticket that yields a 75% chance of winning 20€. With 25% probability it is worthless. Which alternative do you choose?
Risk Preference II	You have to pay 5000€ as your debt due. Would you prefer to replace this payment through the following alternative: With a probability of 75%, you must pay 10000€. With 25% probability you do not have to pay anything.
Conjunction Fallacy	Linda is 31 years old, single, outspoken, and very bright. She majored in philosophy. As a student, she was deeply concerned with issues of discrimination and social justice, and also participated in anti-nuclear demonstrations. Which is more probable? (a) Linda is a bank teller. (b) Linda is a bank teller and is active in the feminist movement.
Illusion of control	During a game, do you prefer to throw the dice, or it doesn't make difference if someone else does it? (a) makes difference (b) it doesn't make difference
Time preference	Suppose that you won 70000€ as a prize in a lottery and there are two options, which one do you choose: (1) take the prize immediately and (2) take the prize after a month with 5% premium.
Base rate fallacy	There are 100 officers in a commercial building, including 70 lawyers and 30 engineers. We interviewed a person from the building. Panos is a 30-year-old man. He is married with no children, a man of high ability and motivation, he promises to be quite successful in his field. He is well liked by his colleagues. What is the probability that he is an engineer?
Hyperbolic discount	Suppose that you get a lump sum payment of 70000€ and there are two options, which one do you choose: (1) take the money immediately and (2) take the money after eight years with 100% premium.
Status quo	You have to choose between three alternative scenarios. The first scenario is to stay in the current job, the second to move to a village with equal chances to double your income or lose 30% of it and the last one is to move to a village with 50% chances to increase your income by 30%, 20% chance not to increase and 30% chance to lose 20% of the income.

Conservatism	You have a friend who works in a brokerage firm, and he is active in stock trades. Recently he suggested to you to buy a pharmaceutical company's stock, and he said that, these days, he receives numerous buy order for that stock. Furthermore, you found other information which supports the company's profitability. Based on these facts, you bought 200000 shares yesterday. Today, you heard news about fire in one of the company's warehouses, news that your friend confirmed. What is your reaction? a) I wait for later news to get assured about the events that happened in the company, and after that I will decide, b) I send sell order to my broker immediately.
Overconfidence	we asked participants, after answering CRT questions, to estimate the number of correct answers

Table A2. Financial Literacy questions

Task	Question
Compounding	Suppose you had \$100 in a savings account and the interest rate was 5% per year. After 2 years, how much do you think you would have in the account if you left the money to grow?
Inflation	Imagine that the interest rate on your savings account was 1% per year and inflation was 2% per year. After 1 year, how much would you be able to buy with the money in this account?
Mortgage	A 15-year mortgage typically requires higher monthly payments than a 30-year mortgage, but the total interest paid over the life of the loan will be less.
Diversification	Buying a single company's stock usually provides a safer return than a stock mutual fund
Bond pricing	If interest rates fall, what should happen to bond prices?

Table A3. Berlin Numeracy Test Questions

Question	Correct
Out of 1,000 people in a small town 500 are members of a choir. Out of these 500 members in the choir, 100 are men. Out of the 500 inhabitants that are not in the choir 300 are men. What is the probability that a randomly drawn man is a member of the choir?	35.6%
Imagine we are throwing a five-sided die 50 times. On average, out of these 50 throws how many times would this five-sided dice show an odd number (1,3,5)?	53.2%
Imagine we are throwing a loaded dice (6 sides). The probability that the die shows a 6 is twice as high as the probability of each of the other numbers. On average, out of these 70 throws how many times would the die show the number 6?	24.3%
In a forest 20% of mushrooms are red, 50% brown and 30% white. A red mushroom is poisonous with a probability of 20%. A mushroom that is not red is poisonous with a probability of 5%. What is the probability that a poisonous mushroom in the forest is red?	13.1%

Table A4. Cognitive reflection Test Questions

Question	% of correct
----------	--------------

A ball and a bat cost 110€ in total. The bat costs 100 dollar more than the ball. How much does the ball costs? (intuitive answer: 10; correct answer: 5)	46.4%
If it takes 5 machines 5 minutes to make 5 widgets, how long would it take 100 machines to make 100 widgets? (intuitive answer: 100; correct answer: 5)	56.8%
In a lake there is a patch of lily pads. Every day, the patch doubles in size. If it takes 37 days for the patch to cover the entire lake, how long would it take for the patch to cover half the lake? (intuitive answer:19; correct answer: 36)	29.0%

Table A5. Berlin Numeracy Test per answer

Question	Correct	False	No answer	Male (%correct)	Female (%correct)
Choir members	35.59%	64.41%	-	35.9%	35.2%
five-sided dice	53.15%	46.85%	-	61.5%	44.2%
Six-sided dice	24.32%	72.97%	2.7%	23.8%	27.0%
Mushrooms	13.06%	84.23%	2.7%	16.4%	10.0%

Table A6. Financial Literacy questions (% of correct questions by CRT group, Gender and in total)

Question	%Correct	Low	High	p-value	Male	Female	p-value
<i>Compounding</i>	25.2	19.6	30.4	<0.05	31.6%	18.1%	<0.05
<i>Inflation</i>	54.8	49.0	60.0	<0.1	61.5%	47.1%	<0.05
<i>Diversification</i>	32.9	25.7	39.5	<0.05	39.8%	24.7%	<0.05
<i>Mortgage</i>	57.8	52.5	63.0	<0.1	54.9%	61.0%	n.s
<i>Bond pricing</i>	38.0	34.9	40.9	n.s	39.3%	36.5%	n.s
Total (average)	2.1	1.9	2.4	<0.05	1.4	1.1	n.s

Table A7. CRT score per answer

Question	Ball and Bat	Widget	Lily-pad
Impulsive	42.8%	29.3%	28.9%
Correct	46.4%	56.8%	59.3%
Other	10.8%	14.0%	11.8%
Female (%correct)	41.9%	50.5%	51.4%
Male (%correct)	50.4%	26.5%	66.4%

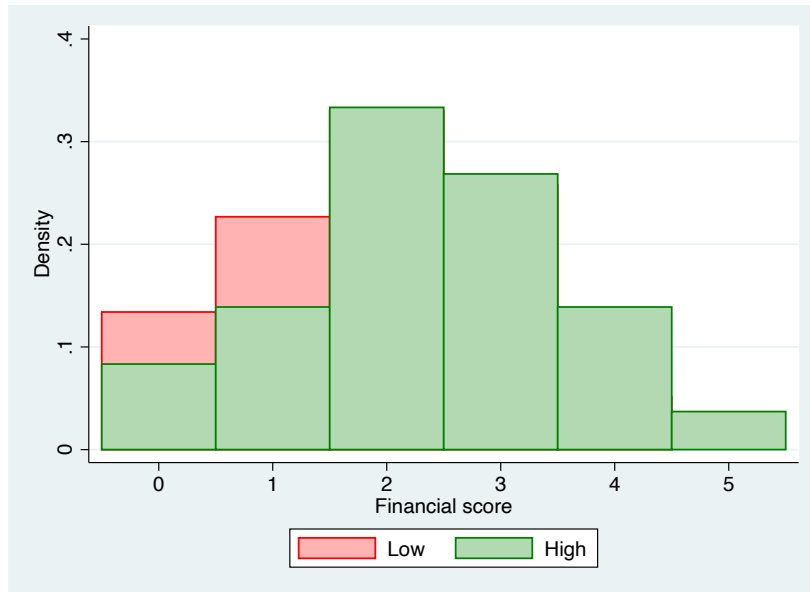


Figure A1. Financial Score by CRT Score

## References

- Anderson, A., Baker, F., & Robinson, D. T. (2015). 'Optimism, financial literacy and participation'. *National Bureau of Economic Research*.
- Ateş, S., Coşkun, A., Şahin, M. A., & Demircan, M. L. (2016). 'Impact of Financial Literacy on the Behavioral Biases of Individual Stock Investors: Evidence from Borsa Istanbul.' *Business & Economics Research Journal*, 7(3).
- Bikhchandani, S., Hirshleifer, D., & Welch, I. (1998). 'Learning from the behavior of others: Conformity, fads, and informational cascades'. *Journal of economic perspectives*, 12(3), 151-170.
- Brañas-Garza, P., García-Muñoz, T., & González, R. H. (2012). 'Cognitive effort in the beauty contest game'. *Journal of Economic Behavior & Organization*, 83(2), 254-260.
- Camerer, C. (1998). 'Bounded rationality in individual decision making'. *Experimental economics*, 1(2), 163-183.
- Camerer, C., & Lovallo, D. (1999). 'Overconfidence and excess entry: An experimental approach'. *American economic review*, 89(1), 306-318.
- Cokely, E. T., Galesic, M., Schulz, E., Ghazal, S., & Garcia-Retamero, R. (2012). 'Measuring risk literacy: The Berlin numeracy test'. *Judgment and Decision making*.
- Coyle, D. (2021). *Cogs and Monsters*. Princeton University Press.
- Crosan, R., & Gneezy, U. (2009). 'Gender differences in preferences'. *Journal of Economic literature*, 47(2), 448-74.
- De Neys, W. (2021). 'On dual-and single-process models of thinking'. *Perspectives on Psychological Science*, 1745691620964172.
- Deck, C., & Jahedi, S. (2015). 'The effect of cognitive load on economic decision making: A survey and new experiments'. *European Economic Review*, 78, 97-119.

- Drydakis, N. (2009). 'Sexual orientation discrimination in the labour market.' *Labour Economics*, 16(4), 364-372.
- Eckel, C. C., & Grossman, P. J. (2008). 'Differences in the economic decisions of men and women: Experimental evidence'. *Handbook of experimental economics results*, 1, 509-519.
- Fama, E. F. (1998). 'Market efficiency, long-term returns, and behavioral finance'. *Journal of financial economics*, 49(3), 283-306.
- Friedman, D. (1998). 'Monty Hall's three doors: Construction and deconstruction of a choice anomaly'. *The American Economic Review*, 88(4), 933-946.
- Frederick, S. (2005). 'Cognitive reflection and decision making'. *Journal of Economic perspectives*, 19(4), 25-42.
- Hair, J. F., Page, M., & Brunsveld, N. (2019). *Essentials of business research methods*. Routledge.
- Holt, C. A., Porzio, M., & Song, M. Y. (2017). 'Price bubbles, gender, and expectations in experimental asset markets'. *European Economic Review*, 100, 72-94.
- Huettner, F., & Sunder, M. (2012). 'Axiomatic arguments for decomposing goodness of fit according to Shapley and Owen values'. *Electronic Journal of Statistics*, 6, 1239-1250.
- Huston, S. J. (2010). 'Measuring financial literacy'. *Journal of consumer affairs*, 44(2), 296-316.
- Hyde, J. S. (2005). 'The gender similarities hypothesis'. *American psychologist*, 60(6), 581.
- Kahneman, D. (2000). 'Evaluation by moments: Past and future'. *Choices, values, and frames*, 693-708.
- Kahneman, D. (2003). 'Maps of bounded rationality: Psychology for behavioral economics'. *American economic review*, 93(5), 1449-1475.
- Kahneman, D., Slovic, S. P., Slovic, P., & Tversky, A. (Eds.). 1982. *Judgment under uncertainty: Heuristics and biases*. Cambridge university press.
- Lindskog, M., Kerimi, N., Winman, A., & Juslin, P. (2015). 'A Swedish validation of the Berlin numeracy test'. *Scandinavian journal of psychology*, 56(2), 132-139.
- Lukas, M., & Nöth, M. (2019). 'Interest rate changes and borrower search behavior'. *Journal of Economic Behavior & Organization*, 163, 172-189.
- Lusardi, A., & Mitchell, O. S. (2011). *Financial literacy around the world: an overview* (No. w17107). National Bureau of Economic Research.
- Lyberaki, A. (2017): *Women in the Economy*, Athens: Papadopoulos (in Greek).
- Lyberaki, A., Meghir, C., & Nicolitsas, D. (2017). 'Labor market regulation and reform in Greece'. *Beyond austerity: Reforming the Greek economy*, 211-250.
- Meghir, C., Pissarides, C. A., Vayanos, D., & Vettas, N. (Eds.). (2017). *Beyond austerity: reforming the Greek economy*. Mit Press.
- Morewedge, C. K., & Kahneman, D. (2010). 'Associative processes in intuitive judgment'. *Trends in cognitive sciences*, 14(10), 435-440.
- Nelson, J. A. (2012). *Are women really more risk-averse than men?*
- Noori, M. (2016). 'Cognitive reflection as a predictor of susceptibility to behavioral anomalies'. *Judgment and Decision Making*, 11(1), 114.
- Oechssler, J., Roider, A., & Schmitz, P. W. (2009). 'Cognitive abilities and behavioral biases'. *Journal of Economic Behavior & Organization*, 72(1), 147-152.
- Philippas, N. D., & Avdoulas, C. (2020). 'Financial literacy and financial well-being among generation-Z university students: Evidence from Greece'. *The European Journal of Finance*, 26(4-5), 360-381.
- Rabin, M., & Thaler, R. H. (2001). 'Anomalies: risk aversion'. *Journal of Economic perspectives*, 15(1), 219-232.
- Ross, M., & Sicoly, F. (1979). 'Egocentric biases in availability and attribution'. *Journal of personality and social psychology*, 37(3), 322.

- Seru, A., Shumway, T., & Stoffman, N. (2010). 'Learning by trading'. *The Review of Financial Studies*, 23(2), 705-739.
- Shulman, E. P., Smith, A. R., Silva, K., Icenogle, G., Duell, N., Chein, J., & Steinberg, L. (2016). 'The dual systems model: Review, reappraisal, and reaffirmation'. *Developmental cognitive neuroscience*, 17, 103-117.
- Simon, A. F., Fagley, N. S., & Halleran, J. G. (2004). 'Decision framing: Moderating effects of individual differences and cognitive processing'. *Journal of Behavioral Decision Making*, 17(2), 77-93.
- Simon, H. A. (1990). Bounded rationality. In *Utility and probability* (pp. 15-18). Palgrave Macmillan, London.
- Skagerlund, K., Lind, T., Strömbäck, C., Tinghög, G., & Västfjäll, D. (2018). 'Financial literacy and the role of numeracy—How individuals' attitude and affinity with numbers influence financial literacy'. *Journal of behavioral and experimental economics*, 74, 18-25.
- Sunstein, C. R. (2014). *Why nudge?*. Yale university press.
- Sutton, R. S., & Barto, A. G. (1998). *Reinforcement Learning: An Introduction*.
- Tinios, P. (2020), Pensions in the Greek Political Economy, Chapter 31 in K. Featherstone and D. Sotiropoulos (eds) *The Oxford Handbook of Greek Politics*, OUP, Oxford, pp 489-504.
- Tversky, A., & Kahneman, D. (1983). 'Extensional versus intuitive reasoning: The conjunction fallacy in probability judgment'. *Psychological review*, 90(4), 293.
- Zhang, H., & Maloney, L. T. (2012). 'Ubiquitous log odds: a common representation of probability and frequency distortion in perception, action, and cognition'. *Frontiers in neuroscience*, 6, 1.