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DOES SMART MEAN RATIONAL?

A study of cognitive dispositions, heuristics and rationality

Economics

Master's thesis

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Abstract

Human decision making is systematically less-than-fully rational and partly unconscious. Importantly, people's decisions deviate from the recommendations by "standard" economics in somewhat predictable ways, while some people are more prone to commit bias than others. Lately, there has been efforts to identify characteristics that can be used to predicts one's susceptibility to bias.

This thesis studies the effects of cognitive characteristics of individuals on classical heuristics-and-biases tasks. The thesis utilizes data gathered in an online survey that had over 800 participants. Both the Cognitive Reflection Test and Need for Cognition score are found to correlate positively with consistent preferences, risk neutrality and more liberal views on social policy issues. The overlap between biases associated with CRT and NFC is limited, and both measures reliably predict outcomes in several decision making tasks, independent of each other.

Keywords cognitive disposition, heuristics, rationality

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Abstract

I study the effects of cognitive characteristics of individuals on classical heuristics-and-biases tasks. Both the Cognitive Reflection Test and Need for Cognition score are found to correlate positively with consistent preferences, risk neutrality and more liberal views on social policy issues. The overlap between biases associated with CRT and NFC is limited, and both measures reliably predict outcomes in several decision making tasks, independent of each other.

Keywords: Heuristics-and-Biases tasks, inconsistent preferences, Need for Cognition, Cognitive Reflection Test

Contents

1 Introduction

Empirical research in behavioral economics has established that human decision making is systematically less-than-fully rational and partly unconscious. More importantly, people's decisions deviate from the recommendations by "standard" economics in somewhat predictable ways (Ariely, 2008), while some people are more prone to commit bias than others (e.g. Stanovich and West (1998)). Lately, there has been development in identifying characteristics that can be used to predicts one's susceptibility to bias. Such measures include the Need for Cognition (NFC) score by Petty et al. (1984) and the Cognitive Reflection Test (CRT) by Frederick (2005). Both measures have been linked to a variety of biases in several studies (see, e.g. Toplak et al. (2011), Weber and Johnson (2009), West et al. (2008)).

One would expect certain overlap and interaction between the measures of cognition, but in studies relating a given cognitive disposition to performance in heuristics-and-biases tasks, cognitive traits other than intelligence are rarely controlled for. By simultaneously measuring several cognitive dispositions, I aim to enhance our understanding regarding different cognitive dispositions and associated behavioral phenomena. Moreover, by utilizing multiple regressions to analyze survey responses, I aim to find out whether all measures are linked to a certain set of biases, or whether different measures are better at explaining different behavioral phenomena.

Meanwhile, there is "a rapidly growing interest in replication within psychology and concern over failures to replicate published findings" (Cesario, 2014). While my primary aim is to map the connections between certain cognitive dispositions and biased behavior, the study also serves a secondary purpose of conducting a robustness check on previous findings linking cognitive disposition to certain behavioral patterns.

If we were able to understand how biased behavior arises and which individual characteristics are affiliated with biased behavior, we might be more able to i) make hiring decisions that better serve our needs ii) shape our education systems to support better decision making, iii) identify arbitrage opportunities that arise from biased decisions made by others, and iv) in the spirit of the Delphic maxim *Know thyself*, observe and reduce bias in our own decision making.

This study is built around an online survey that had over 800 participants. Each individual was given a Cognitive Reflection Test score and a Need for Cognition score in order aim to measure the extent to which they employ deeper levels of their thinking capacity. In addition to NFC and CRT scores, I utilize the Wason selection task by Wason (1966) and Actively Open-minded Thinking (AOT) score by Stanovich and West (2007) to further distinguish between the cognitive tendencies of the participants. The participants also an-

swered some well-known heuristics-and-biases tasks[1], as well as several questions regarding policy issues and religious beliefs.[2].

As it turns out, higher scores in the selected measures of cognitive dispositions are associated with lower rates of bias and loss aversion, higher rates of risk neutrality, more liberal views on social policy issues, and lower rates of religiosity. Although some behavioral patterns were associated with more than one measure of cognitive dispositions, CRT and NFC predicted outcomes in heuristics-and-biases tasks independent of each other: performance in some tasks was better predicted by CRT, vice versa.

This thesis is structured as follows. Section 2 examines research regarding i) heuristics and biases relevant for this study, ii) dual-process thinking, iii) measures of cognitive dispositions, and iv) what is known about the link between bias and cognitive characteristics. Section 3 explains the survey setting and empirical identification strategy employed in this study. Section 4 describes the data, with section 5 providing the analysis and findings. Section 6 summarizes the findings, discusses the key limitations inherent in the present study and concludes.

2 Literature review

2.1 Biases and inconsistent behavior

The biases studied in this thesis work have been chosen, for they i) have been both proven robust in repeated studies, and ii) have been linked to the cognitive dispositions of interest here[3].

In addition to the biases discussed here, my study involves other variables as well, such as risk neutrality and certain opinions and beliefs. To be clear, these are not and should not be considered biases or "bad thinking", but have been included in the study on the ground that they might be related to cognitive characteristics of interest. These variables will not be discussed as part of my literature review, but rather are briefly explained in section 5.

2.1.1 Anchoring effect

Anchoring effect was first established in a classical paper by Tversky and Kahneman (1974), where participants differed in their estimates of the value of 8!, depending on whether they were asked to estimate (1*2*3*4*5*6*7*8) or (8*7*6*5*4*3*2*1), with the latter group yielding higher estimates. "In many situations, people make estimates by starting from

[1] Including measures of Anchoring effect, Conjunction fallacy, Present bias, risk neutrality and loss aversion

[2] Questions included issues such as abortion, gay rights, religiosity and climate change.

[3] Especially Cognitive Reflection Test (CRT) and Need for Cognition (NFC).

an initial value that is adjusted to yield the final answer. [...] adjustments are typically insufficient. That is, different starting points yield different estimates, which are biased toward the initial values. We call this phenomenon anchoring" (Tversky and Kahneman, 1974).

Anchoring effect, or the decision maker's internalizing of an uninformative anchor into her choices, has proved "extremely robust" in research ever since 1974 (Furnham and Boo, 2011). It has been observed - apart from multiple laboratory settings - in real life situations, such as investment decisions by institutional investors (Liao et al., 2013), bookmakers in horse races (McAlvanah and Moul, 2013) and in legal sentencing (Mussweiler, 2001). In a highly interesting finding for momentum-investors, stock market "short-term underreaction is best characterized as an anchoring bias" (George and Hwang, 2004), providing investors sophisticated in behavioral finance arbitrage opportunities (Andersen, 2010).

In a recent working paper Hukkanen and Keloharju showed with real-world data that in mergers and acquisitions, the outcomes are affected by not only the size of the initial cash offer, but also by their *precision* (Hukkanen and Keloharju, 2015). The initial offer, which is usually higher than the final price agreed upon - serves as an anchor. That anchor is stronger for more precise offers, and so more precise initial offers are correlated with higher outcome prices for successful M&A acquisitions.

Clearly, incorporating uninformative anchors into one's decisions stands in stark contrast to the assumed perfect processing of all available information of the *Homo Economicus*.

2.1.2 Conjunction fallacy

One of the most basic tenets of probability theory is that the joint probability P(AB) cannot be higher than either P(A) or P(B) alone. As shown by Tversky and Kahneman, people are easily tricked to believe otherwise (1983b).

The classic example is that of "Linda", who is described as single, outspoken, very bright, philosophy major, who has taken interest in issues of discrimination. Participants are then asked to estimate which of the following is more probable:

1. She works in a bank

2. She works in a bank and is active in the feminist movement

Clearly, the former (works in a bank) has higher probability than the latter, which consists of a joint probability (works in a bank, active in the feminist movement). However, the majority of participants chose the *latter* option. Even in a debiased condition, in which the first option was formulated "She works in a bank whether or not she is active in the feminist movement", 57 percent of respondents chose the false option (Tversky and Kahneman,

1983b).

The clear tendency to fall prey to conjunction fallacy can be used as an argument against assuming people behave fully rationally like *Homo Economicus*, i.e. are able to correctly estimate probabilities, and poses a challenge for perfect market hypothesis.

2.1.3 Present-bias

"Empirical studies [...] suggest that, *ceteris paribus*, humans and animals [...] act as though they *discount* future payoffs [...] with discount rates that increase as the time before those payoffs grows shorter. In other words, subjects act as though they become less patient, when the payoffs are more imminent." (Dasgupta and Maskin, 2005)

Expected Utility Theory, one of the cornerstones of standard economics, assumes that discount rates for a given period are not affected by how far in the future that period lies - i.e. it assumes - or rather, depends on - time-consistent discounting, or constant utility discount function.

"A vast literature in experimental psychology has studied time preferences by eliciting preferences over various alternative rewards obtained at different times, that is, over reward–time pairs." (Benhabib et al., 2010) An important behavioral regularity observed is "reversal of preferences", which occurs, "for example, when a subject prefers $10 now rather than $12 in a day, but he/she prefers $12 in a year plus a day rather than $10 in a year. Reversals of preferences are not consistent with exponential discounting." (Benhabib et al., 2010)

Hyperbolic discounting, or present bias, induces dynamically time-inconsistent preferences. It is a state where rewards not in the immediate future are discounted with a higher interest rate (Rubinstein, 2003), leading to higher decision weights to immediate returns. Moreover, hyperbolic discounting function has been observed to better fit participant preferences than exponential discounting functions (Kirby and Maraković, 1995), which have been offered as an alternative explanation to the anomaly.

Hyperbolic discounting is of interest for policymakers and social scientists, as it greatly influences people's decisions with long-term consequences, such as unhealthy consumption (Cremer and Pestieau, 2011). Taking present-bias into account in retirement savings plan design has been shown to increase personal saving rates (Thaler and Benartzi, 2004). In a very recent paper in the American Economic Review, researchers found that impoverished households showed significantly more present-bias in their decision making right before payday, than immediately after it Carvalho et al. (2016).

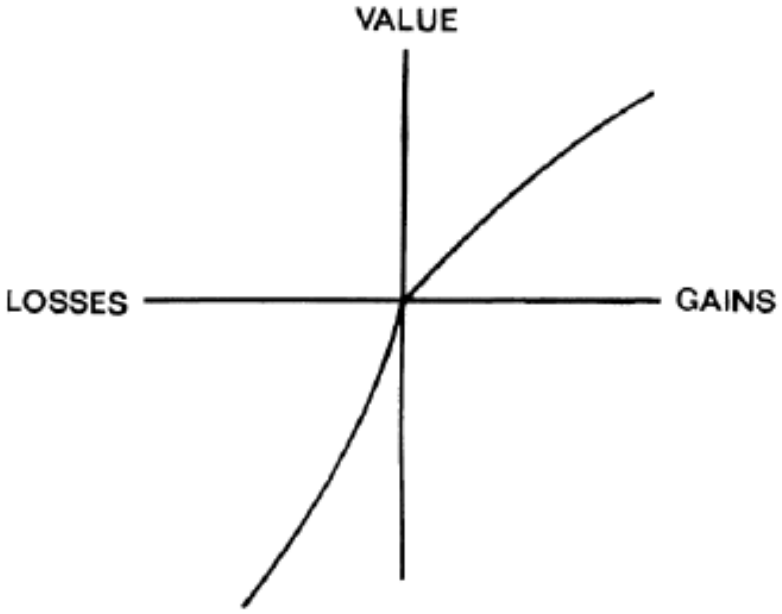

Figure 1: Hypothetical value function, source: Kahneman and Tversky (1979)

2.1.4 Loss aversion

In their landmark paper of 1979, Daniel Kahneman and Amos Tversky laid down the foundations of behavioral economics by introducing Prospect Theory: a theoretical model, backed by observations and experiments, that explains how and why people's decisions contrast the expected utility theory (EUT).

"In Prospect theory, outcomes are expressed as positive or negative deviations (gains or losses) from a neutral reference outcome". Tversky and Kahneman propose "that the value function is commonly S-shaped, concave above the reference point and convex below it". (Tversky and Kahneman, 1985) In short, losses are felt as more intense than gains of the same size[4], while both domains (loss and gain) have a diminishing sensitivity to the magnitude of the outcome[5], giving us a (hypothetical) value function - pictured below - very different from the homogeneously upwards sloping utility curve assumed in standard economics (Kahneman and Tversky, 1979).

[4]E.g. the disutility of losing 10 euros feels more intense than the additional utility of gaining 10 euros. It is estimated that losses of a given size are felt as twice as intense as gains of the same size. (Tversky and Kahneman, 1992)

[5]E.g. the difference between a gain of 100 euros and 105 euros feels lesser than the difference between a gain of 15 euros and 10 euros.

Standard economics assumes that decision maker's utility is determined by final total wealth, and not whether that total wealth is the result of an initial gain and a subsequent loss or vice versa. However, Tversky and Kahneman showed that people's behavior predictably violates the assumption - in an survey setting, participants chose different health policies in choice situations with equal probability distributions of final outcomes, depending on whether the change was framed as a gain (saved lives) or as a loss (lost lives). (Tversky and Kahneman, 1985)

Prospect theory implies a risk attitude that is inconsistent, and so fits the standard utility function poorly, if at all. Namely, the implied risk preference is one where decision maker avoids risk in the positive domain, while also being risk seeking in the negative domain. The reason is quite simple: if the additional discomfort of a marginal increase in loss is smaller for larger losses, gambling on losses generates utility. Similarly, gambling on gains would be utility destroying, as a marginal increase in possible gains is not worth the risk.

2.2 Dual-processes in decision making

"In every one of us there are two ruling and directing principles, whose guidance we follow wherever they may lead; the one being an innate desire of pleasure; the other, an acquired judgment which aspires after excellence"

Since Plato's account of Socrates in Phaedrus in 370 BC (above), and at least since the 1872, when Friedrich Nietzsche wrote about Dionysian and Apollonian motives of the mind, the concept of two conflicting modes of thinking in one brain has been familiar to the educated public (Russell, 1945). 140 years and massive amounts of scientific research later, psychologists nowadays believe that human thinking is characterized by (at least) two distinct systems of thinking (Evans, 2003) - a book called Dual-Processes in Social Psychology discusses 30 different (yet not mutually exclusive) dual-process models (Chaiken and Trope, 1999), and more have emerged since (see, e.g. Stanovich (2009)).

As popularized by Nobel-laureate Daniel Kahneman in his best-selling book *Thinking, Fast and Slow* (2011), System 1 is quick, effortless, unconscious and constantly active, while deliberate and analytical thinking belong to the domain of System 2, which is believed by some to be uniquely human (Evans, 2003). Intuition, being based on the System 1, works well in certain situations, but is prone to bias in others (Kahneman, 2003). I found it very illustrative when, designing and testing the survey for this study, a test participant - a very bright economics student - commented on the beta-version that "I can't decide whether to follow my intuition here, or to use the calculations in my head, because they are very different things and I can't foresee how I would really choose".

Stanovich (2009, 2011) develops, on top of the more traditional dual-process model of

the mind a tripartite structure, in which System 2 is further divided into algorithmic and reflective minds. The former has individual differences in fluid intelligence, whereas reflective mind has individual differences in rational thinking dispositions.

In an illustrative remark, Stanovich and West, after studying the link between SAT scores and behavioral biases - using between-subjects design - concluded that "people of higher cognitive ability [here: SAT scores] are no more likely to recognize the need for a normative principle than are individuals of lower cognitive ability. When the former[6] believe that nothing normative is at stake, they behave remarkably like other people. If told, however, that they are in a situation of normative conflict and if resolving the conflict requires holding a prepotent response in abeyance, then the individual of high cognitive ability will show less of many different cognitive biases." (Stanovich and West, 2008)

2.3 Measures of cognitive dispositions

I use two distinct measures of cognitive disposition, namely the Cognitive Reflection Test (CRT) and the Need for Cognition Scale (NFC) score. Both measures are estimated based on individual's survey answers. Even though a strong link exists, neither measure directly corresponds to intelligence, but rather aims at processes of the reflective mind, advanced by Stanovich (2008, 2009, 2011).

The two measures are linked to, yet distinct from each other and other domains of intelligence. In the original paper introducing CRT, the observed correlation between CRT and NFC was 0.22, the correlation between CRT and SAT scores 0.44, while the correlation between NFC and SAT scores was 0.3 (Frederick, 2005). Later, CRT has been observed to correlate strongly with other measures of general intellect (Bergman et al., 2010).

2.3.1 Cognitive Reflection Test (CRT)

CRT is a simple, three-item questionnaire, that suggests impulsive wrong answers to participants, whose ability to overcome the impulsive answer by means of analytical thought is measured on a scale of zero to three (Frederick, 2005).

The three questions included in a CRT are:

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

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

[6] People of higher cognitive abilities

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

The usual incorrect answers to the questions are (in order listed above) 10 cents, 100 minutes and 24 days[7].

CRT has been linked to several cognitive biases. In the original study by Frederik, individuals with a high CRT score were found to be more patient, less risk averse in positive domain, and less risk seeking in the negative domain (Frederick, 2005). CRT has even been called the "most consistent predictor across choice measures" (Weber and Johnson, 2009). It has been found to predict performance in heuristics-and-biases tasks better than intelligence tests, possibly because "neither intelligence tests nor measures of executive functioning assess the tendency toward miserly[8] processing in the way that the CRT does" Toplak et al. (2011)

High CRT scores have been linked with lower base rate fallacy, higher accuracy in self-assessment, and less (irrational) conservatism in Bayesian probability re-evaluation (Hoppe and Kusterer, 2011). Higher CRT has also been linked with lower rates on conjunction fallacy (Oechssler et al., 2009), although the finding has not replicated consistently (Albaity et al., 2014).

In the "Newsvendor problem" - a classic on the field of operations management - where participants have to decide how much stock to buy for each day, participants with high CRT have been observed to make more optimal choices, with CRT being a better predictor for success than college major, years of experience or managerial position Moritz et al. (2013).

An expanded 7-item version of the original CRT has been observed to reliably predict i) general openness of thinking, ii) being more considerate of future consequences, iii) lower belief bias in evaluating validity of premise-conclusion pairs and iv) lower tendency of denominator neglect Toplak et al. (2014). Individuals with higher CRT have been observed to be generally less religious Pennycook et al. (2014).

CRT has been set under scrutiny on the basis of being - allegedly - only another form of mathematical ability, as mathematical ability seems to explain away some covariance between CRT and biased decision making (Welsh et al., 2013).

2.3.2 Need for Cognition (NFC)

Attempting to measure one's extent of thinking across a variety of domains is difficult and time-consuming, but estimating that based on subjective evaluations is quick and effortless.

[7]The correct answers are, naturally, 5 cents, 5 minutes and 47 days

[8]Here, "miserly processing" describes thinking for which one doesn't utilize her full cognitive capacity. Personally, I would call it "lazy thinking".

Need for Cognition refers to "individual's chronic tendency to engage in and enjoy effortful cognitive activities" and has been linked to general intelligence (Cacioppo and Petty, 1982).

With regard to the dual-process theories of decision-making, NFC has been "used as a way to determine the mechanism by which individual's judgments would be formed or changed." (Petty et al., 2009)

Like most other research taking advantage of NFC, this thesis work follows the shortened version of 18 question, as introduced by the original authors two years after the original (Petty et al., 1984). In each of the questions, the participants are asked to evaluate how characteristic a statement is of themselves, each evaluation being graded on a scale of [-4, 4], resulting in final scores between -72 and 72. Some items on the survey are "I prefer complex to simple tasks" and "Thinking is not my idea of fun", the latter being reverse scored. Minor modifications regarding vocabulary were used in a few questions to enable participation by individuals with less-than-stellar English; e.g. the word "deliberating" was changed to "thinking deeply".

The Need for Cognition Scale has been linked to a higher tendency to "think about a variety of things", including one's own thoughts, giving some protection from common judgmental biases (Petty et al., 2009).

It has been shown that the mere perception of message complexity varies the probability of processing by individuals of varying NFC, with messages labeled complex being processed mainly by individuals with higher NFC scores (See et al., 2009).

Higher NFC has been linked with higher number of thoughts and more metacognition (thoughts about the thoughts one has) (Petty et al., 2007), smaller anchoring effect (Epley and Gilovich, 2006) and tendency to consider all available information (Levin et al., 2000). In general, individuals with lower NFC tend to be more susceptible for bias that results from thinking too little (such as the Halo-effect[9]), whereas individuals with high NFC are more susceptible to bias that results from overthinking (such as priming effects and creating false memories) (Petty et al., 2009).

2.3.3 Wason and AOT - other cognitive dispositions

While the present study focuses on CRT and NFC as main indicators of the cognitive processes that are of interest for our current purposes, two other crude, but possibly effective measures have emerged: the Wason selection task and the Actively Open-minded Thinking scale.

In the Wason selection task, a classical logic puzzle, the participants are shown four

[9]Halo effect, or attribute substitution, is a bias due to which "evidence of one favorable trait induces favorable judgments on a wide range of other dimensions Morewedge and Kahneman (2010)

cards, each with a letter on one side, and a number on the other side. They are then given a statement and asked which cards they would have to turn over to validate or disqualify the statement (Wason, 1966).

The four cards are G, 7, 2, U. The participants are then asked to evaluate which card(s) they would have to turn around to evaluate whether the following statement is true: "all cards with a vowel on one side have an even number on the other side". The right answer is to turn around the two cards that can prove the statement wrong, namely 7 and U, and to not turn around the other two cards. The most common mistake is to unnecessarily turn the number three, while neglecting the card with the number seven, i.e. failing to spot "implicit negation" (Evans, 2016).

The extent to which one takes evidence into account in forming conclusions regarding the world we live in is fundamental for not only the efficient market hypothesis, but also for the extent that science and facts are valued in society and the political process. This attitude towards principles, evidence and changing one's mind is estimated using so-called AOT[10] scale (see, e.g., (Stanovich and West, 2007)), which has been found to predict "the tendency to collect information [...]. To the extent that available information is predictive of future outcomes, actively open-minded thinkers are more likely than others to make accurate forecasts." (Haran et al., 2013)

2.3.4 Other individual characteristics, bias and life outcomes

To be sure, CRT and NFC are only part of the myriad of cognitive aspects likely to affect individual decision making and life outcomes. In this chapter I will - very briefly - make a few notions about endogeneity and other important aspects.

It could be hypothesized that tendency for biased decision-making affects one's probability for success in other domains in life, including being financially well-off. Also, it might be argued that being financially well-off affects one's behavior regarding financial incentives; as mentioned earlier, people's present-bias has been found to be far greater right before payday, than immediately after one (Carvalho et al., 2016). A recent experimental study mapping differences in risk and time preferences in Vietnam found out that "in villages with higher mean income, people are less loss-averse and more patient" (Tanaka et al., 2016). As discussed earlier, high CRT has been linked with increased risk neutrality. Whether this is due to differentiated cognitive processes, or due to higher CRT leading to financial success and thus risk neutrality regarding moderate amounts of money, remains unknown.

It is not known whether high CRT scores and positive outcomes in life correlate because of the cognitive reflection, or the numeric ability demonstrated in the CRT. High

[10] Actively Open-minded Thinking

intelligence scores, especially those measuring mathematical ability, has been observed to correlate negatively with financial mistakes later in life (Agarwal and Mazumder, 2010).

In a study by Burks et al. (2009), individuals with higher cognitive skill (measured as non-verbal IQ, planning ability or "Hit 15" and quantitative literacy or "numeracy") were observed to differ from individuals with low cognitive skills in terms of economic preferences: they were more patient both in short term and long term, better at forecasting behavior of others in prisoner's dilemma games, and more persevering on the job with penalties for early exit.

It has been argued that expertise might reduce biased behavior. This argument seems to hold, as shown by John List in an experimental setting as regards sports cards dealers and endowment effect (2004). In a survey setting, expertise in finance has been linked to diminishing anchoring effect in finance-related estimates (Kaustia et al., 2008). There seems to exist a possibility of debiasing through experience, but the plausibility and extent of that option are not known - partly due to lack of controls in the studies above. It might well be, that those professionals with higher tendency to show certain biases simply are forced out of the market, or that other, similarly non-random, selection processes apply.

Bergman et al. (2010) found a significant link between anchor strength and general intelligence, but no link between anchor strength and CRT. As mentioned in section 2.3.2, anchor strength has been shown to correlate negatively with NFC.

To complicate the matter further, two other important factors are worth mentioning, but far outside the scope of this study. Bastian et al. (2005) and others have shown that emotional intelligence, or detecting and using emotional information - can be used to predict life outcomes. How emotional intelligence is connected to general intelligence or heuristics-and-biases tasks, remains unknown.

Individuals with more willpower - also called "the greatest human strength" - tend to succeed in various domains in life, as popularized by Baumeister and Tierney (2011). "To recapitulate, the skills and motivations that enable the phenomenon of 'willpower', and particularly the ability to inhibit prepotent 'hot' responses and impulses in the service of future consequences, appear to be important early-life markers for long-term adaptive mental and physical development." (Mischel et al., 2011)

Clearly, mapping the effects and cross-dependencies of different cognitive measures and dispositions has only begun.

3 Survey setting

The survey was conducted online and distributed on social media and university mailing lists in February 2016. No prizes or payments were promised for participating, but rather I relied on voluntary participants' intrinsic motivation to provide accurate and truthful replies. The survey was estimated to take 15 to 20 minutes to complete.

To tackle problems related to priming or boredom-effect, the within-section question order was randomized between individuals, except for anchoring effect measurement, which explicitly requires a certain order. The section order was i) background information, ii) anchoring effect iii) all other questions and lastly iv) feedback to the survey.The participants were given only a general description of the survey, and were neither informed of the survey's design, the research objectives, the measuring of cognitive abilities nor warned against any potential biases.

The empirical strategy starts from the hypothesis that cognitive dispositions have a causal effect on the extent of bias in one's choices, and so CRT and NFC scores are correlated with survey answers in heuristics-and-biases tasks. The correlation coefficients between various cognitive dispositions and behavioral traits are estimated using multiple regressions, while controlling for various background variables. These control variables include age, gender and level of education, but also the level of education received by each parent as a proxy for socioeconomic status.

4 Data

In total, 818 participants answered[11] the survey, out of which 34 replies were disregarded as invalid, leaving 784 replies to be analyzed. The invalid responses were either incomplete, or the participants admitted to using external help, such as talking the questions through with a friend or seeking advice online. Additionally, 33 participants did not specify the level of education received by either one of the parents, leaving regressions utilizing parental education with 751 observations. Individual participants could not be identified from the data.

4.1 Descriptive statistics

The average age of the participants was 27.2, with 72 percent of respondents being 20 to 29 years old. The standard deviation of age was 7.58 years. The oldest participant was 82

[11] As the survey was distributed on social media and emailing lists, it is impossible to know the number of people who saw the invitation to participate, but chose not to. This is obviously a source of selection bias, the extent of which remains unknown.

Table 1: Descriptive statistics

Variable	**Mean**	**St. dev**	**Min**	**Max**	**Median**
CRT	1.97	1.08	0	3	2
NFC	22.56	18.88	-40	72	23
Age	27.21	7.59	18	82	25
Gender	0.37	0.48			
Education	2.96	0.83	1	5	3
Mother's education	2.96	1.11	1	5	3
Father's education	2.99	1.25	1	5	3
Mathematics	3.12	1.61	1	6	3

Note: Gender is a dummy variable where one stands for male and zero for female. Educational variables are all on a scale of (1, 5), with one being "only primary education" and five being "Doctoral degree or equivalent. Mathematics is a variable on a scale of (1, 6), where one stands for "my field of studies is not mathematical at all (e.g. humanities)" and six for "my field of studies is highly mathematical (mathematics, statistics etc.)

years old, while the youngest individual was 18 years old.

Almost two thirds of participants (496 individuals, or 63.3 percent) were female, while 288 were were male. The mean ages for female and male were 27.2 and 27.3, respectively. 93 percent, or 732 participants, were Finnish nationals[12].

The sample has a high degree of education[13]: 67 percent of participants had a Bachelor's degree or higher, while one in four participants reported having Master's degree. 21 participants had already received their PhD's, while only four individuals out of 784 had not (yet) graduated from high school or equivalent. The majority of those without a university degree are expected to be students - the median age of participants without a degree was 22 years, while 90 percent of cohort were 27 years old or younger. The parents' educations were strongly correlated with each other: the correlation coefficient between mother's education and father's education was 0.49, yet there was almost no correlation between one's level of education and that of their parents'.

The level of education was fairly similar between male and female participants, but the fields of studies differed dramatically. Male participants were more likely to have studied at least some economics or finance: 57 percent, compared to 33 percent for female partic-

[12]Of the 52 non-Finnish participants, 37 were from EU/ETA countries. Nationality was not found to be a significant predictor in any of the questions of interest.

[13]For the sake of numerical estimation, the levels of education received by the participant and each of her parents were rated on a scale of (1, 5), with one being primary education, two being secondary education, three standing for Bachelor's degree, four for a Master's and five for a PhD.

Table 2: Level of education

	(1) education	(2) education	(3) education
CRT	0.00247	-0.00165	-0.000108
	(0.0254)	(0.0261)	(0.0258)
NFC	0.00387**	0.00368*	0.00416**
	(0.00136)	(0.00143)	(0.00146)
age	0.0576***	0.0570***	0.0570***
	(0.00513)	(0.00522)	(0.00527)
male		-0.0541	-0.0440
		(0.0556)	(0.0558)
pseudo-AOT			-0.0169
			(0.0105)
religiosity			-0.00427
			(0.0126)
parents' education		YES	YES
Constant	1.322***	1.319***	1.383***
	(0.147)	(0.172)	(0.179)
Observations	784	751	750
R^2	0.287	0.286	0.288
F	35.04	23.87	17.88

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Standard errors in parentheses. OLS regressions: participants' level of education regressed on cognitive measure (CRT, NFC, pseudo-AOT), their age and gender, the education level of their parents', and their reported religiosity.

Table 3: Correlation of background variables

	Age	CRT	NFC	Gender	Math	Education
Age	1.0000					
CRT	-0.1762	1.0000				
NFC	0.0396	0.2304	1.0000			
Gender	0.0024	0.2885	0.2344	1.0000		
Math	-0.0935	0.3070	0.2140	0.3679	1.0000	
Education	0.5278	-0.0835	0.0967	-0.0093	-0.0457	1.0000
Parental education	-0.2147	0.1096	0.0914	0.0781	0.1429	-0.0907

The table reports correlations between several variables used in the study. Parental education is the sum of each parents' level of education, both of which are measured on a scale of one to five. N=751

ipants[14]. Male participants also reported having significantly more mathematical fields of studies: on a scale of one to six, male participants estimated the level of mathematics in their studies to be a 3.89, while females averaged 2.67.

Results from the OLS regressions[15] mapping the relations between education, CRT, NFC and background variables can be seen in table 2. Interestingly, within the sample, parents' education does not reliably predict the education level of their children - although this is probably due to selection bias rather than evidence of absence. Of all the variables, only NFC score[16] is related to to education level with an acceptable confidence level. The point estimate of the coefficient is, however, only 0.00387, meaning that for every additional point of NFC, the participant is estimated to have 0.004 points higher education (on a scale of one to five). Frankly, it is so insubstantial that differences in NFC can hardly be used to estimate one's educational level, even if a statistically significant correlation exists[17].

[14]The high share of economics and finance students is explained by the fact that all students at Aalto University School of Business - where many participants currently study - are required to study the principles of economics and finance during their first year of college. For regression purposes, the extent of economics or finance one had studied was rated on a scale of (0, 2), with zero being "no studies", one being "some studies" and two standing for "extensive studies"

[15]All the regressions used in this study utilize heteroscedasticity robust standard errors.

[16]Additionally, age has a positive coefficient, most probably because older people have had more time to finish their education.

[17]See table 4 for estimating NFC based on education.

4.2 Cognitive Reflection Test

On average, the participants solved correctly almost two out of the three questions in the CRT (average 1.97 points).[18] Specifically, 15 percent of the participants answered none of the three questions correctly, scoring zero points, similarly 15 percent of the participants scored one point, 28 percent scored two points and 42 percent scored the full three points. The average score for females was 1.73, while the average for males was 2.38.

CRT score was correlated with age, although the correlation was driven by over 30-year-olds. The group that scored the full three points in CRT had an average age of 26.0, with average age increasing for lower scoring groups: 27.1 for those who scored two points, 28.5 for those who scored one point and 29.5 for the group that scored zero points. Age was negatively correlated with CRT score even when controlling for factors such as level of education and gender ($P<0.001$). While fluid intelligence has been shown to decrease with age (Horn and Cattell, 1967), this also raises the question whether some age-related selection process applies to sample[19]. No significant link between CRT and age was observable for adults under 30 years old (see section 7.2 for additional analysis).

The level of education was not a significant predictor of one's CRT score and neither was the education received by either one of the parents. Given the numerical nature of CRT, it should come as no surprise that the level of mathematics in one's field of study was positively correlated with one's CRT score - variance in the former explains approximately 9.7 % of the variance in the latter.

For ease of interpretation, key point estimates for both CRT and NFC are as follows. For every additional point of NFC score, the participant is expected to have 0.0088 points higher CRT score, and similarly, each additional point of CRT is associated with a 2.83 -point increase in one's NFC score. Other things constant, males tended to have 0.42 points higher CRT scores and 5.16 points higher NFC scores. More mathematical fields of studies were correlated with higher CRT scores so that each additional level[20] of mathematics was associated with a 0.13 point increase in one's CRT and 1.07 point increase in NFC. For each additional level of education received, the participants tended to have 2.14 points higher NFC scores.

[18] Interestingly enough, this places the survey respondents between students in Princeton University (average 1.63 points) and Massachusetts Institute of Technology (average 2.18 points). (Frederick, 2005). Clearly, some non-random selection process is at work here.

[19] E.g. working age population that finds and participates in questionnaires on social media might be different from the working age population that doesn't.

[20] Self-reported, on a scale of 1-6

Table 4: CRT, NFC and background variables

	(1) CRT	(2) NFC
NFC	0.00879***	
	(0.00206)	
CRT		2.832***
		(0.654)
age	-0.0224***	0.113
	(0.00539)	(0.0990)
male	0.419***	5.161***
	(0.0810)	(1.428)
education	0.00240	2.138*
	(0.0526)	(0.912)
mother's education	0.0246	1.440*
	(0.0385)	(0.703)
father's education	0.000502	-0.172
	(0.0318)	(0.600)
math in studies	0.132***	1.074*
	(0.0261)	(0.470)
econ studies	-0.0365	1.613
	(0.0516)	(0.935)
Constant	1.753***	-2.103
	(0.212)	(3.797)
Observations	751	751
R^2	0.177	0.118
F	25.04	13.26

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Standard errors in parentheses. OLS regressions: participants' CRT (1) and NFC (2) scores regressed on each other, the individual's age and gender, level of education, the education level of each parent, the extent of mathematics in one's field of study and the extent of studies in economics and finance studies.

4.3 Need for Cognition

The average NFC score was 22.56, with a standard deviation of 18.9 points. The highest (lowest) NFC score observed was 72 (negative 40) points and the interquartile range was from 11 to 36 points. Female participants scored, on average, 19.13 points, while the average NFC score for male participants was 28.46. The correlation between CRT and NFC measured 0.226. In regressions with various controls, Need for Cognition score was correlated positively with both the participant's and her mother's level of education[21], but perhaps more surprisingly, no link was found between NFC and age.

The OLS regression results table on the next page shows inter-dependencies between the two measures of cognitive dispositions and the background variables[22].

4.4 Statement validation

Out of 784 participants, 92 (11.73 %) answered the Wason selection task correctly. In table 5 below I provide the results of logistic regressions showing the relations between cognitive dispositions, background characteristics and the probability of correctly solving the Wason selection task. In both regressions, CRT score and gender were highly significant in predicting success in the Wason selection task, with male participants and those with a higher CRT score having a higher probability of correctly solving the Wason selection task.

As I will discuss later in the study, success in statement validation task was found to be associated with less biased behavior.

4.5 Pseudo-AOT

In an approximation of the Actively Open-minded Thinking scale, two questions were asked to determine the participants' attitude towards evidence and changing one's mind.

- "People should always take into consideration evidence that goes against their beliefs. Do you agree?"
- "Certain beliefs are just too important to abandon no matter how good a case can be made against them." Do you agree?

[21] Due to multicollinearity between father's education and that of mothers, the coefficients between parental education and NFC should be taken with a grain of salt - especially the negative (but insignificant) coefficient between NFC and father's education begs no other questions than those of technical nature as regards econometrical modeling. The same goes for all regressions with both parents' educations.

[22] "male" is a dummy variable, with a value of zero for females and one for males. The OLS regressions utilize heteroscedasticity robust standard errors.

Table 5: Wason selection task

	(1)	(2)
	Wason task	Wason task
CRT	0.593***	0.556***
	(0.153)	(0.156)
NFC	0.0138	0.0129
	(0.00748)	(0.00780)
age	-0.0193	-0.00196
	(0.0221)	(0.0234)
male	0.771**	0.748**
	(0.239)	(0.248)
math in studies	-0.0974	-0.112
	(0.0731)	(0.0783)
econ studies		0.0616
		(0.162)
education		-0.164
		(0.184)
pseudo-AOT		0.0387
		(0.0420)
parents' education		YES
Constant	-3.227***	-3.936***
	(0.818)	(0.921)
Observations	784	751

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Standard errors in parentheses. The dependent dummy variable indicates whether the participant correctly solved the Wason selection task (1=correct answer, 0=incorrect answer). The table provides results of a logit regression with success in Wason selection task regressed on CRT, NFC and pseudo-AOT scores, age and gender, extent of mathematics and economics in one's studies and the level of education received by both the participant and her parents.

The two items were taken from the Actively Open-minded Thinking (AOT) scale (see, e.g. Stanovich and West (2007)). The answers[23] were graded on a scale of (-4, 4), producing a total score on a scale of (-8, 8) with a higher number representing higher openness to evidence and lower dogmatism. The sample average was 4.28, the standard deviation 2.76 and the mode was six.

Even with this stub measurement (the original scale uses 41 items), "pseudo-AOT" correlated positively with CRT, NFC, and negatively with one's reported religiosity. These correlations were also significant in OLS regressions[24], controlling for background variables. Table 6 below shows the results. Interestingly, this "pseudo-AOT" was a reliable predictor of various opinions on controversial topics, for which I will provide evidence in subsection 5.5.

Point estimates of significant coefficients were as follows: each additional point of CRT score was associated with a pseudo-AOT score higher by 0.25-0.28 points before controlling for religiosity, and 0.20 after controlling for religiosity[25]. An increase in one's NFC was associated with an increase of 0.028-0.32 points on the pseudo-AOT scale. Males tended to have pseudo-AOT scores 0.72-0.81 points higher, other things being equal. Each point on the self-reported religiosity scale of (1, 9) was associated with a pseudo-AOT score 0.40 points lower, ceteris paribus.

4.6 Representativeness

While my sample is definitely not representative of the population as a whole[26], I consider it fairly well representative of the well-educated, younger sub-population - for the very least, I consider my selection bias less pronounced than is the case in many empirical studies conducted solely on, say, freshmen of a single university or even a single study program that have specifically applied to participate in research at a given faculty.

5 Results

5.1 Anchoring effect

The anchoring method developed for the study was the following: participants were first asked on which day of the month they were born on, which is assumed to be a random

[23] The answers were on a scale of (1, 9), that is from "I disagree very strongly" to "I agree very strongly".
[24] Heteroscedasticity robust standard errors
[25] Column (3)
[26] Given the young age, high education and astonishing CRT score.

Table 6: Pseudo-AOT

	(1) pseudo-AOT	(2) pseudo-AOT	(3) pseudo-AOT
CRT	0.280**	0.247*	0.201*
	(0.0996)	(0.102)	(0.0972)
NFC	0.0295***	0.0316***	0.0283***
	(0.00550)	(0.00577)	(0.00554)
age	0.00204	0.0151	0.0198
	(0.0122)	(0.0149)	(0.0151)
male	0.722**	0.808***	0.744**
	(0.225)	(0.237)	(0.226)
math in studies	-0.0386	-0.0225	-0.0588
	(0.0684)	(0.0719)	(0.0707)
econ studies		-0.318*	-0.261
		(0.148)	(0.144)
education		-0.193	-0.184
		(0.138)	(0.133)
Wason task		0.199	0.175
		(0.280)	(0.264)
religiosity			-0.395***
			(0.0496)
parents' education		YES	YES
Constant	2.864***	3.022***	4.102***
	(0.441)	(0.612)	(0.605)
Observations	784	751	750
R^2	0.094	0.103	0.186
F	15.54	8.078	15.08

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Standard errors in parentheses. The table provides results of an OLS regression with pseudo-AOT score regressed on CRT and NFC score, success in Wason selection task, age and gender, extent of mathematics and economics in one's studies, the level of education received by both the participant and her parents and one's reported religiosity.

variable between 1 and 31[27]. That anchor was used for two purposes, for i) willingness to pay and ii) estimating economic growth in China. [28]

Table 7: Anchoring effect

	(1)	(2)	(3)
	estimated GDP growth	estimated GDP growth	estimated GDP growth
day of birth	0.0871***	0.0819***	0.0972
	(0.0242)	(0.0242)	(0.0723)
NFC		-0.00640	-0.00255
		(0.00927)	(0.0176)
CRT		-0.267	-0.193
		(0.222)	(0.372)
Control variables		YES	YES
CRT*birthday			-0.00496
			(0.0290)
NFC*birthday			-0.000241
			(0.00110)
Constant	5.150***	9.385***	9.153***
	(0.335)	(0.949)	(1.255)
Observations	784	784	784
R^2	0.019	0.052	0.052
F	12.93	5.957	4.909

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Standard errors in parentheses. OLS regression: Estimates of GDP growth - in percentage points - regressed on the individual's day of birth, i.e. the anchor, one's CRT and NFC scores and interaction terms between the anchor and one's CRT and NFC scores. Control variables include age, gender, education and extent of studies in economics or finance.

In part i) the participants were then asked to evaluate whether they would be willing to

[27] not taking into account the fact that February has only 28 or 29 days and some months only have 30 days.

[28] Using birthday as an anchor is - to my knowledge - unique to the present study. The chosen method has a clear advantage: an anchor dependent on one's day of birth requires neither physical presence (such a s a wheel of fortune), nor sophisticated survey programs (such as an algorithm to generate random numbers). Similar anchoring structure (with U.S. social security numbers) was utilized by Ariely et al. (2006).

spend an amount that equals their day of birth (in euros) on a ticket to the world premiere of an assumed sequel to their favorite movie. After answering yes or no, the participants were asked to indicate their maximum willingness to pay for the said ticket. The null hypothesis was, in addition to observing anchoring effect, i.e. correlation between the day of birth (within the given month), to observe a stronger anchoring effect for individuals with lower CRT and/or NFC scores.

In part ii) of the anchoring questions, the anchoring mechanism was identical to that in part i). The participants were asked first whether, in their estimate, the GDP of China will grow more or less than x% percent in 2016, x being the day of month they were born on. In the follow-up question participants were asked to evaluate the said growth rate.

The economic rationale here is that the day of month one is born contains absolutely no information about either the utility the individual receives from watching a particular movie, or about the economic growth in China. Incorporating the number into one's estimates of either value stands in contradiction with the idea of perfectly rational decision making. Indeed, any predictive power of the random variable over either one's willingness to pay or stated growth estimate is a strong indicator of less-than-fully rational behavior.

Empirical analysis showed anchoring effect, i.e. correlation between one's birthday (within the birth month) and estimated growth of the Chinese economy, but the strength of the anchor did not predictably vary between low and high scoring individuals. No anchoring effect was evident in part i.

The regression results can be found in the table 7 "Anchoring effect".[29] Anchoring effect is evident in regressions (1) and (2), as day of birth is highly significant predictor for the growth estimate: when one's birthday was one day larger[30], the participant is predicted to give 0.087 percent points higher estimate of GDP growth in China.

However, in regression (3), the interaction terms[31] had no predictive power over one's estimate of GDP growth in China. Moreover, regression model (3) has no additional predictive power[32] over the dependent variable, and so the null hypothesis of predictable differences in anchor strength for participants of different cognitive dispositions cannot be rejected.

[29]Day of birth stands for the day of month one was born on, CRT*birthday and NFC*birthday are interaction terms between day of birth, NFC and CRT.

[30]Within the given month, as in "27" for 27th September 1989, or "28" for the 28th.

[31]The interaction terms between CRT or NFC and birthday (the anchor) measure whether differences in test score are correlated with differences in the coefficient of day of birth, i.e. the strength of the anchor.

[32]The larger model (regression (3)) has the same R^2, but lower F-score than model (2). Additionally, a Wald-test for the two interactions terms turned out to have an insignificant F-score.

5.2 Conjunction fallacy

Two questions were used to test conjunction fallacy, the first one being the classical Linda problem used by Tversky and Kahneman (1983a) already described in section 2.1.2. In the second question participants were asked to evaluate which one of the following scenarios has a higher probability to happen in 2016:

1. The Russian economy will recover, causing the stock prices of Finnish exporting companies to rise

2. The Russian economy will recover, whether or not it affects stock prices in Finland

The second question contains the same P(AB) < P(A) structure as the Linda problem, with an attempt to debias the participant with the subordinate clause, similar to that used by Tversky and Kahneman (1983a). Ability to correctly assess likelihoods of events is a cornerstone of the expected utility theory, and failing to do so is a fallacy of the most basic kind.

Conjunction fallacy was apparent in both questions, with 52.4 percent of participants failing to correctly answer Linda problem and 30.2 percent failing the question regarding Russia and Finnish stock prices[33].

Table 8 "Conjunction fallacy" shows the results from logistic regressions[34]. CRT score was highly significant in predicting conjunction fallacy in the Linda problem with a negative coefficient. CRT was, however, not significant in predicting conjunction fallacy in the Russia problem. In regression two, both Wason selection task and pseudo-AOT scores were significant at the laxer 10 % confidence level, with negative coefficients. The interpretation is clear: participants that had higher CRT or pseudo-AOT scores or had solved the Wason selection task were, other things being equal, less likely to commit conjunction fallacy.

Conjunction fallacy in one problem was highly significant in predicting conjunction fallacy in the other problem - interestingly, almost no other variable has a significant coefficient to predict bias in both problems. Males have a lower probability to show bias in the Linda problem, yet seem to have a higher probability of falling prey to conjunction fallacy in the Russia problem[35]. Whether the apparent anomaly is related to the intricacies of conjunction fallacy, to the topic of stock movements, or are the effect of randomness in data, remains unknown. However, one might hypothesize that some background characteristics - be it gender or field of study - make participants view the "story" of stock market effects as

[33] 19.3 percent failed both questions, a significant overlap.

[34] The regressions utilize heteroscedasticity robust standard errors. Dependent variable is a dummy variable that has the value of one if the participant answered wrong in the given problem. The independent variable "conjunction fallacy" (dummy) shows whether the participant answered the other problem correctly.

[35] This phenomena was not observed for under 30 year olds, see appendix for further discussion.

Table 8: Conjunction fallacy

	(1)	(2)	(3)	(4)
	fallacy, Linda	fallacy, Linda	fallacy, Linda	fallacy, Russia
CRT	-0.340***	-0.310***	-0.328***	0.0448
	(0.0755)	(0.0767)	(0.0797)	(0.0814)
NFC	-0.00416	-0.00212	-0.00350	0.00254
	(0.00424)	(0.00437)	(0.00452)	(0.00455)
age	-0.00502	-0.00686	-0.00313	-0.00664
	(0.0105)	(0.0127)	(0.0133)	(0.0104)
male	-0.439**	-0.354*	-0.414*	0.449*
	(0.168)	(0.176)	(0.184)	(0.192)
math in studies	-0.109*	-0.108*	-0.0915	-0.00570
	(0.0510)	(0.0529)	(0.0550)	(0.0585)
econ studies		-0.0615	-0.0883	0.179
		(0.112)	(0.117)	(0.115)
education		0.0262	0.00575	
		(0.109)	(0.109)	
Wason task		-0.441	-0.364	-0.542
		(0.237)	(0.246)	(0.280)
pseudo-AOT		-0.0497	-0.0423	-0.0207
		(0.0283)	(0.0290)	(0.0304)
parents' education			YES	
conjunction fallacy			0.733***	0.765***
			(0.178)	(0.175)
Constant	1.510***	1.639***	1.330**	-1.340**
	(0.368)	(0.406)	(0.508)	(0.416)
Observations	784	784	751	784

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Standard errors in parentheses. Logit regression: conjunction fallacy (dummy) in Linda problem (regressions 1-3) and in Russia problem (regression 4) regressed on one's CRT and NFC scores, age, gender, extent of mathematics in one's field of studies, the extent of studies in economics and finance, level of education, solving the Wason selection task, pseudo-AOT score, education level of both parents', and conjunction fallacy in the other problem (Russia problem in (3), Linda problem in (4)).

more plausible, rendering them more prone to bias regarding the specific topic. The level of mathematics in one's field of studies was significant at five percent level in regressions one and two, and at ten percent level in regression three.

5.3 Impatience and present-bias

In the questionnaire present bias was measured using a pair of questions in which they were asked, essentially, to indicate how much money they were willing to forgo in order to receive a payment 12 months earlier. If the implied discount rate differs significantly between the two cases, and one assumes no predictable changes in liquidity between participating in the survey and six months later, one plausible explanation would be present bias.

Impatience is measured as the difference between 100 and their answer to the second question[36] (see below): a large difference implies a higher discount rate, i.e. that the participant is willing to forgo a higher sum in order to receive the money one year earlier[37].

- Suppose that you will receive 100 euros in one year for certain. If you accepted a smaller amount, you could receive the money today instead. What is the smallest amount to have today that you would prefer over the 100 euros in one year?
- Suppose that you will receive 100 euros in 18 months for certain. If you accepted a smaller amount, you could receive the money in six months instead of 18. What is the smallest amount to have in half-a-year that you would prefer over the 1000 euros in one-and-a-half years?

The regression results can be seen in table 9 below[38]. NFC has a significant ($P<0.05$), negative coefficient in explaining impatience with a limited set of variables. However, in regression number two in the table, NFC is insignificant ($P=0.103$), whereas a correlated variable I call "pseudo-AOT" and discuss in chapter 6 is significant at 10 percent confidence level.

Time-inconsistency of implied discount rate is estimated as the difference in answers to questions one and two, i.e. the answer to the second question less the answer to the first. A positive number indicates that the discount rate is higher for the more immediate reward, i.e. time-inconsistent preferences. The median difference observed was zero. In the regressions, only two variables have significant coefficients as regards time-inconsistency[39]. These are

[36] It is assumed to reflect impatience with higher accuracy than the first question, which might be troubled by hyperbolia.

[37] For example, an impatience of 10 means, that the participant would rather have 90 euros in six months, than 100 euros in 18 months, i.e. they would be willing to forgo 10 euros to receive the money one year earlier.

[38] I use standard OLS regressions with heteroscedasticity robust standard errors.

[39] In the regressions I only consider the answers with a non-negative difference.

Table 9: Impatience and time-inconsistency

	(1)	(2)	(3)	(4)
	impatience	impatience	time-inconsistency	time-inconsistency
CRT	-1.476	-0.819	0.715	1.194
	(1.347)	(1.556)	(1.090)	(1.251)
NFC	-0.102*	-0.0784	-0.0303	-0.00471
	(0.0470)	(0.0508)	(0.0523)	(0.0579)
age	-0.0602	-0.0174	-0.184	-0.167
	(0.132)	(0.168)	(0.121)	(0.133)
male	6.359	6.834	5.681	7.260*
	(4.192)	(4.329)	(3.250)	(3.453)
math in studies	-0.575	-1.227	-1.466	-1.646
	(1.238)	(1.701)	(0.919)	(1.182)
econ studies		4.085		0.777
		(3.376)		(2.372)
education		-0.162		0.0340
		(2.284)		(1.632)
pseudo-AOT		-1.362		-0.932
		(0.818)		(0.570)
Wason task				-7.274**
				(2.747)
parents' education		YES		YES
Constant	24.60***	26.37***	18.55***	20.21***
	(4.333)	(5.881)	(4.062)	(5.411)
Observations	784	751	664	635
R^2	0.008	0.025	0.012	0.029
F	3.129	2.344	1.189	1.607

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Standard errors in parentheses. OLS regressions: impatience (i.e. payment forgone to receive the money earlier) and extent of time-inconsistency (i.e. difference between preferences, in euros) regressed on CRT, NFC, pseudo-AOT, Wason selection task, age, gender, extent of mathematics and economics in one's studies, and the education level of the participant and her parents.

gender - males have higher hyperbolia[40] - and correctly solving Wason selection task, that was highly significant with a negative coefficient - having solved the Wason selection task was associated with a reduction of 7.27 euros in the degree of time-inconsistency.

5.4 Risk neutrality and loss aversion

The risk neutrality of participants was estimated with two questions regarding a hypothetical lottery ticket with 50 percent chance of winning (losing) 1000 euros. The participants were asked to indicate how much money they would require (be willing to pay) to sell (discard) the lottery ticket. Each participant's degree of risk neutrality was estimated as the difference between the expected value of such a gamble, and their reply, i.e. how much money they "left on the table" in expected terms. It should be mentioned here that non-neutral risk preference is not considered a behavioral bias.

Prospect theory predicts that for the two questions regarding lottery tickets with positive or negative outcomes, people would be risk averse in the positive domain, yet risk seeking in the negative domain. In other words, they would be willing to accept a loss in expected value for each question: to sell the positive lottery ticket below expected value, and to pay more than the expected loss to discard of the negative one. If one is risk averse in the positive domain and we assume, as Expected Utility Theory does, a concave utility function of final wealth, then it is difficult to see how risk seeking behavior in the negative domain could be consistent with non-behavioral economics.

Out of the 785 participants, 289 (51) were risk averse in the positive (negative) domain, 318 (271) were risk neutral and 177 (462) were risk seeking. 190 were risk neutral in both domains, while 221 were risk averse in the positive domain, but risk seeking in the negative domain, i.e. had inconsistent risk preference as predicted by Prospect theory.

The median loss in expected value was 300 euros, the average 361 euros and the standard deviation 460 euros.

As observable in the regressions[41] table 10 "Risk neutrality and Prospect theory", CRT was significant in all the regressions, and linked to both risk neutrality (higher CRT is linked to decrease in expected loss, i.e. higher risk neutrality) and risk inconsistency, with which it has a negative coefficient. Each additional point of CRT was associated with an increase of 34 to 39 euros in expected return.

In regression number one in the table, higher NFC was linked to lower expected loss (P=0.054), but insignificant (P=0.125) in regression number two. In regressions for the

[40] P=0.81 and P=0.36 in the two regressions

[41] Regressions, as regards Expected loss, are standard OLS regressions, while risk inconsistency is estimated with logistic regressions. All regressions use heteroscedasticity robust standard errors.

Table 10: Risk neutrality and Prospect theory

	(1)	(2)	(3)	(4)
	expected loss	expected loss	inconsistency	inconsistency
CRT	-39.34**	-34.58*	-0.201*	-0.192*
	(14.72)	(15.54)	(0.0812)	(0.0854)
NFC	-1.768	-1.431	-0.00606	-0.00502
	(0.917)	(0.931)	(0.00422)	(0.00437)
age	2.768	3.220	0.0111	0.00535
	(2.065)	(2.022)	(0.00998)	(0.0124)
male	-156.7***	-145.3***	-0.0700	-0.0632
	(30.39)	(29.87)	(0.184)	(0.195)
math in studies	-27.23*	-24.76*	-0.0187	-0.00749
	(11.04)	(11.84)	(0.0563)	(0.0607)
econ studies		-26.77		-0.0244
		(22.10)		(0.125)
education		-12.01		0.0774
		(18.92)		(0.119)
Wason task		-102.4***		-0.126
		(29.99)		(0.273)
parents' education		YES		YES
Constant	545.5***	591.4***	-0.643	-0.823
	(71.44)	(101.4)	(0.359)	(0.507)
Observations	784	751	784	751
R^2	0.091	0.100		
F	31.59	18.07		

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Standard errors in parentheses. Regressions (1) and (2) are OLS regressions, regressions (3) and (4) logit-regressions. Expected loss (compared to risk neutral alternative) and inconsistent risk-preferences (dummy variable) regressed on CRT, NFC and Wason selection task, age and gender, extent of mathematics and economics in studies, and the level of education of both the participant and her parents.

sub-group of under 30 year olds, NFC was highly significant in predicting risk neutrality - see appendix for further discussion.

Additionally, males were more risk neutral, as were those with more mathematical fields of studies and those who correctly solved the Wason selection task. None of these variables was significant in predicting risk inconsistency.[42]

5.5 Religious and political attitudes

In addition to the heuristics-and-biases tasks, the participants were asked to indicate, on a scale of 1 to 9, i) how religious they considered themselves and ii) their attitudes towards several moral issues: abortion, the rights of sexual minorities, poverty and responsibility, global warming. The correlations between the opinions on each issue are presented in table 5.5 .

In many of the topics discussed here, CRT, NFC and pseudo-AOT were all linked to more liberal attitudes on certain topics: controlling for various factors, high scoring people were often less religious, more likely to consider climate change as a serious threat, more likely to support the equality of sexual minorities and more likely to recommend an abortion for an unwilling parent-to-be. However, the relations were not homogeneous - all of the measures were associated with liberal views on some topics, but no single measure could predict moral judgments on all of the issues.

Table 11: Correlations between religious and political beliefs

	Religiosity	Discr.	Conserv.	Judgment.	CC denial
Discriminatory attitude	0.3993	1.000			
Conservative on abortion	0.3868	0.2676	1.000		
Judgmental on poverty	0.0432	0.1672	-0.0047	1.000	
Climate change denial	0.0861	0.2481	0.0585	0.3309	1.000
pseudo-AOT	-0.3251	-0.2444	-0.1839	-0.0638	-0.1070

Note: The table provides the correlations between opinions on religious and political issues, as well pseudo-AOT score received by the individual. Higher values stand for more conservative views (with the exception of pseudo-AOT score, for which a low score implies higher rate of dogmatism. Pseudo-AOT is discussed in section 6). The variables are reported religiosity, reported discriminatory attitudes towards sexual minorities, reported judgmental attitudes towards the poor, reported extent of climate change denial and one's pseudo-AOT score.

[42]There is an unexpected relation between parental education and inconsistency in risk preferences. While higher education received by the mother was linked to a lower probability of inconsistency, higher education received by the father had an opposite coefficient. This oddity is most likely caused by high multicollinearity between the education received by the two parents.

Table 12: Religion and attitude towards sexual minorities

	(1)	(2)	(3)	(4)	(5)
	Religiosity	Religiosity	Sexual discr.	Sexual discr.	Sexual discr.
CRT	-0.175*	-0.0758	-0.0288	-0.0128	0.00382
	(0.0756)	(0.0724)	(0.0430)	(0.0419)	(0.0396)
NFC	-0.00726	-0.000435	-0.00832**	-0.00537*	-0.00528*
	(0.00402)	(0.00411)	(0.00259)	(0.00268)	(0.00252)
age	0.0111	0.0153	0.00332	0.00587	0.00249
	(0.0100)	(0.0115)	(0.00533)	(0.00697)	(0.00622)
male	-0.175	0.0446	0.283**	0.299**	0.289**
	(0.163)	(0.172)	(0.0956)	(0.102)	(0.0970)
education		-0.0338		-0.0548	-0.0475
		(0.0940)		(0.0636)	(0.0588)
Wason task		-0.0177		-0.0187	-0.0148
		(0.212)		(0.120)	(0.106)
pseudo-AOT		-0.234***		-0.109***	-0.0570***
		(0.0298)		(0.0199)	(0.0171)
math in studies		-0.0946		0.0556	0.0764*
		(0.0509)		(0.0323)	(0.0312)
religiosity					0.221***
					(0.0366)
parents' education		YES		YES	YES
Constant	2.843***	3.521***	1.556***	1.948***	1.171***
	(0.326)	(0.460)	(0.182)	(0.292)	(0.263)
Observations	783	750	784	751	750
R^2	0.024	0.121	0.025	0.091	0.219
F	4.983	9.158	4.270	4.167	5.899

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Standard errors in parentheses. The table provides results of several OLS regressions, with the dependent variable being either one's reported religiosity (columns (1) and (2)) or one's reported level of discriminatory attitudes against sexual minorities (columns (3) to (5)). The dependent variables are regressed on CRT, NFC and pseudo-AOT scores, success in Wason selection task, age and gender, level of education received by both the participant and her parents, and the extent of mathematics in one's field of studies. Additionally, discriminatory attitudes were regressed on one's reported religiosity (column (5)).

In table 12 I present the regression results[43] as regards self-reported religiosity and discriminatory attitudes towards sexual minorities[44].

In regression one both CRT and NFC have a negative coefficient (P=0.21 and 0.71, respectively). In regression two, with more controls, pseudo-AOT score is the only highly significant determinant of religiosity, with the variable math having a negative coefficient and a P-value of 0.064.

In regressions three to five, CRT was insignificant, whereas both NFC and pseudo-AOT score were significant, with a negative link to discriminatory attitudes. More religious participants, males and those whose fields of study was more mathematical expressed more discriminatory attitudes.

Climate change denial[45] has several significant explanatory variables. As seen in the regressions table 13 below, CRT, NFC and pseudo-AOT scores all are linked to lower climate change denial. Male participants and those with more mathematical fields of studies were on average less alarmed by global warming.

In regressions three to five I present the regression results for attitudes towards abortion[46]. In regression three, CRT is significant (with a negative coefficient, i.e. decreases stated anti-abortion attitude). Controlling for pseudo-AOT, pseudo-AOT becomes highly significant and CRT becomes insignificant. Controlling for religiosity, pseudo-AOT becomes insignificant, while religiosity is highly significant[47]. Moreover, older people have more conservative opinions on abortion.

The participants were asked whether they hold the poor responsible for their poverty, or

[43]"religiosity", on a scale of one to nine, is the answer provided to "How religious do you consider yourself?", whereas in the variable "sexual discrimination" one stands for "Sexual minorities should have perfect equality", and nine stands for "The freedoms of sexual minorities should be very restricted". For religiosity, the median answer was 2.0, the average 2.57 and standard deviation 2.05. For discrimination of sexual minorities, the median, average and standard deviation were 1.0, 1.51 and 1.18, respectively.

[44]I use the word "equality" as it stands in the Constitution of Finland, Chapter two, Section six: "No one shall, without an acceptable reason, be treated differently from other persons on the ground of sex [...] or other reason that concerns his or her person"Ministry of Justice (1999). I hold that any opinion that deviates from perfect equality is discriminatory in nature.

[45]"CC denial" is a variable on a scale of one to nine, with one being "Global warming is a serious threat and everything should be done to prevent it", while nine stands for "Global warming is not real and should not be considered by politicians". The median answer was 2, the mean was 1.97 and standard deviation 1.19.

[46]In the questionnaire, the participants were presented a story with imaginary friend becoming pregnant unintentionally and asks for advice. The participants are then asked if they would advice the friend to have an abortion, on a scale of one to nine, with one being "Absolutely yes, she should have an abortion" and nine being "Absolutely no, she should keep the baby".

[47]This interchangeability is most likely due to the high correlation between the variables - I deem i imprecise to claim that CRT plays no role after controlling for, say, pseudo-AOT, as the interplay between the two variables remains unclear.

Table 13: Attitudes on global warming and abortion

	(1)	(2)	(3)	(4)	(5)
	CC denial	CC denial	Pro-life	Pro-life	Pro-life
CRT	-0.0887*	-0.123**	-0.160*	-0.109	-0.0776
	(0.0391)	(0.0399)	(0.0730)	(0.0750)	(0.0688)
NFC	-0.00897***	-0.00813**	-0.00527	-0.00405	-0.00393
	(0.00250)	(0.00252)	(0.00410)	(0.00426)	(0.00398)
age	-0.00956	-0.00545	0.0519***	0.0469**	0.0414**
	(0.00571)	(0.00678)	(0.0118)	(0.0145)	(0.0133)
male	0.577***	0.489***	-0.181	-0.0969	-0.112
	(0.0940)	(0.0995)	(0.162)	(0.172)	(0.161)
education		-0.0265		0.0372	0.0534
		(0.0613)		(0.105)	(0.0981)
Wason task		0.0538		0.0793	0.0869
		(0.146)		(0.234)	(0.206)
pseudo-AOT		-0.0457**		-0.114***	-0.0312
		(0.0149)		(0.0283)	(0.0269)
math in studies		0.106***		-0.0276	0.00802
		(0.0292)		(0.0520)	(0.0486)
religiosity					0.361***
					(0.0395)
parents' education		YES		YES	YES
Constant	2.397***	2.246***	2.396***	2.911***	1.619***
	(0.201)	(0.266)	(0.372)	(0.543)	(0.487)
Observations	784	751	784	751	750
R^2	0.063	0.096	0.059	0.084	0.199
F	11.55	8.035	9.515	5.452	15.32

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Standard errors in parentheses. OLS regressions: climate change denial ("CC denial", scale: 1-9) and anti-abortion attitudes ("pro-life", scale: 1-9) regressed on CRT, NFC and pseudo-AOT scores, Wason selection task, age and gender, the extent of mathematics in one's studies, the level of education received by both the participant and her parents. Additionally, Pro-life regressed on reported religiosity.

Table 14: Holding the poor responsible for poverty

	(1)	(2)	(3)
	conservative on poverty	conservative on poverty	conservative on poverty
CRT	-0.0503	-0.0864	-0.0393
	(0.0576)	(0.0596)	(0.0574)
NFC	-0.00807*	-0.00845**	-0.00530
	(0.00313)	(0.00320)	(0.00310)
age	-0.0339***	-0.0281**	-0.0260**
	(0.00735)	(0.00911)	(0.00921)
male	0.590***	0.492***	0.299*
	(0.128)	(0.139)	(0.138)
pseudo-AOT		-0.0458*	-0.0280
		(0.0225)	(0.0220)
education		-0.0268	-0.0162
		(0.0855)	(0.0818)
math in studies		0.156***	0.115**
		(0.0403)	(0.0398)
climate change denial			0.390***
			(0.0525)
parents' education		YES	YES
Constant	5.140***	4.772***	3.896***
	(0.250)	(0.361)	(0.375)
Observations	784	751	751
R^2	0.054	0.082	0.153
F	12.04	8.206	13.74

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Standard errors in parentheses. OLS regressions: the extent to which one holds the poor responsible for their poverty ("conservative on poverty", scale: 1-9) regressed on CRT, NFC and pseudo-AOT scores, age and gender, the extent of mathematics in one's studies, the level of education received by both the participant and her parents. Additionally, Pro-life regressed on reported religiosity.

whether environmental factors were to blame. The table 14 presents the results from OLS regressions[48]. NFC score has a significant, negative coefficient on the dependent variable in regressions one and two, pseudo-AOT in regression two, while CRT is insignificant. None of the three cognitive factors remain significant in regression three, in which I'm controlling for an additional proxy variable, climate change denial. Additionally, age is linked to a decline in the dependent variable, whereas variables "male" and "math in studies" have significant, positive coefficients.

6 Discussion

6.1 Summary of findings

In analyzing the survey responses, I find that CRT and NFC are negatively correlated with bias in decision making, positively with consistent preferences and liberal opinions and attitudes. Moreover, the two-item pseudo-AOT score and having correctly solved the Wason selection task both are surprisingly robust in predicting choices.

The multivariable regressions show that people with higher CRT scores tend to have higher NFC scores, higher pseudo-AOT scores and they solve the Wason selection task with higher probability. Moreover, they are less prone to Conjunction fallacy, more risk neutral and less likely to have inconsistent risk preferences. Moreover, they are less religious, less likely to deny the reality of climate change and have more liberal views on abortion. It is noteworthy that even though CRT is numerical in nature (and therefore inevitably requires some mathematical attenuation), the related behavioral patterns are not simply measures of numeracy[49]. Therefore, CRT cannot be discarded simply as a measure of numerical aptitude.

Controlling for various factors, participants who scored higher on the NFC scale were, on average, better educated, scored higher on CRT and pseudo-AOT scales, were more patient with monetary rewards, less likely to discriminate against sexual minorities, less likely to deny climate change exists and less harsh in their opinions regarding the poor. There is also some evidence for higher risk neutrality and less time-inconsistency of preferences among high-NFC participants. It should be noted that the behavioral phenomena linked to higher NFC are only moderately overlapping with those linked to CRT scores.

In the regressions, having a higher pseudo-AOT score was associated with more liberal views on all the issues presented: the trait was associated with less religiosity, less discrim-

[48] Median answer 4, average 4.15, standard deviation 1.64.

[49] Risk neutrality and conjunction fallacy have calculable solutions, but abortion or the (non-)existence of God arguably have not.

ination against sexual minorities, lower levels of climate change denial, being pro-choice on abortion issues and being less judgmental of the poor. It seems, however, that the a-dogmatism measured by pseudo-AOT does not necessarily translate to better results in heuristics-and-biases tasks - at least not directly.

Correctly solving the Wason selection task seems to be a sign of being less susceptible to bias in some heuristics-and-biases tasks, but did not predict variance in any of the issues of religious or political nature. While controlling for various factors, solving the Wason selection task was related to lower probability of conjunction fallacy, lower rate of time-inconsistency of preferences and higher risk neutrality.

Having a more mathematical field of study is linked lower conjunction fallacy and higher risk neutrality. At the same time, those with more mathematical fields of studies seem to be more conservative on some of the policy issues studied, at least when compared to their peers from less mathematical fields of studies.

The different measures of cognitive dispositions are distinct yet highly interconnected and associated with a range of intertwined aspects of decision making, rendering their one-by-one analysis extremely difficult. It remains clear that the jungle comprising of all the different measures of cognitive dispositions as well as numerous biases with interwoven causes and effects is an area requiring a lot of sorting out.

In some heuristics-and-biases tasks, no link was found between performance in the task and cognitive dispositions. Most notably, none of the cognitive dispositions measured could predict the size of Anchoring effect, even though anchoring was widely observed among the participants. CRT or NFC had no predictive power over participants' time-inconsistency[50].

Many coefficients regarding religious and political beliefs are rather small, yet robust and significant: individuals with high scores on the measures of cognitive dispositions have a clear tendency to show more liberal views on controversial issues. Given the sample's homogeneity in terms of age and education, I suspect the sample might be so single-minded on many of the issues presented as to almost hide the extent to which cognitive dispositions are linked to judgments about religious and political issues. This, naturally, is a field that requires further research.

6.2 Limitations

It should be noted that the methods used in this survey are open for several limitations. First of all, the setting is a survey, not an experiment, making it impossible to control for all the variables required to claim causal interpretation in any scientifically credible manner. The correlations identified between the variables *might be* of causal nature, but further

[50] As noted above, success in Wason selection task was associated with a reduction in time-inconsistency.

research is required to (dis)qualify such claims.

Another factor possibly affecting the interpretation of single coefficients is multicollinearity, i.e. strong correlations between some of the independent variables.[51] The independent variables of highest interest - those measuring cognitive dispositions - had only moderate correlation coefficients[52]. Collinearity between the variables generally goes hand in hand with higher variance, i.e. to broader confidence intervals and thus failure to reject a false null hypothesis (see, e.g. Mason and Perreault Jr (1991)). Clearly, experimental settings are required to reliably study the effects of single measures on heuristics and biases.

As shown by Holt & Laury (2002), people sometimes behave differently in experimental choice situation depending on whether the payoffs they face are hypothetical or real. The survey used for the present study measured stated preferences with hypothetical outcomes, possibly resulting in bias. Levitt and List (2007) - citing numerous experiments in social psychology - shows that behavior in laboratory experiments are affected by reputation building, privacy and anonymity, selection into the experiment, social preferences and other factors not completely controlled by the experimenter, challenging the plausibility of any generalizations into the outside world. Gneezy and List (2006) observed that a framed field experiment showed similar patterns to a laboratory experiment - until a few hours later, as the observed effect all but disappeared with time. Moreover, in "naturally occurring environments, the choice set often is almost limitless and institutions arise endogenously", in stark contrast to most experiments, an issue best tackled with properly randomized field experiments (Levitt and List, 2007).

The findings relating to the online survey should be regarded with caution as there always exists the possibility of cooperation by participants, using online search tools to solve the puzzles or other phenomena that would undermine the findings. Although we explicitly asked the participants whether they had used external help and disqualified data from all participants who answered "yes" (N=34) the possibility of cooperation or other kinds of "fraud" cannot be excluded.

Another highly relevant critique regarding the online survey is possible selection bias, as people might choose to not participate in the survey (especially in a foreign language), and that choice might correlate with their cognitive characteristics or tendency to show biased behavior. Especially, it could be argued that NFC is an important determinant in whether one decides to spend 15 minutes solving puzzles. Moreover, the way the survey is distributed in social media and via mailing lists might yield non-random selection - whether

[51] This is especially the case with parental education and age and education: education received by the father was highly correlated with that of the mother (0.49), while age had a 0.53 correlation with education.

[52] Up to 0.25 between pseudo-AOT and NFC. These correlations are moderate enough to necessitate no attention. I have provided VIF tables in the appendix.

the selection is less random than that of an experiment with under-graduate participants from a single college remains an open question. Still another concern regarding selection is that of people giving up during the survey and not finishing - this issue could not be tracked and so its extent is impossible to know.

Lastly, it should be noted that the questionnaire was in English, while the majority of the participants were Finnish citizens - a country where English language skills are relatively high, but still far from native level. Perceptual disfluency (such as a difficult typewrite) has been linked to bias and learning by engaging higher-level processing (see eg. Yue et al. (2013) and Hernandez and Preston (2013)) - whether a foreign language one has not quite mastered has similar effects on survey participants remains unknown.

6.3 Concluding remarks

It might be a uncomfortable conclusion that cognitive skills and the degree of rationality vary predictably between individuals, and even more controversially, that signs of rationality are more common among advocates of certain political or religious beliefs. I firmly believe that both science and society will be better off if we keep on pushing the boundaries of knowledge and keep searching for the sources of better decision making - whether it makes us feel uncomfortable or not.

So far, we do not know whether a decrease in dogmatism leads to higher appreciation of deep thought and numeric savviness or vice versa, whether these traits are fixed at birth or whether they can be taught in school. While these questions - and many others - remain unanswered, one thing is clear: if a few questions can predict various biases and behavioral patterns in individuals, an underlying system linking different parts of our thinking exists out there. With determination and ingenuity, it can be found.

7 Appendices

7.1 Education, endogeneity and experimental settings

This study, as regards education, lacks robustness, for education is clearly endogenous in the setting. It is common to expect education to change one's thinking patterns, whereas behavioral biases and less-than-fully rational behavior, such as hyperbolic discounting, can be plausibly expected to affect educational outcomes. A person that has a tendency to purport some behavioral biases, such as the ones covered in this study, can be expected to show a tendency for other biases as well. Therefore it is completely plausible to expect a crucial Gauss-Markov assumption (of zero correlation between the error term and all

independent variables).

Education has been proven to increase earnings in marginally admitted students (Zimmerman, 2014). In the favorable case of availability of several rounds of experiments, a similar discontinuity design could be used to study whether those effects are due to signaling, or to education's effects on cognitive processes.

In Finland, entrance exams have a key role in the admission process. At the margin, the difference between receiving an admission and not is a matter of a single percentage point, which can be considered arbitrary. Therefore, the student who just received his spot and one who just didn't can be considered identical in terms of pre-existing cognitive processes and rationality of behavior. Therefore, a classic discontinuity design applies, and the latter group of people can be used as a control group, while the treatment group consists of the ones admitted by an arbitrarily small margin. This notion is an important one, and can be used for an unbiased interpretation of post-treatment outcomes.

7.2 Robustness checks

7.2.1 VIF check for multicollinearity

In the table below I provide VIF tests ran on two regressions: one for OLS, one for Logit. The results from OLS do not necessitate reconsidering the variables used in this study, but the logistic regression VIF results are high, including for the measures of cognitive dispositions. Thus, especially in the case of logistic regressions in this study, there exists a heightened probability for failure to reject a false null hypotheses. This highlights the need for randomized experiments to further proceed our understanding of the topic.

7.2.2 Clearing the effect of age

Below I have conducted robustness checks on my findings by re-running the regressions on participants under 30 years old. The reason to conduct these tests is that the survey was spread through social media and university email lists, which might lead to stronger selection bias in the age groups that not as easily reached through these channels.

In table "NFC, CRT for under 30 year olds" is presented the coefficients of various background variables on CRT and NFC. Also, the results of the Wason selection task and pseudo-AOT are included in regressions three and four. The results differ slightly from the general analysis done earlier - whereas mother's education is no more significant for cognitive characteristics, one's own level of education has a significant, positive coefficient on one's NFC score. Age is no more significant. Moreover, the "pseudo-score" for Actively Open-minded Thinking is significant in predicting NFC with a positive coefficient, whereas

Table 15: VIF tests for multicollinearity

Variable	OLS	Logit
age	1.49	15.51
education	1.42	17.67
mother's education	1.4	9.73
father's education	1.34	8.62
math	1.27	6.10
NFC	1.22	2.83
CRT	1.18	2.05
studies in economics	1.17	1.96
pseudo-AOT	1.10	3.67
Wason test	1.05	1.21

Notes: VIF test results for important variables.

the Wason selection task has a positive and significant coefficient in predicting CRT.

In table "Risk neutrality and Prospect theory for under 30 year olds" we find that NFC is now very significant, whereas CRT - while still significant - does not stand out as much. In predicting Prospect theory, both NFC and CRT were significant at 10% confidence level in regression number three.

In table "Conjunction fallacy for under 30 year olds" I present findings relating to Conjunction Fallacy. In the subset (N=632), the major finding holds: CRT and "math" are highly significant, as well as whether the participant answered the other conjunction fallacy-related problem correctly. Moreover, age, NFC and Wason selection task are significant in one or more regressions: NFC in regression one[53], age in regressions two and three[54] and Wason selection task in regressions two and four[55]. In regressions one to three, gender in no more a significant predictor.

In table 19 there are significant differences to the regressions with the full sample - namely, NFC is significant in predicting impatience and time-inconsistency, while CRT is significant in predicting time-inconsistency - all with a negative coefficient.

In regressions related to Anchoring effect, findings did not differ for under 30 year olds.

[53]Note, that "math" was not controlled for in this regression

[54]P=0.086 and P=0.045, respectively

[55]P=0.040 and P=0.057, respectively

Table 16: NFC, CRT for under 30 year olds

	(1) CRT	(2) NFC	(3) CRT	(4) NFC
NFC	0.00976***		0.00862***	
	(0.00238)		(0.00247)	
age	0.0127	-0.354	0.0117	-0.549
	(0.0189)	(0.341)	(0.0190)	(0.338)
male	0.390***	4.550**	0.331***	2.489
	(0.0905)	(1.543)	(0.0928)	(1.576)
education	-0.0386	3.021*	-0.0276	3.666**
	(0.0700)	(1.269)	(0.0696)	(1.258)
father's education	-0.0271	-0.250	-0.0351	-0.447
	(0.0351)	(0.666)	(0.0348)	(0.650)
mother's education	0.0404	0.953	0.0391	0.893
	(0.0436)	(0.770)	(0.0429)	(0.735)
math in studies	0.118***	1.237*	0.121***	1.190*
	(0.0291)	(0.524)	(0.0290)	(0.507)
econ studies	-0.0825	1.957	-0.0737	2.460*
	(0.0583)	(1.010)	(0.0577)	(0.985)
CRT		3.052***		2.576***
		(0.742)		(0.739)
Wason task			0.346***	3.032
			(0.101)	(2.193)
pseudo-AOT			0.0168	1.529***
			(0.0161)	(0.285)
Constant	1.121**	7.400	1.062*	5.814
	(0.426)	(7.548)	(0.423)	(7.342)
Observations	606	606	606	606
R^2	0.133	0.121	0.147	0.173
F	12.80	9.946	13.12	13.01

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Standard errors in parentheses. Sample includes only participants under 30 years of age. OLS regressions, with CRT and NFC scores regressed on each other and background and control variables. See table 4.

Table 17: Risk neutrality and Prospect theory for under 30 year olds

	(1)	(2)	(3)	(4)
	loss in expected value	loss in expected value	prospect theory	prospect theory
CRT	-43.07**	-33.24	-0.149	-0.140
	(14.81)	(17.10)	(0.0885)	(0.0960)
NFC	-3.114***	-2.461***	-0.00840	-0.00666
	(0.705)	(0.723)	(0.00486)	(0.00513)
age	-5.068	-8.367	0.0240	0.0170
	(4.643)	(5.760)	(0.0338)	(0.0440)
male	-157.3***	-113.1***	-0.0685	0.0219
	(30.88)	(29.49)	(0.199)	(0.223)
math in studies		-29.25*		-0.00984
		(13.26)		(0.0685)
econ studies		-27.73		-0.0925
		(23.18)		(0.143)
education		1.713		0.0820
		(21.43)		(0.161)
Wason task		-108.4***		-0.347
		(29.28)		(0.314)
parents' education		YES		YES
Constant	673.3***	862.2***	-1.108	-1.241
	(124.5)	(166.8)	(0.856)	(1.034)
Observations	632	606	632	606
R^2	0.102	0.130		
F	28.24	15.28		

Standard errors in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 18: Conjunction fallacy for under 30 year olds

	(1)	(2)	(3)	(4)
	fallacy, Linda	fallacy, Linda	fallacy, Linda	fallacy, Russia
CRT	-0.350***	-0.288***	-0.322***	0.0394
	(0.0828)	(0.0854)	(0.0889)	(0.0906)
NFC	-0.00908*	-0.00631	-0.00708	0.00212
	(0.00461)	(0.00486)	(0.00504)	(0.00494)
age	-0.0355	-0.0664	-0.0803*	0.0512
	(0.0299)	(0.0387)	(0.0400)	(0.0320)
male	-0.277	-0.0166	-0.109	0.485*
	(0.176)	(0.198)	(0.209)	(0.211)
math in studies		-0.156**	-0.130*	0.00703
		(0.0585)	(0.0606)	(0.0647)
econ studies		-0.0406	-0.0639	0.166
		(0.125)	(0.131)	(0.127)
education		0.139	0.151	
		(0.145)	(0.147)	
Wason task		-0.525*	-0.426	-0.570
		(0.256)	(0.265)	(0.299)
pseudo-AOT		-0.0393	-0.0272	-0.0522
		(0.0315)	(0.0326)	(0.0331)
fallacy, Russia			0.710***	
			(0.197)	
fallacy, Linda				0.742***
				(0.191)
parents' education			YES	
Constant	1.982**	2.814***	3.025**	-2.604**
	(0.753)	(0.823)	(0.932)	(0.863)
Observations	632	632	606	632

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Standard errors in parentheses. Sample includes only participants under 30 years of age. Logit regression, with conjunction fallacy dummy regressed on measures of cognitive dispositions and background and control variables. See table 8.

Table 19: Impatience and time-inconsistency for under 30 year olds

	(1)	(2)	(3)	(4)
	impatience	impatience	time-inconsistency	time-inconsistency
CRT	-0.925	0.0735	2.670**	3.175*
	(1.220)	(1.734)	(1.014)	(1.244)
NFC	-0.149**	-0.111	-0.112*	-0.0979
	(0.0500)	(0.0568)	(0.0502)	(0.0603)
age	-0.177	-0.379	-0.0764	-0.123
	(0.688)	(0.500)	(0.483)	(0.531)
male	7.764*	9.787	4.841	7.332*
	(3.695)	(5.531)	(2.705)	(3.596)
math in studies		-2.228		-1.368
		(1.951)		(1.213)
education		0.891		0.239
		(2.683)		(2.161)
econ studies		4.818		0.395
		(3.618)		(2.306)
pseudo-AOT		-1.318		-0.457
		(0.992)		(0.627)
Wason task		-3.396		-4.496
		(3.745)		(2.965)
parents' education		YES		YES
Constant	25.00	31.86*	4.894	8.691
	(18.04)	(13.40)	(12.69)	(12.22)
Observations	632	606	632	606
R^2	0.010	0.032	0.018	0.030
F	5.799	2.485	3.698	2.137

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Standard errors in parentheses. Sample includes only participants under 30 years of age. OLS regression, with impatience (columns (1) and (2)) and hyperbolia (columns (3) and (4)) regressed on measures of cognitive dispositions and background and control variables. See table 9.

7.3 Survey questionnaire

The survey questionnaire used in this study is to be found on the pages below in its totality. Please not that the within-section item order was randomized. Section structure was as follows: background information (questions one through 8), then in order questions 9, 10, 11, 12, 13. After the anchoring part, the main section comprised of questions 14 through 48. Feedback section (question 49-53) were presented last.

Survey for Juuso Nisula's Master's thesis

In this Master's thesis I study opinion forming and decision making under uncertainty. Most questions presented do not have a right-or-wrong answer. If you do not know an answer, please make an estimate or guess.

Please provide all answers honestly and without assistance or external help - do not ask a friend, even if a question is difficult! Please do not use google, a calculator or other similar appliances. If you need to use a vocabulary to understand a question, please indicate that after the survey. This survey is completely anonymous.

Thank you for your time, I appreciate your help.

*Required

Background information

Background information

1. **What is your gender?**
   Mark only one oval.

   - Male
   - Female

2. **What is the highest degree your mother has obtained?**
   Mark only one oval.

   - High school degree (or equivalent)
   - Bachelor's degree (or equivalent)
   - Master's degree (or equivalent)
   - Doctoral degree
   - My mother has not obtained any of the above
   - I do not know

3. **What is the highest degree you have obtained? ***
   Mark only one oval.

   - High school degree (or equivalent)
   - Bachelor's degree (or equivalent)
   - Master's degree (or equivalent)
   - Doctoral degree
   - I have not obtained any of the above

4. **How mathematical is (was) your field of studies?** *

If your studies vary significantly in terms of the level of mathematics required, please estimate the average.
Mark only one oval.

	1	2	3	4	5	6	
Not mathematical at all (e.g. humanities)	◯	◯	◯	◯	◯	◯	Highly mathematical (mathematics, statistics etc.)

5. **What is the highest degree your father has obtained?**

Mark only one oval.

- ◯ High school degree (or equivalent)
- ◯ Bachelor's degree (or equivalent)
- ◯ Master's degree (or equivalent)
- ◯ Doctoral degree
- ◯ My father has not obtained any of the above
- ◯ I do not know

6. **What is your age?** *

.....

7. **What is your nationality?**

.....

8. **Do you work in economics or finance, or have you studied the said subjects on a university level?**

Please choose all that apply.
Tick all that apply.

- ☐ I have studied some economics or finance on a university level
- ☐ I have studied economics and/or finance extensively on a university level
- ☐ I have some working experience in economics or finance
- ☐ I have significant working experience in economics and/or finance
- ☐ I do not work in economics or finance, and have not studied either on a university level

9. **Which day of the month were you born on?** *

Please provide a numerical answer: if you were born on x'th of March in 1987, you would answer x

.....

10. **Suppose your favorite movie is getting a sequel, and you could buy a ticket to the world premiere. Now, consider the day of the month you were born on: would you be willing to pay more euros than that to buy the ticket?** *
    In other words, if you were born on the x'th day, then would you pay more than x euros for the ticket to the world premiere of the sequel to your favorite movie?
    Mark only one oval.

    - ◯ Yes, I would pay more than that
    - ◯ No, I would not pay that much

11. **How much would you be willing to pay for a ticket to the world premiere of the sequel to your favorite movie?** *
    Please provide a numerical answer (in euros).

    .....

12. **Again, consider the day of the month you were born on, and use that number (in percentage points) as a reference point. In your opinion, will China's economy grow slower or faster than that in 2016?** *
    If you were born on the x'th day, then, in your opinion, will China's economy (GDP) grow over or under x% in 2016, compared to 2015? Please consider the change in absolute size (growth of the economy), not change in growth rate. Remember, that it is quite normal to not know the precise answer - please use your best estimate.
    Mark only one oval.

    - ◯ China's economy will grow faster than that
    - ◯ China's economy will not grow that fast

13. **In your opinion, by how many percentage points will China's economy grow in 2016?** *
    Please provide your answer in a number form. For clarity, write x for growth of x% (or -x for growth of -x%, indicating a decline of x%).

    .....

14. **I really enjoy a task that involves coming up with new solutions to problems.** *
    Choose a high number if the statement is very characteristic of you, and a low number if it is not.
    Mark only one oval.

	1	2	3	4	5	6	7	8	9	
I disagree very strongly	◯	◯	◯	◯	◯	◯	◯	◯	◯	I agree very strongly

15. **I would prefer a task that is intellectual, difficult, and important to one that is somewhat important but does not require much thought.** *

Choose a high number if the statement is very characteristic of you, and a low number if it is not.
Mark only one oval.

	1	2	3	4	5	6	7	8	9	
I disagree very strongly	◯	◯	◯	◯	◯	◯	◯	◯	◯	I agree very strongly

16. **I try to anticipate and avoid situations where there is likely a chance I will have to think in depth about something.** *

Choose a high number if the statement is very characteristic of you, and a low number if it is not.
Mark only one oval.

	1	2	3	4	5	6	7	8	9	
I disagree very strongly	◯	◯	◯	◯	◯	◯	◯	◯	◯	I agree very strongly

17. **I would prefer complex to simple problems.** *

Choose a high number if the statement is very characteristic of you, and a low number if it is not.
Mark only one oval.

	1	2	3	4	5	6	7	8	9	
I disagree very strongly	◯	◯	◯	◯	◯	◯	◯	◯	◯	I agree very strongly

18. **Suppose that you will receive 100€ in one year for certain. If you accepted a smaller amount, you could receive the money today instead of in one year. What is the smallest amount to have today that you would prefer over the 100€ in one year?** *

Please provide a numerical answer in euros

_____

19. **I prefer my life to be filled with puzzles that I must solve.** *

Choose a high number if the statement is very characteristic of you, and a low number if it is not.
Mark only one oval.

	1	2	3	4	5	6	7	8	9	
I disagree very strongly	◯	◯	◯	◯	◯	◯	◯	◯	◯	I agree very strongly

20. **I find satisfaction in thinking hard and for long hours.** *

Choose a high number if the statement is very characteristic of you, and a low number if it is not.
Mark only one oval.

	1	2	3	4	5	6	7	8	9	
I disagree very strongly	◯	◯	◯	◯	◯	◯	◯	◯	◯	I agree very strongly

21. **Suppose your friend, a young woman, gets pregnant unintentionally, and neither she or her partner would want to keep the baby. It is now the third week of pregnancy, and they are considering an abortion. She asks for your opinion; would you recommend her to have an abortion, or to keep the baby?** *

Choose a number between the two extremes that best describes your opinion.
Mark only one oval.

	1	2	3	4	5	6	7	8	9	
Absolutely yes, she should have an abortion.	◯	◯	◯	◯	◯	◯	◯	◯	◯	Absolutely not, she should keep the baby.

22. **The idea of relying on thought to make my way to the top appeals to me.** *

Choose a high number if the statement is very characteristic of you, and a low number if it is not.
Mark only one oval.

	1	2	3	4	5	6	7	8	9	
I disagree very strongly	◯	◯	◯	◯	◯	◯	◯	◯	◯	I agree very strongly

23. **Suppose you have a lottery ticket that has a 50% chance of winning 1000€ (and otherwise has a value of zero). What is the smallest amount you would sell it for?** *

In other words, you have a 50% chance of winning 1000€. Please provide a numerical answer.

_____

24. **What is your take on global warming?** *

Choose a number between the two extremes that best describes your opinion.
Mark only one oval.

	1	2	3	4	5	6	7	8	9	
Global warming is a serious threat, and everything should be done to prevent it.										Global warming is not real, and should not be considered by politicians.

25. **It's enough for me that something gets the job done; I don't care how or why it works.** *

Choose a high number if the statement is very characteristic of you, and a low number if it is not.
Mark only one oval.

	1	2	3	4	5	6	7	8	9	
I disagree very strongly										I agree very strongly

26. **Suppose you have a "negative lottery ticket" that has a 50% chance of losing 1000€ (and otherwise has a value of zero). What is the largest amount you would be willing to pay to get rid of it?** *

In other words, you have a 50% chance of losing 1000€. How much would you be willing to pay to eliminate that risk? Please provide a numerical answer (in euros). Assume that there is no other possibility to get rid of the negative lottery ticket than to pay.

27. **How religious do you consider yourself to be?**

Mark only one oval.

	1	2	3	4	5	6	7	8	9	
Not religious at all										Very religious

28. **The notion of thinking abstractly is appealing to me.** *

Choose a high number if the statement is very characteristic of you, and a low number if it is not.
Mark only one oval.

	1	2	3	4	5	6	7	8	9	
I disagree very strongly	◯	◯	◯	◯	◯	◯	◯	◯	◯	I agree very strongly

29. **I prefer to think about small, daily projects to long-term ones.** *

Choose a high number if the statement is very characteristic of you, and a low number if it is not.
Mark only one oval.

	1	2	3	4	5	6	7	8	9	
I disagree very strongly	◯	◯	◯	◯	◯	◯	◯	◯	◯	I agree very strongly

30. **A bat and a ball cost 1.1€ in total, the bat costs 1€ more than the ball. How many cents does the ball cost?** *

Please provide a numerical answer

_____

31. **"Certain beliefs are just too important to abandon no matter how good a case can be made against them." Do you agree?** *

Choose a high number if you agree with the statement, and a low number if you disagree
Mark only one oval.

	1	2	3	4	5	6	7	8	9	
I disagree very strongly	◯	◯	◯	◯	◯	◯	◯	◯	◯	I agree very strongly

32. **Suppose that you will receive 100€ in two years for certain. If you accepted a smaller amount, you could receive the money in one year instead of two years. What is the smallest amount to have in one year that you would prefer over the 100€ in two years?** *

Please provide a numerical answer in euros

_____

33. **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 alternative do you consider more likely?** *

Mark only one oval.

- Linda is a bank teller
- Linda is a bank teller and is active in the feminist movement

34. **What is your take on the freedoms of sexual minorities?**

Mark only one oval.

	1	2	3	4	5	6	7	8	9	
Sexual minorities should have perfect equality										The freedoms of sexual minorities should be very restricted

35. **I like tasks that require little thought once I've learned them.** *

Choose a high number if the statement is very characteristic of you, and a low number if it is not.
Mark only one oval.

	1	2	3	4	5	6	7	8	9	
I disagree very strongly										I agree very strongly

36. **I like to have the responsibility of handling a situation that requires a lot of thinking.** *

Choose a high number if the statement is very characteristic of you, and a low number if it is not.
Mark only one oval.

	1	2	3	4	5	6	7	8	9	
I disagree very strongly										I agree very strongly

37. **I usually end up thinking in depth about issues even when they do not affect me personally.** *

Choose a high number if the statement is very characteristic of you, and a low number if it is not.
Mark only one oval.

	1	2	3	4	5	6	7	8	9	
I disagree very strongly										I agree very strongly

38. **Suppose there are four cards, all of which have a number on one side, and a letter on the other side. You only see one side of each card. The cards have the following symbols on them: G, 7, 2, U. Which card(s) you would have to turn around to evaluate whether the following statement is true: "if a card has a vowel on one side, then it has an even number on the other side".** *

Only turn around the card(s) that you would have to in order to make a judgement about whether the statement is true or false.
Tick all that apply.

- [ ] G
- [ ] 7
- [ ] 2
- [ ] U

39. **"People should always take into consideration evidence that goes against their beliefs." Do you agree?** *

Choose a high number if you agree with the statement, and a low number if you disagree
Mark only one oval.

	1	2	3	4	5	6	7	8	9	
I disagree very strongly	◯	◯	◯	◯	◯	◯	◯	◯	◯	I agree very strongly

40. **The Russian economy has been in turmoil for a while, and Finnish exports to Russia have declined. Which alternative do you consider more likely to happen in 2016?** *

Please only consider the two alternatives given here.
Mark only one oval.

◯ The Russian economy will recover, causing the stock prices of Finnish exporting companies to rise

◯ The Russian economy will recover, whether or not it affects stock prices in Finland

41. **It takes five machines five minutes to finish five products. How many minutes does it take 100 machines to finish 100 products?** *

Please provide a numerical answer

.....

42. **I would rather do something that requires little thought than something that is sure to challenge my thinking abilities.** *

Choose a high number if the statement is very characteristic of you, and a low number if it is not.
Mark only one oval.

	1	2	3	4	5	6	7	8	9	
I disagree very strongly	◯	◯	◯	◯	◯	◯	◯	◯	◯	I agree very strongly

43. **I only think as hard as I have to.** *

Choose a high number if the statement is very characteristic of you, and a low number if it is not.
Mark only one oval.

	1	2	3	4	5	6	7	8	9	
I disagree very strongly	◯	◯	◯	◯	◯	◯	◯	◯	◯	I agree very strongly

44. **If somebody is very poor in a Western society (e.g. Finland), is it his/her own fault?** *

Choose a number between the two extremes that best describes your opinion.
Mark only one oval.

	1	2	3	4	5	6	7	8	9	
It is never his own fault, at all	◯	◯	◯	◯	◯	◯	◯	◯	◯	It is always and completely his own fault

45. **I feel relief, rather than satisfaction, after completing a task that required a lot of mental effort.** *

Choose a high number if the statement is very characteristic of you, and a low number if it is not.
Mark only one oval.

	1	2	3	4	5	6	7	8	9	
I disagree very strongly	◯	◯	◯	◯	◯	◯	◯	◯	◯	I agree very strongly

46. **Thinking is not my idea of fun.** *

Choose a high number if the statement is very characteristic of you, and a low number if it is not.
Mark only one oval.

	1	2	3	4	5	6	7	8	9	
I disagree very strongly	◯	◯	◯	◯	◯	◯	◯	◯	◯	I agree very strongly

47. **Learning new ways to think doesn't excite me very much.** *

Choose a high number if the statement is very characteristic of you, and a low number if it is not.
Mark only one oval.

	1	2	3	4	5	6	7	8	9	
I disagree very strongly	◯	◯	◯	◯	◯	◯	◯	◯	◯	I agree very strongly

48. **Imagine a pond in which there is a patch of water-lilies that doubles in size (area) every day. It takes the patch 48 days before it covers the whole pond. How many days does it take for the patch to cover half the pond?** *

Please provide a numerical answer

49. **If you want to be notified about the results once the thesis is finished, please leave your email address here**

50. **Have you ever studied behavioral economics or psychology of decision making, or read literature related to the subject?**

51. **Now that you have taken the survey, would you like to comment on it?**

52. **Had you encountered the puzzles in this survey before? Please specify.**

53. **Did you use external help, such as a pocket calculator or Google to answer the questions, or did you cooperate with a friend?** *

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