# Perceived wealth and behavioral inattention*

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**Abstract**

By means of a laboratory experiment, we show that financially equivalent balance sheet profiles may be perceived as non fungible in a controlled frictionless environment with no probabilistic attributes. We find that, contrary to standard consumer theory, a large majority of subjects have a bias in the perception of wealth: for a given net worth with values of assets and debt that are financially certain and risk-free, a greater asset-debt ratio implies greater perceived wealth. This bias in the perception of wealth is explained by low cognitive sophistication and great inattention. Moreover, biased subjects are less patient, less debt averse, more likely to increase spending out of unexpected gains and report greater propensities to consume. A standard optimal consumption choice model, enriched with a rational but inattentive agent à la Gabaix (2014, 2019), aligns our key experimental findings.

JEL: C91, D91, G41, G51

Keywords: perceived wealth, behavioral inattention, cognitive sophistication, laboratory experiment, household debt, consumption

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# 1 Introduction

Existing evidence in economics and psychology shows that people often struggle to have a correct perception of how much they are worth in terms of income or net wealth, both in absolute terms and relative to others (Bénabou and Tirole, 2006; Chambers et al., 2014; Cruces et al., 2013; Dawtry et al., 2015; Gasiorowska, 2014; Hauser and Norton, 2017; Loughnan et al., 2011; Norton and Ariely, 2011; Ravallion and Lokshin, 2002). There may be multiple channels leading to the emergence of net wealth misperception – a deviation of the perceived level of own net wealth from actual net worth. For example, money illusion leads individuals to have an objective function depending on nominal magnitudes (Fehr and Tyran, 2014; Fisher, 1928; Shafir et al., 1997) and may therefore affect the perception of the growth of real wealth (Miao and Xie, 2013). An alternative account is the construct of *pseudo-wealth*, introduced by Guzman and Stiglitz (2016a; 2016b), which is "wealth that individuals perceive they have, but which is to some extent divorced from the physical assets that exist in society" (Guzman and Stiglitz, 2016a, p. 2). Pseudo-wealth arises if agents have heterogeneous beliefs on the materialization of a sunspot. The presence of a market for bets will lead each agent to believe that, on average, he is going to win, thereby resulting in the perception of greater wealth. Another key contributor to wealth misperception is the wealth effect attributable to variations in house prices. In fact, even though higher house prices do not change real financial wealth – for a homeowner, this merely represents a compensation for a higher implicit rental cost of living in the house (Campbell and Cocco, 2007) – they also imply greater financial wealth.

May wealth misperception arise even in the absence of such channels characterized by probabilistic attributes, uncertainty or heterogeneous beliefs? If this is possible, what lies at the root of such misperception? This is the focus of our paper.

In order to address these questions we proceed in four stages. First, by means of a laboratory experiment, we test whether perceived wealth may deviate from actual net wealth in a controlled environment with no frictions, such that financial values are certain, risk free and have no probabilistic components. Secondly, having found evidence of such a deviation, we evaluate different explanations related to individual characteristics, such as cognitive abilities and attention capacity, risk preferences, financial literacy and experience. Third, by means of a survey, we assess the relevance of wealth misperception in our controlled environment by testing whether it has any predictive power over individual attitudes towards consumption and debt. Finally, we show that a standard optimal consumption choice model, enriched with a behaviorally inattentive agent à la Gabaix (2014, 2019), aligns our key experimental findings and can contribute to shed some light on the excess consumption smoothing puzzle in household finance (Beshears et al., 2018; Deaton, 2008; Gorbachev, 2011; Jappelli and Pistaferri, 2010).

The experiment consists of four tasks and a survey. Participants are initially instructed on the necessary financial concepts, as well as the distinctive features of the operating context. In the first task, each subject is shown a number of pairs of financially equivalent balance sheet profiles, $a$ and $b$, that have the same (positive or negative) net worth but different levels of assets and liabilities that are non-interest bearing, financially certain, risk-free and realized in the past. Subjects are asked to compare the two profiles in each pair based on their perceived financial soundness, a proxy for perceived wealth. In this controlled environment with no distortions, one should expect a rational unbiased subject to perceive the two profiles as fungible and associate the same level of perceived wealth to both of them. Standard consumer theory in neoclassical economics indeed predicts that a rational individual treats money as fungible (Hastings and Shapiro, 2013; Thaler, 1990). Fungibility implies that any unit of money is substitutable for another – *a dollar is a dollar* (Hastings and Shapiro, 2013) – and, consequently, the composition of wealth is irrelevant for preferences and choices (Abeler and Marklein, 2017; Thaler, 1990). An agent that is rational and unbiased therefore follows a *balance-sheet-structure-irrelevance* principle à la Modigliani and Miller (1958) such that, absent any friction, her level of perceived wealth is invariant to the composition of the balance sheet. This represents the theoretical benchmark of our study. However, the analysis of our results by means of Bayesian techniques points to a significant departure from the benchmark. In fact, we find that the probability that a subject is unbiased – stating that the two profiles in each pair are financially equivalent – is markedly lower than the probability that a subject is biased – indicating that one profile is financially superior. The fraction of biased subjects is estimated to be greater than 80%. Furthermore, of all possible answers, the one associated with the largest estimated probability (roughly 70%) is the one corresponding to a preference for profiles with greater asset-debt ratios, both when net worth is positive and when is negative. We label this prevailing pattern as the *leverage bias*.

To gain a deeper understanding of the relationship between perceived wealth and balance sheet composition, we introduce a second task. In this case, subjects have to simultaneously evaluate the perceived financial soundness of ten financially equivalent balance sheet profiles with the same net worth but different values of assets and liabilities. Evaluation occurs by assigning a grade from 1 to 10 to each profile. We also instruct subjects on the possibility to assign any equal grade to all profiles that they consider financially equivalent. The tendency to depart from the unbiased rational benchmark is confirmed by a Bayesian OLS regression, which points to the presence of a strong positive correlation between the asset-debt ratios of the profiles and the average grades assigned by subjects with the leverage bias.

Summing up, the first two tasks of the experiment provide evidence of (i) a departure from standard consumer theory and the principle of fungibility: there may be different levels of perceived wealth associated with financially equivalent profiles, based on their balance sheet composition, even in a controlled frictionless environment with no probabilistic attributes; (ii) the existence of the leverage bias: a positive relationship between perceived wealth and the asset-debt ratio, for a given net worth.[1]

Why do subjects perceive financially equivalent balance sheet profiles as non fungible? We collect information on individual characteristics to disentangle the observed deviation from the unbiased rational benchmark. We mainly evaluate three explanations: cognitive sophistication and attention capacity, risk preferences, financial literacy and experience.

We first present subjects with an incentivized version of the Cognitive Reflection Test (CRT) developed by Frederick (2005). CRT evaluates the ability of the subjects to override their impulsive and inattentive answer that is wrong, in favor of the attentive and

[1] A scrupulous reader might note that a preference for greater asset-debt ratios implies choosing profiles with lower levels of assets and debt, when net worth is positive, and higher assets and debt when net worth is negative. This reversal of preferences may seem analogous to the findings of prospect theory and decision-making in risky environments (Kahneman and Tversky, 1979), which suggests a switch from risk aversion to risk seeking when the valence of a gamble changes from positive to negative (Frederick, 2005). In line with this, the reader might relate the observed pattern of choices to a change from debt aversion to debt seeking when the sign of the net worth changes. However, our set-up is risk-free and has no probabilistic properties.Moreover, as reported later in the paper, we find that biased subjects are generally less averse and more prone to borrow for consumption.

consciously deliberated correct answer. To adopt the categorization of Dual Process Theory (Kahneman, 2003a,b, 2011; Stanovich and West, 2003), CRT assess the (im)balance between the attentive effort associated with the analytical and deliberate thinking of System 2 – which indeed takes up a great deal of attention (Toplak et al., 2014) – and the automatic thinking of System 1, which consumes little or no attentional resources (Kihlstrom, 1987; Moritz et al., 2014).

We elicit individual risk preferences by means of a standard multiple price list method structured as a game of 10 rounds (Holt and Laury, 2002).

Finally, to test the role of financial education we carefully design the selection process of the participants in the experiment. In fact, 45 of the 93 participants are randomly selected from those enrolled in any academic program of the Faculty of Economics of Università Cattolica del Sacro Cuore in Milan. All students selected from this pool have successfully passed four courses in finance and accounting with a grade of at least 27/30. The rest of the students are randomly selected from other faculties of the same university. We also ask information on credit-card ownership as a proxy for the level of financial experience of the subjects. Indeed, credit or debit card ownership is often associated with greater user experience and lower cost of fees (Agarwal and Mazumder, 2013) and, as such, it has been used as a proxy for financial sophistication and experience in several empirical analyses (see, e.g., Attanasio et al., 2002; Stango and Zinman, 2009).

A series of Bayesian regressions show that the presence of the leverage bias has a much larger probability of being predicted by individual scores in CRT, rather than risk aversion, financial education and experience. In fact, subjects with the leverage bias perform significantly worse in CRT compared to unbiased subjects. Therefore, while our results do not seem to support explanations related to risk preferences or financial literacy and experience, our main findings suggest that the tendency to perceive financially equivalent balance sheet profiles as non fungible and have greater perceived wealth for higher values of the asset-debt ratio is correlated with a predominance of System 1 type of thinking, which is characterized by a lower level of cognitive sophistication and attention capacity.

Does the leverage bias predict attitudes towards consumption and debt? In the last part of the experiment, we include a small survey to evaluate the relationship between the leverage bias, wealth misperception and consumption and borrowing behavior. Our survey draws on the "reported preference" approach (Fuster et al., 2018; Parker and Souleles, 2017), which relies on reported changes in borrowing or spending in hypothetical scenarios. In addition to a standard set of socio-demographic questions, our survey includes questions about personal attitudes towards credit-financed spending, impatience and saving type, the response to a hypothetical financial emergency, and the likelihood to increase spending out of unexpected gains.

We find that the leverage bias has a strong predictive power over attitudes towards consumption and debt. Biased subjects are generally more comfortable with the use of credit to finance consumption and deal with financial emergencies. Moreover, we find that subjects with the leverage bias are also more likely to borrow for consumption under financial profiles characterized by higher asset-debt ratios, while unbiased subjects make borrowing decisions that are neutral to the composition of the balance sheet. Finally, biased subjects report a greater likelihood to increase consumption out of unexpected gains, as well as larger average propensities to consume, compared to unbiased subjects.

In the last part of the paper, we build a two-period optimal consumption choice model that aligns our key experimental results. The model features two types af agents: (i) a standard rational agent representing the unbiased subject and (ii) a behavioral agent à la Gabaix (2014, 2019) who has a wrong perception of the wealth due to inattention and low cognitive sophistication. The behavioral agent therefore represents the biased subject in our experiment, characterized by a predominance of System 1 over System 2.

We show that, in line with our experimental results, the model produces a greater marginal propensity to consume and lower debt aversion of the biased agent compared to the rational benchmark. Our model not only replicates the main outcomes of the experiment, but it can also contribute to shed some light on a puzzling aspect that characterizes existing models, which typically predict a significantly lower consumption response to both expected and unexpected income shocks, compared to what is found in the data (Beshears et al., 2018; Gorbachev, 2011; Jappelli and Pistaferri, 2010). While we do not provide quantitative estimates, we show that a standard textbook model, augmented with the presence of an inattentive behavioral agent who perceives net wealth as greater than the actual value, produces a pattern of consumption characterized by larger volatility and lower smoothing, relative to the standard benchmark.

Our contribution to the literature is twofold. First, compared to possible explanations that rely on heterogeneity in beliefs, uncertainty and probabilistic components (Fehr and Tyran, 2014; Fisher, 1928; Guzman and Stiglitz, 2016a,b; Miao and Xie, 2013; Shafir et al., 1997), we map the objective reality of actual wealth into the subjective perception of it in a controlled frictionless set-up. In particular, we provide evidence that people do not perceive financially equivalent balance sheet profiles as fungible, even in an environment where values are certain and risk-free. We thus support the literature that questions the fungibility of money and the irrelevance of the composition of wealth for economic choices (Thaler, 1999; Tversky and Kahneman, 1981). Recent findings (Abeler and Marklein, 2017; Hastings and Shapiro, 2013) indeed reveal the violation of fungibility in the realm of consumption decisions and show that these are not based on net wealth alone. Our results indicate that the composition of the balance sheet matters for the majority of our sample and the associated perception of wealth predicts attitudes towards debt, decisions to borrow and consume.

Second, our experimental findings and theoretical model, which are grounded in Dual Process Theory (Kahneman, 2003a,b, 2011; Stanovich and West, 2003) and theories of behavioral inattention (Gabaix, 2014, 2019), contribute to the literature that relates financial mistakes and non-optimal decisions to low cognitive abilities and inattention (Agarwal and Mazumder, 2013; Andersen et al., 2014; Banks and Oldfield, 2007; Gerardi et al., 2013; Sicherman et al., 2016). To the best of our knowledge, ours is the first work providing experimental evidence that ties cognitive sophistication and attention capacity to the perception of wealth and, consequently, individual decisions to consume and borrow.

The rest of this paper proceeds as follows. Section 2 provides an overview of the laboratory experiment: it introduces the main hypotheses, the experimental design and procedures and it presents the key findings. Section 3 introduces the model of behavioral inattention. Section 4 concludes.

## 2 Experiment overview

Our experiment is divided in three parts, with five tasks in total:

1. The first part tests whether, for a given net worth, the perception of wealth changes as a function of the composition of the balance sheet in a context that is risk-free

and has no probabilistic properties. This part is composed of the Profile Evaluation Task (PET) and the Profile Grading Task (PGT).

2. In the second part we evaluate cognitive abilities by means of an incentivized version of the Cognitive Reflection Test (CRT) developed by Frederick (2005). We also elicit risk-aversion via the multiple price list method introduced by Holt and Laury (2002) (RISK henceforth). Finally we evaluate financial sophistication by means of a simple question on credit/debit card ownership.

3. The third part includes a small survey with a set of questions measuring impatience, debt aversion, the likelihood to take on debt for consumption and to increase spending out of unexpected gains.

The experiment was designed using Otree (Chen et al., 2016). A pilot version on the first two parts was run on April 2018. The full experiment was run on September 2018 with the participation of 93 students from Università Cattolica del Sacro Cuore in Milan (Italy). Two groups of students participated in our experiment: one was composed of students randomly selected from those enrolled in any academic program of the Faculty of Economics, conditional on having passed 4 courses in accounting, finance and business with a grade of at least 27/30; the other group was composed of students randomly selected from other academic programs, with no economics or finance background. Such distinction between the two groups is used as a proxy for financial education.

Subjects were paid a €5 show-up fee, plus an amount related to their performance in the incentivized tasks (i.e. CRT and RISK). The average gain was €8.87 (std. 2.82).

## 2.1 Perceived wealth and balance sheet composition

In this subsection we describe PET and PGT. For both tasks, we start by introducing the main assumption; we then illustrate the design and the procedures; eventually, we discuss the results.

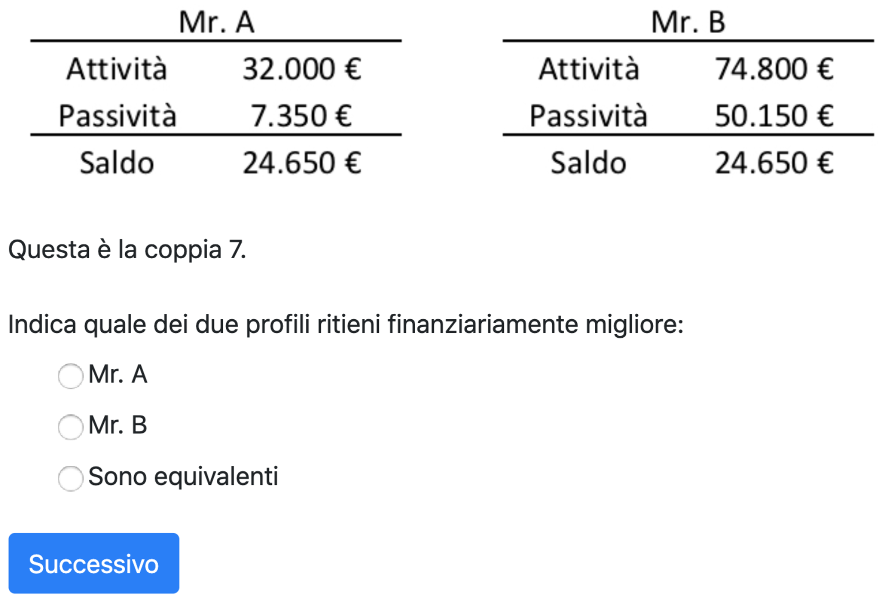
### 2.1.1 Profile Evaluation Task

PET allows to understand whether, in a frictionless context – i.e. a context in which financial values are risk-free, certain, non-interest bearing and have no probabilistic attributes – financially equivalent profiles may be associated with different levels of perceived wealth ($PW$), based on their balance sheet composition. Formally, PET tests the following hypothesis:

**Hypothesis 1**: *For a given pair of financially equivalent balance-sheet profiles* ($i = a, b$)*, with identical net worth but different values of assets and debt that are financially certain, non-interest bearing and risk-free, subjects will choose* $a$ *over* $b$ ($a \succ b$) *or* $b$ *over* $a$ ($a \prec b$).

In order to test Hypothesis 1, participants in PET are shown different pairs of hypothetical financial profiles with identical net worth but different levels of assets and debt. In particular, in each pair we distinguish a profile with a higher asset-debt ratio – High Ratio Profile (HRP) – and a profile with a lower asset-debt ratio – Low Ratio Profile (LRP). Agents see 10 pairs in total: 5 with positive net worth and 5 with negative net worth. The order of the pairs presented to participants is randomized at the individual level. For each pair, subjects have to choose the profile that they consider financially better off, or they can state that they consider the two profiles as financially equivalent (Equivalent Profiles, EQP). Figure 1 shows the interface of PET.[2]

Figure 1: Interface of PET.




The set-up introduced in PET is similar to the one first used in Sussman and Shafir (2012) and later adopted in Sussman (2017) and de Langhe and Puntoni (2015). However, we modify this set-up with some additional options and controls that avert inappropriate considerations about factors that are external to our framework. For example, compared to Sussman and Shafir (2012), Sussman (2017) and de Langhe and Puntoni (2015), the introduction of the EQP option allows for the identification of unbiased subjects, who perceive the two profiles in each pair as fungible. Moreover, before performing the task, all subjects are provided with essential definitions of the financial concepts involved in PET and a set of control questions testing the full understanding of the instructions. Differently from Sussman and O'Brien (2016), Sussman and Shafir (2012) and de Langhe and Puntoni (2015), the design of our experiment rules out any disturbances related to potential risk considerations or unwanted inference about the profiles in each pair. First, in order to avoid general risk considerations, or expectations about asset (or debt) value fluctuations, we state explicitly that all values shown in this task are certain and realized in the past. We also inform subjects that all values of assets and debt are non-interest bearing. In order to avoid evaluations based on possible inference on labor market positions, we point out that all profiles in each pair are associated with the same constant monthly income. Finally, subjects are also told that all profiles correspond to people who can access the credit market at the same conditions. This sets in stone the risk-free, time-invariant and financially certain framework of our experiment. It also represents a setup in which the interest rate plays no role from a rational standpoint, as values are non-interest bearing, while the interest rate on the credit market does not depend on the balance sheet composition.

Table 1 shows the 9 possible patterns that may emerge in PET. For example, pattern 1 corresponds to an individual choosing LRP (low asset-debt ratio profile) both in pairs

[2]The experiment was run in Italian. See Appendix A for a copy of the instructions translated in English.

with positive net worth and in pairs with negative net worth. Analogously, pattern 2 identifies a subject with a preference for LRP in pairs with negative net worth and HRP (high asset-debt ratio profile) in pairs with positive net worth.

Table 1

Patterns of choices in PET

| NW | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|
| $> 0$ | LRP | LRP | LRP | HRP | HRP | HRP | EQP | EQP | EQP |
| $< 0$ | LRP | HRP | EQP | LRP | HRP | EQP | LRP | HRP | EQP |
| Distribution | 0 | 2.74% | 0 | 0 | 78.08% | 4.11% | 0 | 0 | 15.07% |

LRP: low asset-debt ratio profile; HRP: high asset-debt ratio profile; EQP: equivalent. Percentage values indicate the distribution of subjects across the different patterns.

*Results from PET.* Based on Table 1, we introduce the following classification:

- *Unbiased subjects*: all subjects stating that two profiles are equivalent (EQP) both in pairs with positive net worth and in pairs with negative net worth. This corresponds to pattern 9 in Table 1 and it characterizes all individuals whose perception of wealth is invariant to the composition of the balance sheet. These individuals perceive the two profiles in each pair as fungible.

- *Biased subjects*: all subjects with a preference for one of the two profiles, both in pairs with positive net worth and in pairs with negative net worth. This corresponds to patterns 1, 2, 4 and 5. Biased subjects have a level of perceived wealth that, for a given (positive or negative) net worth, changes based on the level of assets and debt. These individuals perceive the two profiles in each pair as non-fungible. Patterns 3, 6, 7 and 8 correspond to subjects who are partially biased: they perceive financial profiles as different only when net worth is either positive or negative.

In order to discard subjects for which we do not identify any regularity, such as those who switch multiple times from LRP to HRP or EQP, for either positive or negative net worth, we introduce the following consistency threshold: we will consider only the subsample of agents making the same type of choice in at least 80% of the pairs, both for positive and negative net worth.

Based on our consistency threshold, our sample includes 73 subjects (78.49% of participating people):[3] 80.82% of them are biased, thus having a preference for one of the two profiles both when net worth is positive and when is negative; 4.11% have a preference for one of the two profiles only for pairs with positive net worth, thereby being partially biased; 15.07% of subjects are unbiased as they state that the financial profiles are equivalent both in pairs with positive net worth and in pairs with negative net worth. This is a first indication that a large majority of the sample is composed of subjects who have a bias in the perception of wealth, such that, for a given net worth, their level of perceived wealth depends on the composition of the balance sheet, even if the context is frictionless. In addition, 96.61% of these subjects choose the HRP both when net worth

[3] There is a trivially inverse relationship between the consistency threshold and the sample dimension: the percentage of consistent subjects would be 51.61% with 100% consistency, while increasing to 95.7% with 60% consistency.

is negative and when is positive. This is pattern 5 in Table 1, which we label as *leverage bias* (the remaining 3.39% of biased subjects aligns pattern 2). The predominance of this type of answer suggests the existence of a positive relationship between the asset-debt ratio and the level of perceived wealth, for a given net worth.

Based on our sample, we want to evaluate the probability associated with each of the possible patterns of answers. To this purpose, we run an intercept-only logistic regression in order to estimate the predicted probability associated with the four possible outcomes: unbiased (pattern 9), leverage bias (pattern 5), other forms of bias (pattern 2) and partial bias (pattern 6). Given the relatively small sample dimension, we proceed by means of Bayesian techniques. In particular, we impose a $N(0,1)$ neutral prior on the coefficients of the four outcomes. We use Markov Chain Monte Carlo (MCMC) sampling with the Metropolis–Hastings algorithm (Hastings, 1970; Metropolis et al., 1953) and a sample size equal to 100000.

Table 2

Predicted probabilities

| | |
|---|---|
| Unbiased | 16.81% |
| Leverage bias | 70.49% |
| Other bias | 5.79% |
| Partial bias | 6.91% |

Random-walk Metropolis-Hastings sampling with 100000 MCMC sample size; acceptance rate: .4398; average efficiency rate: .2195.
Prior $N(0,1)$ on all model coefficients.

Table 2 shows the predicted probabilities of the four outcomes: while being unbiased is associated with a probability of 16.81%, the estimated predicted probability of being biased is 83.19% overall.[4] In particular, the probability associated with the existence of the leverage bias is 70.49%, while the other two patterns have significantly lower probabilities. This result supports our hypothesis, in that the probability that subjects have different perceptions of financially equivalent profiles is much larger than the probability that subjects are unbiased and perceive the profiles as fungible. In particular, the leverage bias emerges as the predominant pattern: for a given net worth, the large majority of subjects have greater perceived wealth for higher values of the asset-debt ratio, both when net worth is positive and when is negative.[5]

### 2.1.2 Profile Grading Task

PGT allows to check the consistency of the answers provided by subjects in PET when the evaluation process involves more than two financially equivalent profiles. In addition, the task tests for the presence of a specific quantitative relationship between perceived wealth and the balance sheet composition. In fact, subjects are simultaneously shown 10

[4] Posterior means and high-posterior density intervals are reported in Appendix 4.

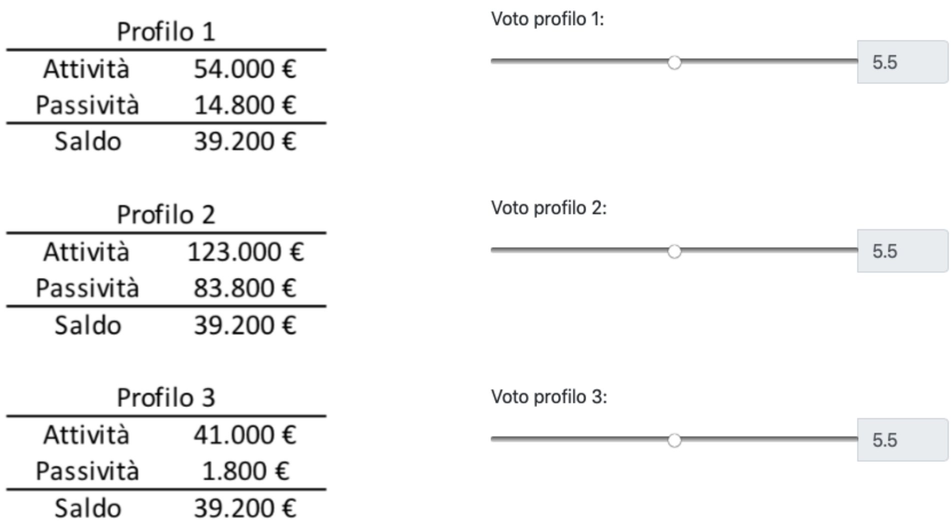
[5] To check for possible explanations related to the framing of the task or computational difficulties, we include two pairs, in which the value of one, between assets and debt, is hidden in both profiles. Also in these pairs all unbiased subjects perceive the two profiles as fungible, while only one biased subject is inconsistent with previous answers. This suggests that the reported pattern of preferences is robust to the framing of the problem and computational difficulties.

financial profiles with equal net worth but different levels of assets and debt. The task consists in grading the financial soundness of each profile on a scale from 1 (worst off) to 10 (best off). Subjects can assign any grade in this range, as the evaluation occurs by moving a pointer on a bar that corresponds to the continuous 1-10 interval.[6] In order to identify unbiased individuals, participants are also told that they may assign the same grade to all the profiles that they consider financially equivalent. Therefore, PGT tests the following hypothesis:

**Hypothesis 2**: *For a given set of profiles* ($i = 1, 2, ..., 10$) *with identical net worth but different values of assets and debt, biased subjects will assign different grades* ($g_i$) *to all profiles, such that* $g_1 \neq g_2 \neq ... \neq g_{10}$.

PGT is repeated twice, once with 10 profiles with positive net worth and once with 10 profiles with negative net worth. Figure 2 shows the interface of PGT with some of the profiles shown to subjects. Before performing the task, subjects are once again provided with the financial definitions of assets, debt and net worth and with the set of information shown in PET, so as to provide a set up that is financially certain, risk-free and time invariant.

Figure 2: Interface of PGT.




*Results from PGT.* Based on the results from PET, we focus the rest of our analysis on the comparison between subjects with the leverage bias (pattern 5 in Table 1) and those who are unbiased (pattern 9 in Table 1).

We find that all unbiased subjects assign equal grades to all profiles, both when net worth is positive and when is negative, thus being 100% consistent with the answers provided in PET. This confirms that their perception of wealth does not change as a function of the composition of the balance sheet, for a given net worth. On the contrary, all subjects with the leverage bias assign different grades to the 10 financially equivalent profiles, both when net worth is positive and when is negative.

Table 3 shows the results from a Bayesian linear regression of average grades assigned by subjects with the leverage bias on the asset-debt ratio of the profiles in PGT, in both

[6] The use of the bar allows to account for the so-called *digit preference*, which is the tendency to round numbers to agreeable digits (Camarda et al., 2017).

Table 3

Bayesian OLS regression of average grades over asset-debt ratio

| | Positive Net Worth | Negative Net Worth |
|---|---|---|
| Mean | .5356 | .1047 |
| Std. dev. | .3766 | .3163 |
| 68% HPD | [.1649 .8984] | [-.1998 .4314] |

Bayesian OLS regression of average grades over asset-debt ratio
Prior $N(0,1)$ on all model coefficients. Random-walk Metropolis-Hastings sampling with 100000 MCMC sample size. Positive net worth, acceptance rate: 0.3789; average efficiency rate: 0.0806. Negative net worth, acceptance rate: 0.4104; average efficiency rate: 0.0897.
Values in parenthesis are 68% highest posterior density intervals.

the positive and the negative net worth case. The informative $N(0,1)$ prior for the coefficients of the asset-debt ratio assumes neutrality and the absence of any relation between the two variables. Nonetheless, results support the existence of a positive relationship between perceived wealth, proxied by the average grade in PGT, and the asset-debt ratio of the profiles shown to subjects: an increase in the ratio by one results in an increase in the average grade of roughly .54 , for a given positive net worth, and .1, in the negative net worth case.

Summing up the results from PET and PGT, we find evidence of a deviation from standard consumer theory: the vast majority of our sample is composed by biased subjects who, absent any friction or probabilistic attribute, perceive financially equivalent profiles as non-fungible and have a level of perceived wealth that relates to the balance sheet composition. In particular, for a given net worth, these individuals have a clear preference for balance sheet profiles with higher values of the asset-debt ratio. Even by imposing a neutral prior, our Bayesian estimation highlights the strength of the relationship between the asset-debt ratio and perceived wealth. Given the absence of any frictions, subjects' answers seem hardly attributable to rational considerations related to risk, interest payments or gains, or financial uncertainty. Results from PET and PGT, therefore, provide suggestive evidence in favor of a behavioral interpretation of the leverage bias, which seems in fact a cognitive bias. We this and alternative explanations in the next section.

## 2.2 Interpretations

First, we investigate whether the presence of the leverage bias relates to individual cognitive abilities. To this purpose, we employ an incentivized version of the Cognitive Reflection Test first proposed by Frederick (2005). CRT is based on three questions that test the ability of the subjects to override the instinctive responses that are wrong, in favor of the more sophisticated correct answers (Bosch-Rosa et al., 2018). In other words, the test assesses the ability of the subject to switch from the fast, intuitive and inattentive thinking associated with System 1, to the attentive, logical and consciously deliberated type of thinking of System 2, as described in Dual Process Theory (Kahneman, 2003a,b, 2011; Stanovich and West, 2003). In fact, CRT is a powerful test and a significant predictor of cognitive abilities, rational thinking and working memory (Toplak et al., 2011).

CRT is composed of the following three questions:

- A bat and a ball cost €1.10. The bat costs €1 more than the ball. How much does the ball cost?
- It takes 5 machines 5 minutes to make 5 widgets. How long would it take 100 machines to make 100 widgets?
- 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?

Subjects have 2 minutes and 30 seconds to answer each question. The agent gets one point for each correct answer, hence the minimum score is 0 and the maximum is 3. We incentivize effort and attention by remunerating the subject with €2 for each point. Therefore, the minimum payoff is €0 and the maximum is €6.

We also test whether the presence of the leverage bias relates to risk attitudes. In particular, we elicit individual risk preferences by means of the multiple price list method introduced by Holt and Laury (2002). This task – RISK – is structured as a game composed of 10 rounds (Figure 3). In each round, participants have to choose between two risky options, A and B, each giving the possibility to participate in a lottery. RISK is an incentivized task: the outcome of one of the 10 chosen lotteries is randomly selected as the individual pay-off at the end of the game.

Figure 3: Lotteries in RISK.

| | *Opzione A* | | | | *Opzione B* | | | |
|---|---|---|---|---|---|---|---|---|
| | Probabilità | Vincita | Probabilità | Vincita | Probabilità | Vincita | Probabilità | Vincita |
| *1* | 1/10 | 2,00 € | 9/10 | 1,60 € | 1/10 | 3,85 € | 9/10 | 0,10 € |
| *2* | 2/10 | 2,00 € | 8/10 | 1,60 € | 2/10 | 3,85 € | 8/10 | 0,10 € |
| *3* | 3/10 | 2,00 € | 7/10 | 1,60 € | 3/10 | 3,85 € | 7/10 | 0,10 € |
| *4* | 4/10 | 2,00 € | 6/10 | 1,60 € | 4/10 | 3,85 € | 6/10 | 0,10 € |
| *5* | 5/10 | 2,00 € | 5/10 | 1,60 € | 5/10 | 3,85 € | 5/10 | 0,10 € |
| *6* | 6/10 | 2,00 € | 4/10 | 1,60 € | 6/10 | 3,85 € | 4/10 | 0,10 € |
| *7* | 7/10 | 2,00 € | 3/10 | 1,60 € | 7/10 | 3,85 € | 3/10 | 0,10 € |
| *8* | 8/10 | 2,00 € | 2/10 | 1,60 € | 8/10 | 3,85 € | 2/10 | 0,10 € |
| *9* | 9/10 | 2,00 € | 1/10 | 1,60 € | 9/10 | 3,85 € | 1/10 | 0,10 € |
| *10* | 10/10 | 2,00 € | 0/10 | 1,60 € | 10/10 | 3,85 € | 0/10 | 0,10 € |

Finally, we want to verify whether subjects that are more financially experienced or literate are less likely to have biased perceptions of wealth. To this purpose, we evaluate subjects' familiarity with basic financial tools by means of the following question, taken from the 2016 Survey of Consumer Finances (SCF): "Do you have at least one credit or debit card?". Credit or debit card ownership and usage has been used as a proxy for financial sophistication in several empirical analyses (see, e.g., Attanasio et al., 2002; Stango and Zinman, 2009). In fact, credit card ownership is often associated with learning mechanisms that increase user experience and reduce the cost of fees (Agarwal and Mazumder, 2013). Also financial literacy is widely recognized as a factor that affects the quality of individual financial decision-making (Lusardi and Tufano, 2015; van Rooij et al., 2011). We therefore exploit the different university background of the students in our experiment as a proxy for their financial literacy. We consider as financially educated all the students randomly selected from the faculty of Economics and having passed 4 courses in finance and accounting with a grade of at least 27/30. All the students who were randomly selected from non-economics courses are labeled as financially uneducated.[7]

### 2.2.1 Results

In Table 4 we report the marginal effects from a series of Bayesian logistic regressions of a dummy equal to 1 for the leverage bias on four variables: CRT score, risk aversion, financial sophistication and financial education. In all regressions, we assume a $N(0, 1)$ prior for model coefficients, thus making a neutral assumption on the predictive power of each of the four individual characteristics. In all regressions we control for age, gender, family size and family education.[8]

Table 4

Behavioral predictors of the leverage bias

| | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| CRT score | -.0823 | | | |
| 68% HPDI | [-.0983 -.0653] | | | |
| Risk aversion | | -.0063 | | |
| 68% HPDI | | [-.0142 .0018] | | |
| Financial sophistication | | | .0176 | |
| 68% HPDI | | | [-.0221 .0628] | |
| Financial education | | | | .0168 |
| 68% HPDI | | | | [-.0155 .0486] |
| Controls | Yes | Yes | Yes | Yes |
| Sample size | 68 | 68 | 68 | 68 |

Marginal effects from a Bayesian logistic regression of a dummy equal to 1 if the subject is biased on (1) CRT score, (2) number of safe choices in RISK, (3) a dummy equal to 1 if the subject has credit/debit card and (4) a dummy equal to 1 if the subject is financially educated. Controls include age, gender dummy, family size and family education level as covariates.
Prior $N(0, 1)$ on all model coefficients. Random-walk Metropolis-Hastings sampling with 100000 MCMC sample size.
Values in parentheses are 68% highest posterior density intervals.

Results show that greater cognitive sophistication is negatively correlated with the presence of the leverage bias: when CRT score increases by 1 point, the probability of being biased decreases by roughly by 8%. Also risk aversion is negatively correlated with the bias but the absolute value is substantially smaller. The other two variables are positively correlated with the probability of being biased, but also in this case the value is smaller compared to the absolute value of CRT score.

We want to test which of the four Bayesian logistic regression models in Table 4 is more likely given the observed experimental data. Table 5 reports the posterior probability of each of the models, under the assumption that all of them are equally probable a priori. We find that the regression model with CRT is substantially more likely given our data,

[7]The university administration has double checked that students from non-economics courses have never attended any financial course during their studies.

[8]Results with no controls are reported in Appendix 4.

as it is associated with a very large posterior probability of 79.56%. This allows us to conclude that the presence of the leverage bias is most probably related to the level of cognitive sophistication and inattention of the subjects, rather than risk aversion or financial experience (measured either as sophistication or as education).

Table 5: Likelihood of the regression models in Table 4

| | $Log(ML)$ | $P(M)$ | $P(M\|Y)$ |
|---|---|---|---|
| Model 1: CRT score | -33.2098 | 0.25 | .7956 |
| Model 2: Risk aversion | -36.7952 | 0.25 | .0221 |
| Model 3: Financial sophistication | -35.1902 | 0.25 | .1072 |
| Model 4: Financial education | -35.5684 | 0.25 | .0752 |

$Log(ML)$: logarithm of marginal likelihood; $P(M)$: prior probability; $P(M|Y)$: posterior probability.

In fact, results in Table 6 show that unbiased subjects have an average CRT score – i.e. the number of correct answers – equal to 1.81, compared to 1 of the biased group. We also report the within-group distribution of subjects: the percentage of subjects answering 0 correct questions is much larger in the biased group (43.86%), while the percentage of subjects obtaining the highest score, thus providing all correct answers, is significantly greater within the unbiased group (45.45%). These results suggest that, realtive to unbiased participants, biased subjects are System 1 type of thinkers, with a greater tendency to abide by the spontaneous but wrong answer that first comes to mind when reading the question (Frederick, 2005).[9] Therefore, the leverage bias seems related to lower cognitive sophistication and a tendency to avoid the attentive effort associated with the deliberate thinking of System 2 – which indeed takes up a great deal of attention (Toplak et al., 2014) – in favor of an intuitive and automatic type of thinking, which instead consumes little or no attentional resources (Kihlstrom, 1987; Moritz et al., 2014). In general, the literature in psychology highlights the existence of a significantly positive correlation between a variety of measures of individual cognitive abilities and attention of different types (see, among others, Allred et al., 2016; Aschersleben et al., 2008; Barrett et al., 2004; Ben-Shakhar and Sheffer, 2001; Dukas, 2004). In fact, attentional neglects can often explain the poor performance in cognitive sophistication tasks (Allred et al., 2016; Dukas, 2004).

## 2.3 Attitudes towards debt and consumption

The final part of the experiment introduces a survey devoted to assessing the relation between the leverage bias, perceived wealth and subjects' attitudes towards debt and

[9] We also find that CRT score is positively correlated with risk aversion (see Appendix 4 for all relevant coefficients) – a result that may contribute to the literature on the relationship between cognitive abilities and risk attitudes, which reports mixed evidence. Some works (e.g. Dohmen et al., 2010) find greater willingness to take risk in subjects with greater scores in widely used IQ tests; others, like Andersson et al. (2016), generate both negative and positive correlations between risk aversion and cognitive abilities, thus concluding that these are related mostly to random decisions rather than risk preferences. Finally, Taylor (2013) show that the correlation depends on whether risk choices are hypothetical or real. We also find that risk aversion negatively correlates with financial education, adding to the existing evidence that higher financial literacy corresponds to a higher willingness to take riskier financial decisions (e.g. Bianchi, 2018; Black et al., 2018).

Table 6

Scores in CRT

| | *Average score* | *Correct answers* | | | |
|---|---|---|---|---|---|
| | | 0 | 1 | 2 | 3 |
| Biased | 1<br>[1.05] | 43.86% | 22.81% | 22.81% | 10.53% |
| Unbiased | 1.81<br>[1.25] | 18.18% | 27.27% | 9.09% | 45.45% |

Average score (standard error in brackets) and distribution of subjects per correct answers in the Cognitive Reflection Test (CRT).

consumption.[10] For the sake of simplicity we divide the set of questions and the discussion of the results in two groups: first we discuss debt behavior and then we focus on consumption.

### 2.3.1 Debt

In order to have a general evaluation of attitudes towards debt, we rely on a question from the 2016 Survey of Consumer Finances by asking participants whether they think it is a good idea to finance expenses by borrowing. There are three possible answers: "Good idea", "Good in some ways, bad in others" and "Bad idea". Even though this question does not allow to discriminate among different types of debt, it is generally considered a good proxy of personal attitudes towards the use of credit for consumption and it has been used as a measure of debt aversion in other works (see, e.g. Chien and Devaney, 2001; Stango and Zinman, 2009).

We also evaluate subjects' approach to credit when they are faced with financial difficulties. In particular, we introduce the following question that allows to test whether the leverage bias predicts the use of credit when struggling with payments: "If tomorrow you experienced a financial emergency that left you unable to pay all of your bills, how would you deal with it?" The set of possible answers includes "borrow money", "spend out of savings", "postpone payments" and "cut back". Although the answer "borrow money" does not mention a specific type of loan, people who find themselves in a cash crunch often tend to make unsound financial decisions by relying on payday loans and other expensive forms of unsecured credit (Bertrand and Morse, 2011; Mullainathan and Shafir, 2014; Shah et al., 2012).

Finally, we dig deeper into the potential link between the leverage bias and attitudes towards debt, by including a question that draws on the so-called "reported preference" approach (Fuster et al., 2018; Parker and Souleles, 2017). This relies on reported changes in borrowing (or spending) in hypothetical scenarios, elicited by means of survey questions, thus allowing a great amount of flexibility in treatment design (Fuster et al., 2018). In particular, we test the relationship between the leverage bias (and, in turn, perceived wealth) and the likelihood to take on debt for consumption, by presenting participants with a hypothetical situation in which they want to buy a product but, due to the lack of liquid assets, they have to borrow. Subjects are also shown two financial profiles with identical net worth but different balance sheet composition and they are asked to state

[10] Appendix A contains the complete list of questions presented in the survey.

Table 7

Debt aversion

| | *Averse* | *Seeker* | *Neutral* |
|---|---|---|---|
| Biased | 12.28% | 43.86% | 43.86% |
| Unbiased | 36.36% | 9.09% | 54.55% |

Averse: spending by borrowing is a bad idea; Seeker: spending by borrowing is a good idea; Neutral: spending by borrowing is good in some ways, bad in others.

under which of the two profiles they would be more likely to borrow €500 to buy the item (a new television). The question is adapted from Sussman and Shafir (2012) but, differently from the original setup, we give subjects the possibility to state that they would borrow under either or neither profile. This allows to identify either aversion to debt (not borrowing under any profile) or neutrality to the balance sheet composition (borrowing under any profile). The question is repeated twice, once with positive net worth and once with negative net worth.

In general, this question is intended to explore the idea that the leverage bias leads to perceptions of wealth that impact the propensity to finance spending by borrowing. If greater perceived wealth were in fact associated with a higher likelihood to take on debt, biased subjects should indicate that they would borrow under the profile with greater asset-debt ratio (HRP). On the contrary, unbiased subjects should be more likely to make a decision that is indifferent to the composition of the balance sheet, given the net worth.

An important remark has to do with the following concern: Do reported preferences have little informative content as to what individuals would do if faced with actual decisions to borrow (or spend)? Fuster et al. (2018) point to the comprehensive analysis carried out by Parker and Souleles (2017) and Parker et al. (2013): the former show that comparing reported consumption responses to hypothetical tax rebates with actual spending responses from past tax rebates, produces very little differences; the latter, found that reported preferences match actual behavior, in that subjects who reported spending their 2008 fiscal stimulus payment did in fact do so. These considerations support the idea that reported preferences, in hypothetical scenarios, may provide significant indications of individual behavior in actual decision-making contexts.

*Findings on general attitudes towards debt.* While a substantial share of both biased and unbiased subjects report that spending by borrowing is neither good nor bad, subjects with the leverage bias seem more comfortable with the idea of debt-financed consumption. Table 7 indeed shows that debt aversion – i.e., stating that borrowing for consumption is a bad idea – is markedly lower for biased subjects (12.28%) compared to unbiased ones (36.36%).

In order to assess the predictive capacity of the leverage bias on general attitudes towards debt for consumption, we run a Bayesian multinomial logistic regression. Once again, we assume that the leverage bias has no predictive power over attitudes towards debt by setting a neutral $N(0,1)$ prior on the coefficient of the bias dummy. We find a significant deviation from our prior: the marginal effects reported in Table 8 indicate that being biased reduces the probability of being debt averse by roughly 18%, while increasing by 24% the probability of being "debt seeker" – i.e. stating that spending by

Table 8

Effect of the leverage bias on borrowing attitudes

| | *Averse* | *Seeker* | *Neutral* |
|---|---|---|---|
| Marginal effect | -.1783 | .2419 | -.0851 |
| 68% HPDI | [-.2381 -.1119] | [.1970 .2991] | [-.1932 -.0350] |
| Controls | Yes | Yes | Yes |
| Sample size | 68 | 68 | 68 |

Marginal effects from a Bayesian logistic regression of the measure of attitudes towards debt on a dummy equal to 1 if the subject is biased. The regression includes age, gender dummy, family size and family education level as covariates.
Prior $N(0, 1)$ on all model coefficients. Random-walk Metropolis-Hastings sampling with 100000 MCMC sample size.
Values in parentheses are 68% highest posterior density intervals.

borrowing is a good idea.[11] These results suggest that the leverage bias corresponds to a positive attitude towards credit-financed consumption and a lower aversion to debt.

Table 9

Reaction to a financial emergency

| | Borrow | Use savings | Postpone | Cut | Other |
|---|---|---|---|---|---|
| Biased | 43.86% | 14.04% | 7.02% | 33.33% | 1.75% |
| Unbiased | 9.09% | 36.36% | 9.09% | 36.36% | 9.09% |

Borrow: "Borrow money"; Use savings: "Spend out of savings"; Postpone: "Postpone payments"; Cut: "Cut back"; Other: "Other".

*Attitudes in a financial emergency.* Table 9 shows that a large number of subjects with the leverage bias feel comfortable with the idea of using debt to cope with the necessity of paying overdue bills (43.86%), while most of unbiased subjects choose to use their savings or to cut other expenses (72.72% in total). We run a Bayesian multinomial logit in order to evaluate the change in the predicted probability of each outcome associated with the leverage bias. In particular, we regress the set of responses to the hypothetical financial emergency on a dummy equal to 1 if the subject is biased. As in the previous analysis, we impose a Normal prior with zero mean and variance equal to 1 on the coefficient of the dummy. Table 10 shows that the leverage bias is associated with a 26.52% increase in the probability of borrowing money in case of financial difficulties, while reducing the probability to rely on own savings by 19% approximately. The key findings from this question therefore points to the existence of a relation between the leverage bias and the tendency to rely on credit in case of financial difficulties.

*Perceived wealth and borrowing for consumption.* In order to investigate the relationship between the leverage bias, perceived wealth and the likelihood to take on debt for consumption in a hypothetical scenario, we combine data from the answers to both the positive and negative net worth case and we classify the agents in three groups: Group 1

[11] All tables reported in this Section include age, gender, family size and family education as controls. Appendix 4 reports the tables of all regressions with no controls.

Table 10

Effect of the leverage bias on reactions to financial emergency

| | Borrow | Use savings | Postpone | Cut | Other |
|---|---|---|---|---|---|
| Marginal effect | .2652 | -.1945 | -.0169 | -.0399 | -.0190 |
| 68% HPDI | [.2257 .3177] | [-.2460 -.1351] | [-.0525 .0326] | [-.1015 .0248] | [-.0256 .0010] |
| Controls | Yes | Yes | Yes | Yes | Yes |
| Sample size | 68 | 68 | 68 | 68 | 68 |

Marginal effects from a Bayesian logistic regression of reactions to a financial emergency on a dummy equal to 1 if the subject is biased. The regression includes age, gender dummy, family size and family education level as covariates.
Prior $N(0,1)$ on all model coefficients. Random-walk Metropolis-Hastings sampling with 100000 MCMC sample size.
Values in parentheses are 68% highest posterior density intervals.

includes all subjects who choose HRP, namely the profile with greater asset-debt ratio; Group 2 features all subjects who are neutral to the composition of the balance sheet, that is those who would borrow under any of the two profiles, and those that are averse to debt and would not borrow at all; Group 3 gathers subjects with any other combination of answers (e.g. those who would borrow under any profile in the positive net worth case but choose HRP in the negative net worth case).

Table 11

Likelihood to take on a loan for consumption

| | *Group 1* | *Group 2* | *Group 3* |
|---|---|---|---|
| Biased | 75.44% | 14.04% | 10.53% |
| Unbiased | 9.09% | 72.73% | 18.18% |

Group 1: subjects choosing the profile with greater asset-debt ratio; Group 2: subjects choosing "I would take the loan under any profile" and "I would not take the loan under any profile"; Group 3: all other combinations.

Table 11 reports that an overwhelming majority (roughly 75%) of subjects with the leverage bias belong to the first group. In other words, biased subjects favor borrowing under HRP, both when net worth is positive and when is negative. On the contrary, a large majority of unbiased subjects belong to the second group, thus pointing to a substantial neutrality of their debt behavior with respect to the composition of the balance sheet, for a given level of net worth. Also in this case, we run a Bayesian multinomial logistic regression in which we regress the group variable on the bias dummy, by imposing a Normal prior with zero mean and variance equal to 1. Table 12 shows that being biased increases the probability of belonging to the first group by 37.11%, while reducing that of being a member of group 2 by 34.32%. Therefore, the pattern of answers that we observe seems to confirm the interaction between the leverage bias and the likelihood to take on debt: biased subjects generally favor borrowing under HRP, that is when their perceived wealth is higher, while unbiased subjects either tend to avoid the use of credit or are generally indifferent to the composition of the balance sheet. In fact, it is important to note that among unbiased subjects in group 2, the ratio between those who indicate that they would not take the loan under any profile and those who say they would take the

Table 12

Effect of the leverage bias on the likelihood to take on debt

| | *Group 1* | *Group 2* | *Group 3* |
|---|---|---|---|
| Marginal effect | .3711 | -.3432 | -.0640 |
| 68% HPDI | [.3251 .4240] | [-.3997 -.2869] | [-.1049 -.0098] |
| Controls | Yes | Yes | Yes |
| Sample size | 68 | 68 | 68 |

Marginal effects from a Bayesian logistic regression of group belonging on a dummy equal to 1 if the subject is biased. The regression includes age, gender dummy, family size and family education level as covariates.
Prior $N(0,1)$ on all model coefficients. Random-walk Metropolis-Hastings sampling with 100000 MCMC sample size.
Values in parentheses are 68% highest posterior density intervals.

loan in any case, is 2 to 3. That is, a substantial majority of unbiased subjects are averse to the idea of taking on debt to consume, consistent with the answers reported in the previous questions on attitudes towards debt.

Summing up our key findings on attitudes towards debt:

- Biased subjects are less debt averse than unbiased subjects, as they feel significantly more comfortable with the idea of borrowing to finance consumption.
- Results confirm the predictive power of the leverage bias on the likelihood to rely on credit as a means to deal with overdue payments. While we do not specify credit conditions, borrowing in a context of financial difficulty may often trigger a perverse spiral with increasing costs of debt (Bertrand and Morse, 2011; Mullainathan and Shafir, 2014; Shah et al., 2012)
- The leverage bias corresponds to a markedly larger tendency to borrow under profiles that have greater asset-debt ratio. This confirms that, for a given net worth, biased subjects feel wealthier for higher values of the asset-debt ratio and this entails a greater likelihood to take on debt for consumption. On the contrary, unbiased subjects correctly perceive the two profiles as fungible, thus making choices that are independent of the balance sheet composition. Moreover, consistent with the results from the first question, unbiased subjects generally oppose the idea of credit-financed spending.

### 2.3.2 Consumption

We start by investigating the relationship between the leverage bias and attitudes towards savings and their time preference. We do so by asking participants whether they self identify as "the type of person that prefers to spend money and enjoy it today or save more for the future", with a binary choice: "spend now" and "save for the future". Parker (2017) uses this question in a survey as a proxy of the patience/impatience of the subjects. He shows that answers to this question strongly predict consumption behavior, in that people who report being "spenders" do not smooth consumption and have a significantly larger spending response to predictable lump-sum payments, compared to people who self-identify as "savers".

Does the leverage bias predict the likelihood to increase spending out of unexpected gains? In order to test the relationship between the bias and consumption behavior, we modify the question introduced by Fuster et al. (2018) to describe an hypothetical scenario in which subjects unexpectedly receive a one-time payment and they are asked to indicate what they would do in the following month. Agents can choose among three options: i) they can increase spending more than if they had not received the payment; ii) they can decrease spending; or iii) they can keep it unchanged. Compared to Fuster et al. (2018), we repeat the question only twice: first, with a €500 payment; then, with €5000. However, in order to test the relationship between perceived wealth and the likelihood to increase spending, we also introduce a third question with a €500 payment, in which each subject is shown two financial profiles with identical net worth but different balance sheet composition. Subjects are eventually asked to state under which of the two profiles they would be more likely to increase their expenses in the following month. They have the possibility to state that they would increase their expenses in either, or neither, case. If greater perceived wealth were linked to a higher likelihood to increase spending out of unexpected gains, biased subjects should choose HRP, while unbiased subjects should make a decision that does not depend on the composition of the balance sheet, given the value of the net worth.

In all three questions, subjects who would increase their expenses are eventually asked the exact amount. This allows us to estimate marginal propensities to consume out of unexpected gains, similar to Fuster et al. (2018).

Table 13

Saving type (patience)

| | *Patient* | *Impatient* |
|---|---|---|
| Biased | 31.58% | 68.42% |
| Unbiased | 81.82% | 18.18% |

Patient: "Save for the future"; Impatient: "Spend now".

*Findings on patience and saving type.* Table 13 shows a major difference between the share of patient and impatient subjects within each of the two groups. In fact, a large majority of biased subjects report being the type of person that is more prone to spend and enjoy the present (68.42%), while the majority of unbiased subjects self-identify as savers (81.82%). In Table 14 we report the marginal effects from a Bayesian logit model in which we regress a dummy for patience on the bias dummy. We impose a neutral $N(0,1)$ prior on the coefficient of the dummy. We find a significant departure from the prior. Indeed, results confirm the strong predictive power of the leverage bias over the measure of impatience, in that being biased is associated with a 39% increase in the probability of being the type of person that spends now and enjoys the present.

*Spending out of unexpected gains.* Table 15 suggests that biased subjects are generally more prone to increase spending out of an unexpected gain of €500 compared to subjects with no leverage bias (54.39% vs. 18.18%). However, when we increase the amount of the windfall from €500 to €5000, the share of subjects who would increase their consumption rises in both groups (63.16% for biased agents and 45.54% for unbiased ones). This result is in line with the findings by Fuster (2018), who finds a size effect which leads respondents to be more willing to increase spending when the size of the windfall increases.

Table 14

Effect of the leverage bias on impatience

| | |
|---|---|
| Marginal effect | .3901 |
| 68% HPDI | [.3455 .4462] |
| Controls | Yes |
| Sample size | 68 |

Marginal effects from a Bayesian logistic regression of the measure of attitudes towards debt on a dummy equal to 1 if the subject is biased. Controls include age, gender dummy, family size and family education level as covariates.
Prior $N(0,1)$ on all model coefficients. Random-walk Metropolis-Hastings sampling with 100000 MCMC sample size.
Values in parentheses are 68% highest posterior density intervals.

Table 15

Spending out of unexpected gains

| Gain | | Biased | | | Unbiased | |
|---|---|---|---|---|---|---|
| | Less | Same | More | Less | Same | More |
| €500 | 3.51% | 42.11% | 54.39% | 9.09% | 72.73% | 18.18% |
| €5000 | 1.75% | 35.09% | 63.16% | 9.09% | 45.54% | 45.54% |

Less: "I would spend less than if I had not received the €500"; Same: "I would spend the same as if I had not received the €500"; Less: "I would spend more than if I had not received the €500". Repeated also for €5000.

We also find that the rise in the share of subjects who would increase their spending is larger among unbiased subjects (about 27 percentage points against an increase of about 9 percentage points for biased subjects), thus narrowing the gap between the two groups (from about 36 percentage points to about 18 percentage points).

Table 16 reports the marginal effects from the Bayesian logit model in which we regress the type of spending response on the bias dummy, both in €500 and the €5000 case. As in all other regressions we impose a neutral $N(0,1)$ prior. The results clearly show that subjects with the leverage bias have a larger probability of increasing their expenses when receiving unexpected income in both scenarios (21.84% and 11.65% respectively).

Table 17 reports the average marginal propensity to consume (MPC) for both biased and unbiased subjects, conditional on spending more. Also in this case we find a size effect, such that an increase in the amount of the windfall decreases the average MPC of both groups. Nonetheless, biased subjects seem to have a more pronounced reaction to unexpected positive income shocks in both scenarios, thus suggesting lower consumption smoothing compared to unbiased subjects.

We finally analyze the results from our very last question, in which we replicate the €500 scenario with the introduction of two profiles with equal (positive) net worth but different values of assets and liabilities. Table 18 shows that biased subjects are much more likely to increase their expenses under the profile with higher asset-debt ratio (71.93%), while unbiased subjects seem neutral to the amount of assets and liabilities (81.82%). In particular, within unbiased subjects in the group classified as neutral we find that 44.44% state that they would increase their expenses in any case, while 55.56%

Table 16

Effect of the leverage bias on spending response

| | *Less* | *Same* | *More* |
|---|---|---|---|
| Marginal effect, €500 scenario | .0028 | -.2144 | .2184 |
| 68% HPDI | [-.0122 .0241] | [-.2756 -.1633] | [.1706 .2757] |
| Marginal effect, €5000 scenario | -.0195 | -.1021 | .1165 |
| 68% HPDI | [-.0261 .0029] | [-.1604 -.0440] | [.0599 .1708] |
| Controls | Yes | Yes | Yes |
| Sample size | 68 | 68 | 68 |

Marginal effects from a Bayesian logistic regression of spending responses on a dummy equal to 1 if the subject is biased. The regression includes age, gender dummy, family size and family education level as covariates.
Prior $N(0,1)$ on all model coefficients. Random-walk Metropolis-Hastings sampling with 100000 MCMC sample size.
Values in parentheses are 68% highest posterior density intervals.

Table 17

Marginal propensities to consume

| | Biased | Unbiased |
|---|---|---|
| €500 | .38 | .32 |
| | [.147] | [.113] |
| €5000 | .23 | .20 |
| | [.195] | [.188] |

Average hypothetical marginal propensities to consume (conditional on spending more) out of €500 and €5000 for biased and unbiased subjects.
Standard errors in brackets.

would not do so, regardless of the composition of the balance sheet. Results from the Bayesian logistic regression reported in Table 19 indicate that being biased increases the likelihood to rise consumption under HRP by 39.51 % while reducing by 4.58% the probability of increasing consumption regardless of the balance sheet composition.

Summing up:

- The leverage bias corresponds to a considerably larger probability of being a more impatient type of person, self-identifying as a spender, rather than a saver.
- The leverage bias also entails lower consumption smoothing and a greater response to unexpected positive income shocks. In fact, biased subjects are more likely to increase consumption out positive gains and the size of the spending reaction is larger compared to unbiased subjects.
- Similar to our question on credit-financed spending, a higher asset-debt ratio implies a greater value of perceived wealth, which leads to a higher likelihood to increase spending for subjects with the leverage bias. The majority of unbiased subjects,

Table 18

Spending out of unexpected gains for profile type

| | *HRP* | *LRP* | *Neutral* |
|---|---|---|---|
| Biased | 71.93% | 8.77% | 19.30% |
| Unbiased | 9.09% | 9.09% | 81.82% |

Percentage of subjects that would increase spending out of an unexpected gain under the high-ratio profile (HRP), low-ratio profile (LRP) and under any profile (or would not increase spending at all).

Table 19

Effect of the leverage bias on increase in consumption

| | *HRP* | *LRP* | *Neutral* |
|---|---|---|---|
| Marginal effect | .3951 | -.0458 | -.3570 |
| 68% HPDI | [.3465 .4550] | [-.0723 -.0040] | [-.4113 -.3134] |
| Controls | Yes | Yes | Yes |
| Sample size | 68 | 68 | 68 |

Marginal effects from a Bayesian logistic regression of profile selection on a dummy equal to 1 if the subject is biased. The regression includes age, gender dummy, family size and family education level as covariates.
Prior $N(0, 1)$ on all model coefficients. Random-walk Metropolis-Hastings sampling with 100000 MCMC sample size.
Values in parentheses are 68% highest posterior density intervals.

instead, do not increase consumption or state that they would increase it regardless of the balance sheet composition.

In general, our laboratory experiment highlights the existence a deviation from standard consumer theory and the predominance of a bias that, based on balance sheet composition, leads the majority uf subjects to have different perceptions associated with financially equivalent balance sheet profiles.

The key characteristics that seems to differentiate biased subjects from the rest is the lower level of cognitive reflection. The leverage bias is related to a type of thinking that is fast, intuitive and makes limited use of attention.

Finally, the leverage bias predicts low debt aversion and a greater tendency to rely on credit as a means to finance consumption and react to a financial emergency. The bias also correlates with a positive spending reaction to unexpected gains, thus predicting lower consumption smoothing compared to unbiased individuals.

# 3 A model of behavioral inattention

In this section we introduce a simple two-period optimal consumption model that aligns our main experimental results. The model allows to compare two types of agents: (i) a standard rational agent, representing unbiased subjects in our experiment, who will be the benchmark of the model; (ii) a behavioral agent à la Gabaix (2014, 2019), who has a wrong perception of her wealth due to low cognitive sophistication and inattention. This agent therefore represents biased subjects. In particular, our behaviorally inattentive agent has the following distinctive characteristics:

- In line with the sparse-max operator, as described in Gabaix (2014, 2019), the optimization problem for this individual consists of a two-step problem. In the first step, the agent builds a perceived value of her total net wealth by choosing the optimal amount of attention to allocate to the problem; eventually, she chooses the optimal consumption level, conditional on her perception of wealth. Consumption allocation is therefore the outcome of a process endowed with procedural rationality but no substantive rationality (Simon, 1978), as the agent's consumption decision is not determined exclusively by the characteristics of the environment but, rather, by her perception of it.
- As in Dual Process Theory (Kahneman, 2003a,b, 2011; Stanovich and West, 2003), the agent's action is the result of the interaction between System 1 and System 2. Specifically, for a given value of wealth, the agent's System 1 generates a noisy representation, whose value depends positively on the magnitude of the asset-debt ratio – in line with the leverage bias found in the experiment. However, since attention is cognitively costly, the level of cognitive sophistication of the agent determines the optimal amount of attention allocated to the true value of wealth, thereby establishing whether perceived wealth is ultimately closer to the true level or to the noisy representation of it.
- In line with our experimental results, the biased agent is characterized by a predominance of System 1 and a low level of cognitive sophistication. Hence, she does not allocate full attention to the true value of her wealth. This results in a perceived level of wealth that is higher than the actual value.

## 3.1 Rational (unbiased) agent

Let us start by describing the behavior of the rational agent. We assume a well-behaved utility function, such that the rational agent chooses consumption allocation optimally by maximizing her utility subject to the budget constraint in period one and in period two. Hence, she solves the following problem:

$$\max U(c_1, c_2) = U(c_1) + \beta U(c_2) \tag{1}$$

s.t.

$$\begin{cases} c_1 = y_1 + b & (2) \\ c_2 + (1+r)b = y_2 & (3) \end{cases}$$

where $c_t$ $(t = 1, 2)$ identify consumption in each period, while $y_t$ $(t = 1, 2)$ represents the endowment in each period. In particular, $y_1$ is assumed to be determined by two components: the actual income received in period 1 ($\hat{y}_1$) and an inherited stock of net wealth ($NW$) composed of assets ($A$) and debt ($D$), so that $y_1 = \hat{y}_1 + NW$, where $NW = A - D$. Finally, $r$ is the real interest rate and $b$ is either savings, if positive, or debt, if negative. Hence, the agent total (net) wealth is $w = y_1 + \frac{y_2}{1+r}$, while the intertemporal budget constraint is

$$c_2 = (1+r)(y_1 - c_1) + y_2 \tag{4}$$

The optimization problem yields the standard Euler Equation:

$$\frac{U'_{c_1}}{U'_{c_2}} = \beta(1+r) \tag{5}$$

By combining Equations 4 and 5, we find the optimal consumption levels for the rational agent, which will be a function of the interest rate and the total net wealth of the agent. In the following we will refer to optimal consumption allocation for the rational agent in period one and period two with $c_1^*(r, y_1, y_2)$ and $c_2^*(r, y_1, y_2)$ respectively.

## 3.2 Biased agent

We model the behavior of the biased agent after the behavioral inattention setup introduced by Gabaix (2014). In particular, the agent faces the standard optimization problem, but she solves it in two steps according to the sparse-max operator Gabaix (2014, 2019): first, she decides the optimal amount of attention to allocate to the problem, so as to form a perceived value of wealth; eventually, in the second step, the agent chooses the optimal consumption allocation of the two periods, conditional on her perception.

Due to her lower level of cognitive sophistication, the agent does not pay full attention to the problem, so that her perceived wealth does not correspond to the actual wealth. As a consequence, her consumption allocation will differ from that of the rational agent. In the following we provide the details.

### 3.2.1 Behavioral inattention

The biased agent's actual net wealth is the same as the rational agent, that is $w = y_1 + y_2/(1+r)$. We assume that her perceived wealth is $w^s = y_1^s + y_2/(1+r^s)$, where the $^s$ superscript represents perceived (or *sparse*) values. Hence, the agent's perceived wealth deviates from her actual wealth due to a sparse representation of the endowment of period 1 and the interest rate.[12]

$y_1^s$ and $r^s$ are defined as the following convex combinations:

$$y_1^s = m_1 y_1 + (1 - m_1) y_1^d \tag{6}$$
$$r^s = m_2 r + (1 - m_2) r^d \tag{7}$$

Variables with the $^d$ superscript are individual default values, which identify the guess that spontaneously comes to mind with no time to think (Gabaix, 2014), or under limited cognitive resources. In Bayesian terms, the default could also be interpreted as the prior generated by System 1, which, being fast and inattentive, produces an inaccurate guess. The parameter $m_i \in [0, 1], \forall i = 1, 2$, is a measure of attention, such that $m_i = 1$ implies full attention, while $m_i = 0$ implies no attention. Any value $0 < m_i < 1$ implies an inaccurate perception of the true value of the corresponding variable. When $m_i$ increases,

[12]Notice that one could obtain similar qualitative results by applying sparsity on $y_2$ or other combinations of the components of wealth. However, our choice leads to an analytically simpler solution without altering the conclusions.

the agent relies less on the default and more on the true value, as System 2 takes over System 1.

As a microfoundation, we model the default values as the true values altered by a distortion factor:[13]

$$
\begin{aligned}
y_1^d &= y_1 + g_{y_1} && (8)\\
r^d &= r - g_r && (9)
\end{aligned}
$$

where $g_{y_1}$ and $g_r$ represent the distortion in the priors generated by System 1. Specifically, we describe $g_{y_1} = \psi A/D$, with $\log \psi \sim N(0, \eta)$ and $g_r = \gamma A/D$, with $\gamma \sim Beta(\alpha, \beta)$. Equations 8 and 9 imply $y_1^d > y_1$ and $r^d < r$, which guarantee $w^s > w$, for any $m_i < 1, \forall i = 1, 2$. That is, we assume that System 1 generates an inaccurate guess on the value of the endowment that exceeds its true value and the magnitude of the deviation of $y_1^d$ ($r^d$) from $y_1$ ($r$) depends on the level of the asset-debt ratio. This captures the essence of a key experimental finding, namely the leverage bias: for a given value of total net wealth, a greater asset-debt ratio impacts positively on the mental representation of wealth. In other words, the higher it is the asset-debt ratio, the more the agent's default deviates from the actual value of the variable and in turn, the more the individual's perceived welath will deviate from actual wealth.

By combining Equations 6 with 8, and 7 with 9, we obtain:

$$
\begin{aligned}
y_1^s &= y_1 + (1 - m_1) g_{y_1} && (10)\\
r^s &= r - (1 - m_2) g_r && (11)
\end{aligned}
$$

In words, the overall biased perception of wealth is determined by two factors:

- One is the noisy representation of the true values generated by System 1, which, in turn, depends on the magnitude of the asset-debt ratio. In line with the leverage bias found in the experiment, a greater asset-debt ratio increases the value of the fast and inaccurate guesses produced by the less sophisticated mental process of System 1.

- The other is the optimal level of attention $m_i^*$, which may be interpreted as the outcome of the interaction between System 1 and System 2, as in dual process theory (Kahneman, 2003a,b). In a sophisticated agent, System 2 fully overtakes System 1 so that $m_i = 1, \forall i = 1, 2$. The agent is therefore rational and fully attentive, thereby having an unbiased perception that corresponds to the true value of wealth. On the contrary, in an agent with poor cognitive sophistication, System 1 prevails and $m_i$ tends to zero. This agent is rational but inattentive, thus having

[13] As suggested by Gabaix (2019), one could in fact interpret the partially correct perception of the variable as the outcome of a signal extraction process. Khaw et al. (2017, 2019) propose that judgments and choices be based on noisy mental representation of the situation and this involves an average bias in the optimal rule for forming such judgments and making these choices. In fact, "if there were no random noise in the internal representations on which the judgments are based, there should (if the subject forms optimal Bayesian judgments) be no noise in perceptual judgments, and no bias either" (Khaw et al., 2019, p.4). This is philosophically analogous to our set up, in which there exists a strong link between the default values – i.e. the noisy sensory data generated by System 1 – and the perceptual representation of wealth.

a perceived value of wealth that relies on her default and diverges from the true level. The overall amount of the deviation therefore ranges between $[0, g_{y_1}]$ for $y_1$ and $[0, g_r]$ for $r$.

Following Gabaix (2014, 2019), we define the optimal level of attention ($m^*$) as given by a function with two additive components: the utility loss from imperfect attention and the psychological cost for the lack of sparsity.[14] Specifically:

$$m^* = \arg\min_{m\in[0,1]} \frac{1}{2}\sum_{i=1}^{2}(1-m_i)^2\Delta_{ii} + k(\theta)\sum_{i=1}^{2} m_i^\alpha \tag{12}$$

where $\Delta_{ii} := -\sigma_i^2 a_{x_i} U_{aa} a_{x_i}$ is the benefit that the consumer enjoys when her attention on dimension $i$ goes from zero to one. $U_{aa}$ is the second derivative of the utility function with respect to action $a$, while $a_{xi} := \frac{\partial a}{\partial x_i}$ identifies the marginal effect of a change in variable $x_i$ on the action (that is $-U_{aa}^{-1}U_{ax_i}$), evaluated at the default values of the action and the variable $x_i$.[15] In our set-up $x_i = [y_2, r]$ and $a = c_1$. When unable to observe the variable $x_i$, the agent uses the expected magnitude as a proxy, thus setting $\sigma_i = \mathbf{E}[x_i^2]^{1/2}$ and, trivially, $\Delta_{ii} := -\mathbf{E}[x_i^2]a_{x_i}U_{aa}a_{x_i}$. Finally, the function $k(\theta)$ is the penalty for the lack of sparsity, such that the term $k(\theta)m_i^\alpha$ represents the psychological cost of attention. We follow Gabaix (2014) and assume that $\alpha = 1$, so as to have both sparsity and continuity in the attention function. However, since attention is cognitively costly (Kahneman, 1973) and entails the allocation of scarce cognitive resources (Gabaix, 2019), we depart from the setup introduced in Gabaix (2014) by assuming that $k$ depends on the level of cognitive sophistication of the agent ($\theta$). In particular:

$$k(\theta) = \begin{cases} 0, & \forall\theta \geq \overline{\theta} \\ \in [0, k_{max}], k(\theta)' < 0 & \forall\theta < \overline{\theta} \end{cases} \tag{13}$$

where $\overline{\theta}$ represents a threshold in the level of cognitive sophistication, such that $\theta \geq \overline{\theta}$ corresponds to the rational agent, who is endowed with a level of cognitive reflection that corresponds to full attention and a correct perception of the true value of wealth. Nonetheless, biased subjects in our experiment have a greater tendency to rely on System 1, thus employing limited cognitive resources and attention. Hence, the case $\theta < \overline{\theta}$ corresponds to the biased agent, who has a low level of cognitive sophistication that entails a high cost of attention, low $m^*$ and a level of perceived wealth that exceeds the actual value.[16] We assume that for zero cognitive sophistication, $k(0) = k_{max}$ in order to avoid an infinitely positive cost of attention for an extremely cognitively unsophisticated agent.

From Equation 12 we obtain the optimal level of attention on dimension $i$ as a function of the cognitive cost $k(\theta)$, for a given $\Delta_{ii}$:

$$m_i^* = \max\left(1 - \frac{k(\theta)}{\Delta_{ii}}, 0\right) \tag{14}$$

[14]The interested reader is left to refer to Gabaix (2014) for a detailed explanation for this particular functional form.

[15]The default action corresponds to the optimal action under default values of $x$.

[16]The specific functional form of $k(\theta)$ in the interval $[0, k_{max}]$ for $\theta < \overline{\theta}$ is not relevant for the purpose of our analysis. For the sake of simplicity we assume it is a linear function.

where $\Delta_{11} := -\mathbf{E}[y_1^2]a_{y_1}U_{c_1c_1}a_{y_1}$ and $\Delta_{22} := -\mathbf{E}[r^2]a_rU_{c_1c_1}a_r$.

Figure 4.a plots the cognitive cost and optimal attention on $i$ as a function of the level of cognitive sophistication, for a given level of $\Delta_{ii}$. Specifically, for $\theta \in [0, \bar{\theta}]$, the cost for the lack of sparsity decreases in the interval $[k_{max}, 0]$ and, in turn, optimal attention increases in the interval $[0, 1]$. Hence $\lim_{\theta \to \bar{\theta}} k = 0$ and $\lim_{\theta \to \bar{\theta}} m_i^* = 1$. For $\theta > \bar{\theta}$ we have zero cost for the lack of sparsity and full attention. This last scenario, therefore, represents the case of the unbiased agent. Figure 4.b shows optimal attention on $i$ as a function of $\Delta_{ii}$ for different levels of cognitive sophistication $\theta$, with $\theta_1 > \theta_2 > \theta_3$. Given a level of cognitive sophistication and the corresponding cost of attention, a higher value of $\Delta_{ii}$ increases $m_i^*$ (Equation 14) as the benefit of attention is higher. For an agent with greater cognitive sophistication, the cognitive cost is lower. When $\theta = \bar{\theta}$, the cost of attention is zero and $m_i^* = 1$ for any value of $\Delta_{ii}$.

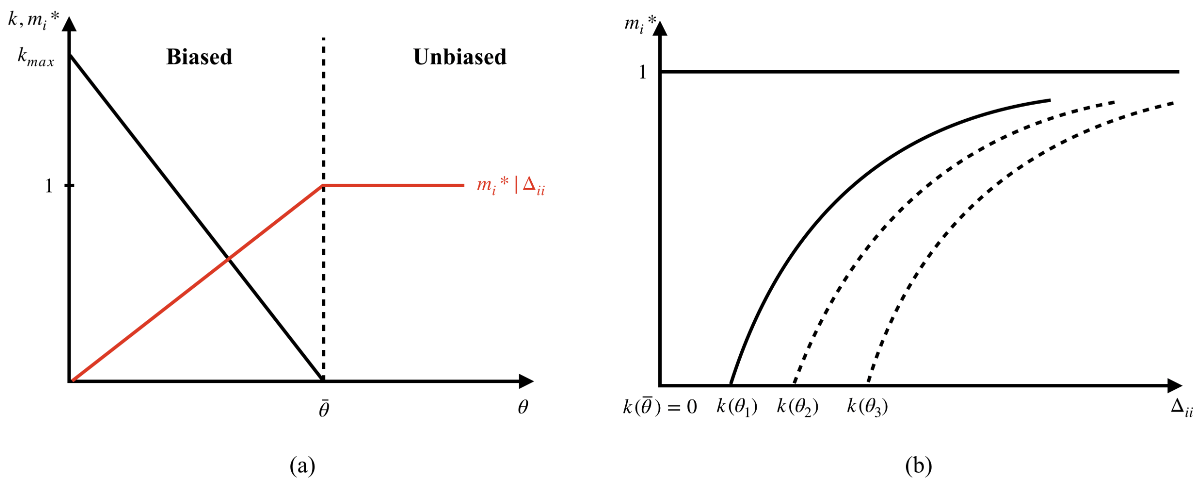



Figure 4: (a): attention cost ($k$, in black) and optimal attention ($m_i^*$, in red) as a function of the level of cognitive sophistication ($\theta$), for a given value of $\Delta_{ii}$. (b): optimal attention as a function of $\Delta_{ii}$, for different values of $\theta$.

Summing up, our set up incorporates the main features of the standard sparse-max operator introduced in the behavioral inattention model by Gabaix (2014, 2019). In fact, attention on each variable increases (1) when the magnitude of the variable is higher; (2) when the variable impacts more on the action $a$; (3) if an imperfect action leads to a greater cost. However, differently from the original set-up, the cognitive cost $k$ is a function of the level of cognitive sophistication of the agent and default values depend on the level of the asset-debt ratio. This allows to capture the following experimental results:

1. *The level of cognitive sophistication correlates with the misperception of wealth.* In the experiment, subjects with low CRT scores are more likely to be biased. In the model, when System 1 prevails over System 2, the agent is sparse and her level of cognitive sophistication is $\theta < \bar{\theta}$. Therefore, her attention is lower and she relies more on the inaccurate prior generated by System 1 (i.e. the default values of the variables).

2. *Perceived wealth increases for higher values of the asset-debt ratio.* The value of the fast and inaccurate prior of System 1 depends positively on the level of the asset-debt ratio. Therefore, for a given level of cognitive sophistication and attention,

a higher asset-debt ratio impacts positively on the perceived wealth of the biased agent.

### 3.2.2 Optimal action

After choosing attention optimally, the agent chooses the allocation of consumption conditional on her sparse representation of wealth. Hence, she solves the following problem:

$$\max U(c_1, c_2) = U(c_1) + \beta U(c_2)$$

s.t.

$$c_2 = (1 + r^s)(y_1^s - c_1) + y_2 \tag{15}$$

The Euler equation for the sparse agent therefore is:

$$\frac{U'_{c_1}}{U'_{c_2}} = \beta(1 + r^s) \tag{16}$$

From the problem above we find the optimal allocation of consumption conditional on the biased perception of wealth, $c_1^s(r^s, y_1^s, y_2)$ and $c_2^s(r^s, y_1^s, y_2)$. However, this allocation lies on the perceived budget constraint, which is different from the actual one. Therefore, the optimal allocation is not feasible.

As pointed out by Gabaix (2014), the sparse agent is behavioral but smart enough to exhaust the true budget constraint, thereby adjusting the allocation of consumption accordingly. Since the agent is biased, the adjusted allocation $(c_1^a, c_2^a)$ has to depend on the perceived value of wealth (i.e. $r^s$ and $y_1^s$) while also being feasible, so that $c_1^a + \frac{c_2^a}{1+r} = y_1 + \frac{y_2}{1+r}$. Therefore, we define an as-if intertemporal budget constraint as follows:

$$c_2^a = (1 + r^s)(y_1^s - c_1^a) + y_2' \tag{17}$$

Following Gabaix, the adjustment occurs by finding the value of $y_2'$ that guarantees that the adjusted allocation is feasible, i.e. it is along the true budget constraint. Hence, the following condition has to be satisfied:

$$c_1^a(r^s, y_1^s, y_2') + \frac{c_2^a(r^s, y_1^s, y_2')}{1 + r} = y_1 + \frac{y_2}{1 + r}. \tag{18}$$

Therefore, the biased agent solves the following problem:

$$\text{find} \quad y_2' \quad \text{s.t.} \quad C^a(r^s, y_1^s, y_2') = w \tag{19}$$

where $C^a(r^s, y_1^s, y_2')$ represents total adjusted consumption, that is the optimal allocation that is also feasible.

By combining the as-if intertemporal budget constraint (17) with condition 19, we can determine adjusted consumption in period one:

$$c_1^a = \frac{y_1(1+r) - y_1^s(1+r^s) - (y_2' - y_2)}{r - r^s} \tag{20}$$

Since $r - r^s > 0$, therefore $c_1^a > 0$ when:

$$y_2' < y_2 + y_1(1+r) - y_1^s(1+r^s) \tag{21}$$

Moreover, the sparse agent is a borrower if her adjusted allocation is such that in period one she wants to consume more than her wealth, i.e. $c_1^a > y_1$. This is true if:

$$y_2' < y_2 - (y_1^s - y_1)(1+r^s) \tag{22}$$

Since $r > r^s$, then it follows that condition 22 implies condition 21. Trivially, when the adjusted agent borrows, her consumption in period 1 is also positive. So, ultimately, condition 22 guarantees both $c_1^a > 0$ and that the agent is a borrower.

By substituting adjusted consumption in period 1 into the as-if intertemporal budget constraint, we can find the allocation of consumption in period two ($c_2^a$), that is:

$$c_2^a = \frac{(y_1^s - y_1)(1+r^s)(1+r) - y_2(1+r^s) + y_2'(1+r)}{r - r^s} \tag{23}$$

Adjusted consumption in period 2 is positive if:

$$y_2' > y_2 \frac{1+r^s}{1+r} - (y_1^s - y_1)(1+r^s) \tag{24}$$

Combining conditions 22 and 24, we obtain

$$y_2 \frac{1+r^s}{1+r} - (y_1^s - y_1)(1+r^s) < y_2' < y_2 - (y_1^s - y_1)(1+r^s) \tag{25}$$

This condition identifies the values of $y_2'$ that guarantee that both $c_1^a$ and $c_2^a$ are positive and that the biased agent is a borrower.

## 3.3 Rational vs. adjusted (sparse) allocation

We now compare the optimal consumption allocation of the rational agent with the adjusted allocation of the biased agent. Our goal is to identify the conditions under which the adjusted consumption of the biased agent in period 1 is greater than the consumption of the rational agent in the same period. In the following analysis we will focus on the case in which both agents are borrowers.

Let us consider the true intertemporal budget constraint and the as-if intertemporal budget constraint. We report them below for the reader convenience:

$$\begin{aligned} c_1 + \frac{c_2}{1+r} &= y_1 + \frac{y_2}{1+r} \\ c_1^a + \frac{c_2^a}{1+r^s} &= y_1^s + \frac{y_2'}{1+r^s} \end{aligned}$$

By substituting for $c_2$ and $c_2^a$ from the Euler equation of the rational agent and the sparse (adjusted) one and taking the difference at both sides, we get:

$$\phi(c_1^a, r, r^s) - \phi(c_1, r^s, r) = (1+r)(1+r^s)y_1^s + (1+r)y_2' - (1+r)(1+r^s)y_1 - (1+r^s)y_2$$

where $\phi(c_1^a, r, r^s) = (1+r^s)(1+r)c_1^a + (1+r)v\left[\frac{U'_{c_1^a}}{\beta(1+r^s)}\right]$, $\phi(c_1, r^s, r) = (1+r^s)(1+r)c_1 + (1+r)^s v\left[\frac{U'_{c_1}}{\beta(1+r)}\right]$ and $v = U'^{-1}$.

Notice that the right-hand side of the relation above is positive in order to guarantee $c_2^a > 0$ (see condition 24). Hence, also the left-hand side is positive. Therefore:

$$\phi(c_1^a, r, r^s) - \phi(c_1, r^s, r) > 0 \tag{26}$$

In order to find under which conditions the relation in Eq. 26 holds we assume a Constant Relative Risk Aversion (CRRA) utility function [17]. In appendix 4 we present and discuss in details all the derivations. With a CRRA utility function, our model captures also the following experimental results:

1. *The biased agent consumes more than the rational agent.* In fact, under the assumption of constant relative risk aversion, it is possible to show that:

$$c_1^a > c_1^* \iff y_2' > \frac{(1+r^s)\left[1+\beta^{\frac{1}{\varepsilon}}(1+r^s)^{\frac{1-\varepsilon}{\varepsilon}}\right]}{1+\beta^{\frac{1}{\varepsilon}}(1+r)^{\frac{1-\varepsilon}{\varepsilon}}}\left(y_1 + \frac{y_2}{1+r}\right) - (1+r^s)y_1^s \tag{27}$$

   Given that we have assumed $r > r^s$, then this condition is always satisfied, $\forall \varepsilon > 0$, and $c_1^a$ is always greater than $c_1^*$.[18]

2. *The biased agent has a greater propensity to consume out of unexpected gains.* That is, period-1 consumption of the biased agent has a positive and more pronounced response to unexpected changes in $y_1$ compared to the consumption of the rational agent in the same period. Indeed

$$\left(\frac{\partial c_1^a}{\partial y_1} > \frac{\partial c_1^*}{\partial y_1}\right) \equiv \frac{1}{1+\beta^{\frac{1}{\epsilon}}\frac{(1+r^s)^{\frac{1}{\epsilon}}}{1+r}} > \frac{1}{1+\beta^{\frac{1}{\epsilon}}\frac{(1+r)^{\frac{1}{\epsilon}}}{1+r}} \iff r > r^s \tag{28}$$

   This result aligns with our experimental finding, as biased subjects report a greater propensity to consume out of unexpected positive gains compared to unbiased subjects.

3. *The biased agent is less debt averse than the rational agent.* Since $c_1^a > c_1^*$, when the rational agent borrows (i.e. $c_1^* > y_1$), the biased agent borrows more. This result matches one of our experimental findings, namely biased subjects' lower aversion to debt and their positive attitude towards debt-financed consumption.

[17] Notice that such specification is in line with our experimental results. In fact, we do not find any correlation between the existence of the bias and agents' risk attitudes.

[18] See Appendix 4 for the derivation of Equations 27 and 28.

Finally, not only the model matches our experimental findings, but it also aligns existing evidence showing that, on average, household consumption responds significantly to unanticipated income shocks (Agarwal and Qian, 2014; Johnson et al., 2006). The size of the response is markedly higher compared to the estimates of standard economic models (Beshears et al., 2018), which typically predict excess consumption smoothing that is in contrast with the data (Gorbachev, 2011; Jappelli and Pistaferri, 2010). On the contrary, our model produces a pattern of consumption that, in the case of the biased agent, is characterized by greater volatility and lower consumption smoothing, with respect to the standard neoclassical benchmark.

## 3.4 Quantitative analysis

In this section we carry out two estimation exercises. First, we exploit the model and experimental data in order to estimate the relationship between cognitive sophistication and the balance sheet composition. In the second exercise, we also estimate the combinations of optimal attention and System 1 priors that yield the observed ratio between the marginal propensities to consume of the two types of subjects in the experiment.

We know that lower cognitive abilities result in a greater cost of attention (Equation 13) and, *ceteris paribus*, lower optimal attention on the variables of the problem (Equation 14). This leads the biased agent to rely more on the default values generated by System 1 and less on the true values (Equations 6 and 7). A biased subject with low cognitive sophistication should therefore be more sensitive to the level of the asset-debt ratio. AS such, we should expect a negative correlation between cognitive abilities and the sensitivity to the asset-debt ratio.

By using experimental data we test this relationship. In fact, the dispersion in the grades assigned by subjects to the profiles shown in PGT may be used as a proxy of the sensitivity of their perceptions to the asset-debt ratio, while individual CRT scores represent a measure of cognitive sophistication. Since unbiased subjects assign the same grade to all profiles, regardless of the balance sheet composition (for a given net worth), their optimal attention on all variables of the problem is equal to 1 and their sensitivity to the asset-debt ratio is zero for any level of cognitive sophistication $\theta$. This indeed implies no deviation of the perceived value of wealth from the true one. Instead, within the group of biased subjects we should observe a negative correlation between CRT scores and the variance of individual grades. Indeed, less cognitively sophisticated biased subjects – i.e. those with lower values of $\theta$ – pay lower attention to the true values and, therefore, should be more sensitive to the differences in the asset-debt ratios of the profiles.

We perform a Bayesian OLS regression of the variance of individual grades on CRT scores, by imposing the prior of neutrality $N(0, 1)$ on the coefficient. Our result in Table 20 indicates that an increase in the CRT score by one reduces the dispersion of the grades assigned by biased subjects by roughly 9%. This result confirms that the level of cognitive sophistication of biased subjects is inversely related to the sensitivity of individual perceptions to the asset-debt ratio in PGT. In other words, a biased subject with lower cognitive sophistication is more inattentive and, therefore, more sensitive to the composition of the balance sheet.

We carry out a second exercise, based on the results reported in Table 15. These imply that the MPC of unbiased subjects is 84.21% the MPC of biased subjects in the €500 case, while the ratio between the two MPCs is 86.95% in the €5000 case.

Under the hypothesis of constant relative risk aversion, the model yields the following

Table 20

Cognitive sophistication and asset-debt ratios

| | |
|---|---|
| Mean | -.0948 |
| Std. dev. | .1424 |
| 68% HPDI | [-.2425 .0386] |

Bayesian OLS regression of the variance of individual scores assigned to profiles in PGT (average across positive and negative net worth profiles) on CRT scores. Controls include: risk aversion, financial sophistication and financial education.
Random-walk Metropolis-Hastings sampling with 100000 MCMC sample size. Acceptance rate: 0.3933; average efficiency rate: 0.1187.
Prior $N(0,1)$ on all model coefficients.
Values in parentheses are 68% highest posterior density intervals.

ratio between the MPC (out of $y_1$) of the rational agent and that of the biased agent:

$$MPC_{ratio} = \frac{1 + \beta^{\frac{1}{\epsilon}}(1+r^s)^{\frac{1}{\epsilon}}(1+r)^{-1}}{1 + \beta^{\frac{1}{\epsilon}}(1+r)^{\frac{1}{\epsilon}}(1+r)^{-1}} \tag{29}$$

By means of the standard parametrization of $r$, $\beta$ and $\epsilon$ reported in Table 21, and given the definition of $r^s$ in Equation 11, we can find the combinations of $m_2^*$ and $g_r$ such that $MPC_{ratio} \in [84.21\%, 86.95\%]$. To this purpose, we randomly draw 1000 values of $m$ uniformly distributed in the interval (0,1). Since $g_r = \gamma A/D$, where $\gamma \sim Beta(\alpha, \beta)$, we also draw 1000 values of $\gamma$ from a $Beta(1,1)$ distribution, and we assume an asset-debt ratio equal to 2.51.[19] Hence, from Equation 11 we have in total 100000 values of the perceived interest rate $r^s$ and, consequently, of the MPC ratio in Equation 29.

Table 21

Parameters values

| | |
|---|---|
| $\beta$ | 0.99 |
| $\varepsilon$ | 0.8 |
| $r$ | 0.04 |
| $m$ | 1000 values from $U(0,1)$ |
| $A/D$ | 2.51 |
| $\gamma$ | 1000 values from $Beta(1,1)$ |

Figure 5 (left) shows all the values of the MPC ratio that correspond to the simulated pairs of $g_r$ and $m_2^*$. The area in black corresponds to all combinations of $g_r$ and $m_2^*$ where the MPC ratio is not defined. Outside this area, the MPC ratio ranges between 50.07% and 99.99%. Note that, since the value of $r^s$ is always lower than $r$ by assumption, the MPC ratio is always lower than one.

The figure on the right highlights the values of the MPC ratio that fall within the interval $[.8421, .8695]$ found in the experiment. This corresponds to maximum values of $m_2^*$ and $\gamma$ equal to 0.91 and 2.51 respectively, as well as to minimum values equal to 0 for

[19] The value of the asset-debt ratio equals the average ratio of the profiles shown to subjects in PGT.

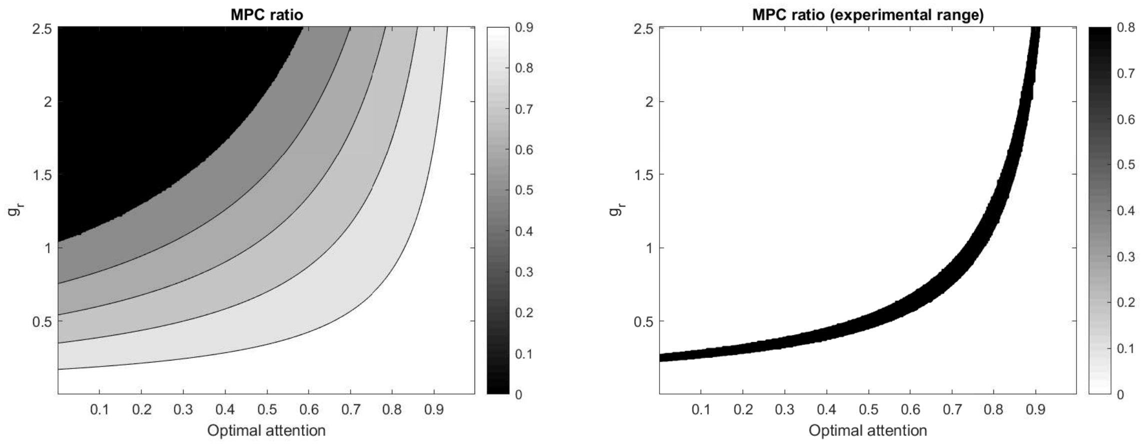



Figure 5: Left: Values of MPC ratio corresponding to any pair of $m$ and $g_r$. Right: Pairs of $m$ and $g_r$ corresponding to values of the MPC ratio in the interval $[.8421, .8695]$.

$m_2^*$ and 0.27 for $\gamma$. Hence, the figure shows that lower values of optimal attention allow to obtain the MPC ratio that ranges in the values observed in the experiment, only as long as the prior generated by System 1 – i.e. the default value of the interest rate – does not differ substantially from the true value. This indeed guarantees a perceived value of the interest rate, $r^s$, such that $MPC_{ratio} \in [84.21\%, 86.95\%]$.

# 4 Conclusion

By means of a laboratory experiment, we test the existence of different levels of perceived wealth associated with financially equivalent balance sheet profiles in a controlled environment. We find that, the majority of subjects give different evaluations of balance sheet profiles with equal net worth, but different levels of assets and debt, even though these are non-interest bearing, risk-free and financially certain. This points to a violation of standard consumer theory and the fungibility of money: balance sheet composition matters for the perception of wealth. In particular, the prevailing emerging pattern is the *leverage bias*, which consists in a strong preference for profiles that have greater asset-debt ratios. Our findings in the first two tasks of the experiment indeed suggest that perceived wealth, for a given net worth, is an increasing function of the asset-debt ratio.

We explore different explanations for our result. We find that risk preferences and financial education and experience do not predict the presence of the leverage bias. On the contrary, our result is related to the differences in the level of cognitive sophistication and attention between biased and unbiased subjects. Indeed, our analysis by means of Bayesian techniques shows that the regression model relating the presence of the bias to the scores in CRT is the one associated with the highest posterior probability. In particular, subjects with the leverage bias perform significantly worse in CRT compared to unbiased subjects. This suggests that the misperception of wealth is related to a predominance of System 1 type of thinking, which is automatic and makes little use of attentional resources (Kahneman, 2003a,b; Kihlstrom, 1987; Moritz et al., 2014; Toplak et al., 2014).

By means of a survey on hypothetical debt and consumption choices, we also find that the leverage bias predicts individual attitudes towards debt, consumption behavior and individual saving types. Biased subjects generally identify themselves as the type of person that spends and enjoys the present, as well as being more comfortable with the idea of buying goods by borrowing. We also find that subjects with the leverage bias are more likely to take on debt for consumption, and more prone to increase spending out of unexpected gains under financial profiles that are associated with greater perceived wealth, while unbiased subjects seem more debt averse and generally indifferent to the composition of the balance sheet for debt and consumption decisions. In addition, our results indicate that biased subjects are more likely to borrow in case of a financial emergency that leaves them unable to finance due payments.

We finally build a simple that provides a structural interpretation of our results. This is a two-period optimal consumption choice model that compares the behavior of a standard rational agent – representing unbiased subjects in our experiment – with a behavioral agent à la Gabaix (2014, 2019) – representing unbiased subjects. Based on our experimental findings, this agent has a wrong perception of wealth due to low cognitive sophistication and greater inattention. We show that the model can account for biased subjects' greater tendency to spend and rely on debt for consumption, compared to rational unbiased subjects. In line with our experimental results, the model also predicts a larger marginal propensity to consume for the biased agent and, therefore, lower consumption smoothing.

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# Appendix A – Experiment instructions

The experiment was carried out in Italian. Instructions were displayed on the computer screen before the beginning of each task. The following pages report an English translation.

WELCOME

Please take your time to read the instructions very carefully: there is no benefit to moving fast through the experiment.

Today's experiment is made of five different parts: Task 1, Task 2, Task 3, Task 4 and Task 5. In each part, you will have to answer some questions.

If you pay attention and complete your tasks, you may earn a considerable amount of money in each part. At the end of the experiment you will be paid a participation fee of 5€ plus the amount won in each of the three parts.

In the next page you will be presented with the instructions of Task 1. After completing Task 1, you will access the other tasks and the corresponding instructions.

During the experiment you are not allowed to talk to the other participants, use cell phones or start any other programs on the computer.

The neglect of these rules will lead to the immediate exclusion from the experiment and all payments.

If you have any questions, please raise your hand.

Please proceed to the next page when you are ready to start.

TASK 1

INTRODUCTION

The financial profile of an individual is generally represented by his assets, liabilities and net worth.

*Assets* refers to the money that represents a person's wealth.

*Liabilities* refers to debt, that is the money a person has to give back.

*Net worth* refers to the difference between assets and liabilities and it may be either positive (if assets are greater than liabilities) or negative (in the opposite case).

For example, the following table represents the financial profile of Mr. Rossi:

| Sig. Rossi | |
|---|---|
| Attività | 8.000 € |
| Passività | 2.000 € |
| Saldo | 6.000 € |

In this example, Mr. Rossi has 8000€ worth of assets and 2000€ worth of liabilities. His net worth is therefore equal to 6000€.

YOUR TASK.

In the next pages you will be shown 12 pairs of financial profiles, described by assets, liabilities and net worth, in line with what mentioned above.

For each pair, you will have to choose the profile that you consider financially better off.

Be careful: once you confirm your choice, you will not be able to modify it.

In making your decisions, keep in mind the following information:

1. All values of assets and liabilities shown are certain, that is they do not change over time;
2. The two profiles in each pair correspond to people who earn the same monthly income;
3. Both individuals in each pair can obtain loans under the same conditions, if necessary;
4. All assets and liabilities are non-interest bearing: both individuals in each pair do not pay any interest on their debt and do not receive any interest on their assets.

Please proceed to the next page when you are ready to start.

Before starting your task, please answer the following questions:

What do assets and liabilities represent in this experiment?

a. Assets represent debt, that is money a person has to give back; liabilities represent the money that defines a person’s wealth.
b. Assets represent the money that defines a person’s wealth; liabilities represent debt, that is money a person has to give back.

All profiles correspond to people who will have to pay an interest on their debt.

a. True
b. False

The values you will be shown represent assets and liabilities that may change over time.

a. True
b. False

Carlo has assets equal to 12500€ and liabilities equal to 2500€. What is his net worth?
Insert the value here:

All profiles correspond to people who can obtain a loan under the same conditions:

a. True
b. False

Pairs shown to participants (sorted randomly for each participant):

| Mr. A | | Mr. B | |
|---|---|---|---|
| Attività | 1.200 € | Attività | 15.000 € |
| Passività | 200 € | Passività | 14.000 € |
| Saldo | 1.000 € | Saldo | 1.000 € |

| Mr. A | | Mr. B | |
|---|---|---|---|
| Attività | 44.200 € | Attività | 12.800 € |
| Passività | 32.000 € | Passività | 600 € |
| Saldo | 12.200 € | Saldo | 12.200 € |

| Mr. A | | Mr. B | |
|---|---|---|---|
| Attività | 50.000 € | Attività | 69.500 € |
| Passività | 800 € | Passività | 20.300 € |
| Saldo | 49.200 € | Saldo | 49.200 € |

| Mr. A | | Mr. B | |
|---|---|---|---|
| Attività | 32.000 € | Attività | 74.800 € |
| Passività | 7.350 € | Passività | 50.150 € |
| Saldo | 24.650 € | Saldo | 24.650 € |

| Mr. A | | Mr. B | |
|---|---|---|---|
| Attività | 135.000 € | Attività | 613.000 € |
| Passività | 7.000 € | Passività | 485.000 € |
| Saldo | 128.000 € | Saldo | 128.000 € |

| Mr. A | | Mr. B | |
|---|---|---|---|
| Attività | 500 € | Attività | 13.500 € |
| Passività | 21.000 € | Passività | 34.000 € |
| Saldo | -20.500 € | Saldo | -20.500 € |

| Mr. A | | Mr. B | |
|---|---|---|---|
| Attività | 2.500 € | Attività | 62.500 € |
| Passività | 39.500 € | Passività | 99.500 € |
| Saldo | -37.000 € | Saldo | -37.000 € |

| Mr. A | | Mr. B | |
|---|---|---|---|
| Attività | 200 € | Attività | 44.000 € |
| Passività | 18.400 € | Passività | 62.200 € |
| Saldo | -18.200 € | Saldo | -18.200 € |

| Mr. A | | Mr. B | |
|---|---|---|---|
| Attività | 1.000 € | Attività | 32.500 € |
| Passività | 28.500 € | Passività | 60.000 € |
| Saldo | -27.500 € | Saldo | -27.500 € |

| Mr. A | |
|---|---|
| Attività | 18.000 € |
| Passività | 48.000 € |
| Saldo | -30.000 € |

| Mr. B | |
|---|---|
| Attività | 400 € |
| Passività | 30.400 € |
| Saldo | -30.000 € |

| Mr A | |
|---|---|
| Attività | 1.300 € |
| Passività | |
| Saldo | 1.000 € |

| Mr B | |
|---|---|
| Attività | 17.000 € |
| Passività | |
| Saldo | 1.000 € |

| Mr A | |
|---|---|
| Attività | |
| Passività | 33.000 € |
| Saldo | 11.200 € |

| Mr B | |
|---|---|
| Attività | |
| Passività | 12.500 € |
| Saldo | 11.200 € |

TASK 2

INTRODUCTION

This task maintains the information provided in the previous task. So, the meaning of assets, liabilities and net worth remains the same as before. For the sake of clarity, we summarize them again here:

*Assets* refers to the money that represents a person's wealth.
*Liabilities* refers to debt, that is the money a person has to give back.
*Net worth* refers to the difference between assets and liabilities and it may be either positive (if assets are greater than liabilities) or negative (in the opposite case).

YOUR TASK

In this task you will be shown 10 financial profiles given by assets, liabilities and net worth. Next to each profile, you will find a pointer on a bar, like this one:




Your task consists in evaluating the financial soundness of each profile by assigning a grade between 1 and 10. To do so, move the pointer along the bar corresponding to each profile.

In range of grades, 1 indicates that your evaluation is extremely negative (you think the profile is not at all financially solid); 10 indicates that your evaluation is extremely positive (you think the profile is very solid from a financial perspective).

If you consider any profiles as financially equivalent, please assign them any same grade.

In making your decisions, keep in mind the following information:

1. All values of assets and liabilities shown are certain, that is they do not change over time;
2. The two profiles in each pair correspond to people who earn the same monthly income;
3. Both individuals in each pair can obtain loans under the same conditions, if necessary;
4. All assets and liabilities are non-interest bearing: both individuals in each pair do not pay any interest on their debt and do not receive any interest on their assets.

Please proceed to the next page when you are ready to start.

TASK 3

Task 3 consists of some questions of differing difficulty. Try to answer as many of them as possible.

You have 2 minutes and 30 seconds of time for each question.

Think carefully about the answer you choose: For each correct answer in this task we will pay you 1€.

Please proceed to the next page when you are ready to start.

QUESTIONS shown to participants (one per page, sequentially):

- A bat and a ball cost 1.10 Euros. The bat costs 1 Euro more than the ball. How much does the ball cost?
- It takes 5 machines 5 minutes to make 5 widgets. How long would it take 100 machines to make 100 widgets?
- 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?

TASK 4

This task is composed of a sequence of 10 decisions. For each decision, you have to choose between Option A and Option B, which are shown in the table below (the table will be shown also in the next pages, so you don't have to learn it by heart).

| Decision | Option A | Option B |
|---|---|---|
| 1 | Win 2,00 € with probability 1 over 10<br>OR<br>Win 1,60 € with probability 9 over 10 | Win 3,85 € with probability 1 over 10<br>OR<br>Win 0,10 € with probability 9 over 10 |
| 2 | Win 2,00 € with probability 2 over 10<br>OR<br>Win 1,60 € with probability 8 over 10 | Win 3,85 € with probability 2 over 10<br>OR<br>Win 0,10 € with probability 8 over 10 |
| 3 | Win 2,00 € with probability 3 over 10<br>OR<br>Win 1,60 € with probability 7 over 10 | Win 3,85 € with probability 3 over 10<br>OR<br>Win 0,10 € with probability 7 over 10 |
| 4 | Win 2,00 € with probability 4 over 10<br>OR<br>Win 1,60 € with probability 6 over 10 | Win 3,85 € with probability 4 over 10<br>OR<br>Win 0,10 € with probability 6 over 10 |
| 5 | Win 2,00 € with probability 5 over 10<br>OR<br>Win 1,60 € with probability 5 over 10 | Win 3,85 € with probability 5 over 10<br>OR<br>Win 0,10 € with probability 5 over 10 |
| 6 | Win 2,00 € with probability 6 over 10<br>OR<br>Win 1,60 € with probability 4 over 10 | Win 3,85 € with probability 6 over 10<br>OR<br>Win 0,10 € with probability 4 over 10 |
| 7 | Win 2,00 € with probability 7 over 10<br>OR<br>Win 1,60 € with probability 3 over 10 | Win 3,85 € with probability 7 over 10<br>OR<br>Win 0,10 € with probability 3 over 10 |
| 8 | Win 2,00 € with probability 8 over 10<br>OR<br>Win 1,60 € with probability 2 over 10 | Win 3,85 € with probability 8 over 10<br>OR<br>Win 0,10 € with probability 2 over 10 |
| 9 | Win 2,00 € with probability 9 over 10<br>OR<br>Win 1,60 € with probability 1 over 10 | Win 3,85 € with probability 9 over 10<br>OR<br>Win 0,10 € with probability 1 over 10 |
| 10 | Win 2,00 € with probability 10 over 10<br>OR<br>Win 1,60 € with probability 0 over 10 | Win 3,85 € with probability 10 over 10<br>OR<br>Win 0,10 € with probability 0 over 10 |

After making all the 10 decisions, your computer will choose one of them randomly.
Each of the 10 decisions has an equal probability of being chosen.

Based on the selected decision, your computer will then determine the amount of your pay.
To this purpose, your computer will throw a 10-sided dice and play the associated lottery.

For example, imagine your computer selects decision number 1. Your computer will then throw the 10-sided dice: if you have chosen option A, you will win 2€ if the dice shows the side "1", or 1.6€ if the dice shows one of the other 9 sides; if instead you have chosen option B, you will win 3.85€ if the dice shows the side "1", or 0.10€ if the dice shows one of the other 9 sides.

Hence, even if you make 10 decisions, only one of them will determine your payment in this task. Clearly, as already pointed out, each decision has an equal probability of being chosen for your payment but you have no possibility to know in advance which of the decisions is going to be selected.

Please proceed to the next page when you are ready.

TASK 5

The last task consists of a short survey of about 20 questions. Please take the necessary amount of time to answer accurately.

How old are you?

What is your gender?
A: female, male

How many people live in your family?
A: 1, 2, 3, 4, 5+

What is your parents' education level?
A: None of my parents holds a degree; Only one of my parents holds a degree; Both of my parents hold a degree

Do you have any financial education?
A: Yes, No

Have you ever participated in experiments like this one before?
A: Yes, No

Do you have at least one credit or debit card?
A: Yes; No

In general, do you prefer to spend money and enjoy it today or save for the future?
A: Spend and enjoy it today; Save for the future

In general, do you think it is a good idea or a bad idea for people to buy things by borrowing?
A: Good idea; Good in some ways, bad in others; Bad idea

If tomorrow you experienced a financial emergency that left you unable to pay all of your bills, how would you deal with it?
A: Borrow money; Spend out of savings; Postpone payments; Cut back; Other

Imagine that your TV is getting old and you want to change it with a new flat screen HD smart TV. However, since you don't have the money to purchase it outright, you would need to borrow 450 € in order to buy it. In which case would you be more likely to borrow to buy the new TV?
A: Mr. A (high profile); Mr. B (low profile); I would borrow in either case; I would not borrow in either case (Asked twice, once with positive NW, once with negative NW)

Consider a hypothetical situation in which you unexpectedly receive a one-time payment of 500 € Euros. What would you do over the next month?
A: I would spend more than if I hadn't received the 500€; I would spend the same as if I hadn't received the 500€; I would spend less than if I hadn't received the 500€.

CONDITIONAL: You indicated that you would increase your spending over the next month following the receipt of the 500 € payment. How much more would you spend than if you hadn't received the 500 €?

Consider a hypothetical situation in which you unexpectedly receive a one-time payment of 5000 € Euros. What would you do over the next month?
A: I would spend more than if I hadn't received the 5000€; I would spend the same as if I hadn’t received the 5000€; I would spend less than if I hadn’t received the 5000€.

CONDITIONAL: You indicated that you would increase your spending over the next month following the receipt of the 5000 € payment. How much more would you spend than if you hadn't received the 5000€?

Consider again a hypothetical situation in which you unexpectedly receive a one-time payment of 500 € today. In which case would you be more likely to increase your expenses?
A: Mr. A (high profile); Mr. B (low profile); I would increase my expenses in either case; I would not increase my expenses in either case

# Appendix B - Further tables

Table 22 reports the posterior mean (i.e. logit coefficients) used for the computation of predicted probabilities in Table 2.

Table 22

Posterior mean for predicted probabilities in Table 2

| | Unbiased | Leverage bias | Other bias | Partial bias |
|---|---|---|---|---|
| Posterior mean | -1.4336 | -.0013 | -2.4976 | -2.3239 |
| Std. dev. | .304 | .994 | .449 | .422 |
| 68% HPDI | [-1.7111 -1.1102] | [-.9563 1.0159] | [-2.8752 -1.9885] | [-2.6882 -1.8631] |

Random-walk Metropolis-Hastings sampling with 100000 MCMC sample size; acceptance rate: .4398; average efficiency rate: .2195.
Prior $N(0,1)$ on all model coefficients.
Values in parentheses are 68% highest posterior density intervals.

Table 23 reports the marginal effects from a series of Bayesian logistic regressions of a dummy for the leverage bias on four variables: CRT score, risk aversion, financial sophistication and financial education. In all regressions, we assume a $N(0,1)$ prior for model coefficients.

Table 23

Behavioral predictors of the leverage bias

| | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| CRT score | -.0322 | | | |
| 68% HPDI | [-.0508 -.0126] | | | |
| Risk aversion | | .0149 | | |
| 68% HPDI | | [.0065 .0242] | | |
| Financial sophistication | | | .0660 | |
| 68% HPDI | | | [.0266 .1117] | |
| Financial education | | | | .0599 |
| 68% HPDI | | | | [.0220 .0978] |
| Controls | No | No | No | No |
| Sample size | 68 | 68 | 68 | 68 |

Marginal effects from a Bayesian logistic regression of a dummy equal to 1 if the subject is biased on (1) CRT score, (2) number of safe choices in RISK, (3) a dummy equal to 1 if the subject has credit/debit card and (4) a dummy equal to 1 if the subject is financially educated. Controls include age, gender dummy, family size and family education level as covariates.
Prior $N(0,1)$ on all model coefficients. Random-walk Metropolis-Hastings sampling with 100000 MCMC sample size.
Values in parentheses are 68% highest posterior density intervals.

Table 24 reports the marginal effects from a Bayesian logistic regression of general attitudes towards debt on a dummy for the leverage bias. We assume a $N(0,1)$ prior for the coefficient of the dummy.

Table 25 reports the marginal effects from a Bayesian multinomial logistic regression

Table 24

Effect of the leverage bias on borrowing attitudes

| | *Averse* | *Seeker* | *Neutral* |
|---|---|---|---|
| Marginal effect | -.1843 | .2013 | -.0170 |
| 68% HPDI | [-.2309 -.1280] | [.1581 .2533] | [-.0690 .0339] |
| Controls | No | No | No |
| Sample size | 68 | 68 | 68 |

Marginal effects from a Bayesian logistic regression of the measure of attitudes towards debt on a dummy equal to 1 if the subject is biased. The regression includes age, gender dummy, family size and family education level as covariates.
Prior $N(0,1)$ on all model coefficients. Random-walk Metropolis-Hastings sampling with 100000 MCMC sample size.
Values in parentheses are 68% highest posterior density intervals.

of responses to the hypothetical financial emergency on a dummy for the leverage bias. We assume a $N(0,1)$ prior for the coefficient of the dummy.

Table 25

Effect of the leverage bias on reactions to financial emergency

| | Borrow | Use savings | Postpone | Cut | Other |
|---|---|---|---|---|---|
| Marginal effect | .2285 | -.1326 | -.0444 | -.0030 | -.0485 |
| 68% HPDI | [.1896 .2783] | [-.1750 -.0775] | [-.0647 -.0113] | [-.0532 .0586] | [-.0611 -.0314] |
| Controls | No | No | No | No | No |
| Sample size | 68 | 68 | 68 | 68 | 68 |

Marginal effects from a Bayesian logistic regression of reactions to a financial emergency on a dummy equal to 1 if the subject is biased. The regression includes age, gender dummy, family size and family education level as covariates.
Prior $N(0,1)$ on all model coefficients. Random-walk Metropolis-Hastings sampling with 100000 MCMC sample size.
Values in parentheses are 68% highest posterior density intervals.

Table 26 reports the marginal effects from a Bayesian multinomial logistic regression of the likelihood to take on debt on a dummy for the leverage bias. We assume a $N(0,1)$ prior for the coefficient of the dummy.

Table 27 reports the marginal effects from a Bayesian logistic regression of a dummy for impatience on a dummy for the leverage bias. We assume a $N(0,1)$ prior for the coefficient of the dummy.

Table 28 reports the marginal effects from a Bayesian logistic regression of a dummy for impatience on a dummy for the leverage bias. We assume a $N(0,1)$ prior for the coefficient of the dummy.

Table 29 reports the marginal effects from a Bayesian logistic regression of a dummy for profile selection on a dummy for the leverage bias. We assume a $N(0,1)$ prior for the coefficient of the dummy.

Table 26

Effect of the leverage bias on the likelihood to take on debt

| | *Group 1* | *Group 2* | *Group 3* |
|---|---|---|---|
| Marginal effect | .4883 | -.4058 | -.0825 |
| 68% HPDI | [.4464 .5458] | [-.4683 -.3450] | [-.1121 -.0439] |
| Controls | No | No | No |
| Sample size | 68 | 68 | 68 |

Marginal effects from a Bayesian logistic regression of group belonging on a dummy equal to 1 if the subject is biased. The regression includes age, gender dummy, family size and family education level as covariates.
Prior $N(0,1)$ on all model coefficients. Random-walk Metropolis-Hastings sampling with 100000 MCMC sample size.
Values in parentheses are 68% highest posterior density intervals.

Table 27

Effect of the leverage bias on impatience

| | |
|---|---|
| Marginal effect | .3091 |
| 68% HPDI | [.2472 .3702] |
| Controls | No |
| Sample size | 68 |

Marginal effects from a Bayesian logistic regression of the measure of attitudes towards debt on a dummy equal to 1 if the subject is biased. Controls include age, gender dummy, family size and family education level as covariates.
Prior $N(0,1)$ on all model coefficients. Random-walk Metropolis-Hastings sampling with 100000 MCMC sample size.
Values in parentheses are 68% highest posterior density intervals.

Table 30 reports correlations among all predictors in our analysis. We include only the correlations whose absolute value is larger than 0.2, as a rule of thumb.

# Appendix C - CRRA case

Let us provide an example of our behavioral model by assuming a constant relative risk aversion (CRRA) utility function. The rational agent faces the following optimization problem:

$$\max U(c_1, c_2) = \frac{c_1^{1-\varepsilon}}{1-\varepsilon} + \beta \frac{c_2^{1-\varepsilon}}{1-\varepsilon}$$

s.t.

$$c_2 = (1 + r^s)(y_1^s - c_1) + y_2$$

Where $y_1 = \hat{y_1} + N$, $N = A - D$.

The optimization problem yields the following Euler Equation:

Table 28

Effect of the leverage bias on spending response

| | *Less* | *Same* | *More* |
|---|---|---|---|
| Marginal effect, €500 scenario | -.0470 | -.1482 | .1951 |
| 68% HPDI | [-.0616 -.0150] | [-.2087 -.0898] | [.1468 .2499] |
| | | | |
| Marginal effect, €5000 scenario | -.0710 | -.0704 | .1414 |
| 68% HPDI | [-.0900 -.0370] | [-.1273 -.0084] | [.0871 .1969] |
| | | | |
| Controls | No | No | No |
| Sample size | 68 | 68 | 68 |

Marginal effects from a Bayesian logistic regression of spending responses on a dummy equal to 1 if the subject is biased. The regression includes age, gender dummy, family size and family education level as covariates.
Prior $N(0,1)$ on all model coefficients. Random-walk Metropolis-Hastings sampling with 100000 MCMC sample size.
Values in parentheses are 68% highest posterior density intervals.

Table 29

Effect of the leverage bias on increase in consumption

| | *HRP* | *LRP* | *Neutral* |
|---|---|---|---|
| Marginal effect | .3944 | -.1079 | -.2865 |
| 68% HPDI | [.3430 .4550] | [-.1391 -.0566] | [-.3400 -.2350] |
| Controls | No | No | No |
| Sample size | 68 | 68 | 68 |

Marginal effects from a Bayesian logistic regression of profile selection on a dummy equal to 1 if the subject is biased. The regression includes age, gender dummy, family size and family education level as covariates.
Prior $N(0,1)$ on all model coefficients. Random-walk Metropolis-Hastings sampling with 100000 MCMC sample size.
Values in parentheses are 68% highest posterior density intervals.

Table 30

Correlations

| | CRT score | Risk av. | Fin. soph. | Fin. edu. | Age | Gender | Fam. size | Fam. Edu. |
|---|---|---|---|---|---|---|---|---|
| CRT score | 1 | | | | | | | |
| Risk aversion | .2123 | 1 | | | | | | |
| Financial sophistication | | | 1 | | | | | |
| Financial education | | -.2195 | | 1 | | | | |
| Age | | | | | 1 | | | |
| Gender | | | | | | 1 | | |
| Family size | | | | | | | 1 | |
| Family education | | | -.3265 | | | | | 1 |

$$c_1^r = \left[\frac{1}{\beta(1+r)}\right]^{\frac{1}{\varepsilon}} c_2^r \tag{30}$$

By making use of the Euler equation and the intertemporal budget constraint, we determine the rational agent's optimal allocation of consumption in both periods:

$$c_1^r = \frac{1}{1+\beta^{\frac{1}{\varepsilon}}(1+r)^{\frac{1-\varepsilon}{\varepsilon}}}\left(y_1+\frac{y_2}{1+r}\right) \tag{31}$$

$$c_2^r = \frac{[\beta(1+r)]^{\frac{1}{\varepsilon}}}{1+\beta^{\frac{1}{\varepsilon}}(1+r)^{\frac{1-\varepsilon}{\varepsilon}}}\left(y_1+\frac{y_2}{1+r}\right) \tag{32}$$

The biased agent, solves the same problem but she uses perceived wealth ($w^s$). Hence:

$$\max U(c_1,c_2) = \frac{c_1^{1-\varepsilon}}{1-\varepsilon} + \beta\frac{c_2^{1-\varepsilon}}{1-\varepsilon}$$

s.t.

$$c_2 = (1+r^s)(y_1^s - c_1) + y_2'$$

So the agent uses the sparse-max procedure in the following order:

1. choose the optimal level of attention in order to form a perceived value of wealth;
2. choose the optimal action, conditional on the perceived value.

Therefore, to compute optimal attention we need the following derivatives at default values:[20]

[20]To compute the derivatives, write the following:

$$\max U(c_1,c_2) = \frac{c_1^{1-\varepsilon}}{1-\varepsilon} + \beta\frac{[(1+r^s)(y_1^s-c_1)+y_2]^{1-\varepsilon}}{1-\varepsilon}$$

$$
\begin{aligned}
U_{c_1}\Big|_{c_1^d} &= (c_1^d)^{-\varepsilon} - \beta(1+r^d)\left[(y_1^d - c_1^d)(1+r^d) + y_2\right]^{-\varepsilon} \\
U_{c_1c_1}\Big|_{c_1^d} &= -\varepsilon(c_1^d)^{-(1+\varepsilon)} - \varepsilon\beta(1+r^d)^2\left[(y_1^d - c_1^d)(1+r^d) + y_2\right]^{-(1+\varepsilon)} \\
U_{c_1y_1}\Big|_{c_1^d;y_1^d} &= \varepsilon\beta(1+r^d)^2\left[(y_1^d - c_1^d)(1+r^d) + y_2\right]^{-(1+\varepsilon)} \\
U_{c_1r}\Big|_{c_1^d;r^d} &= -\beta\left[(y_1^d - c_1^d)(1+r^d) + y_2\right]^{-\varepsilon}
\end{aligned}
$$

Since, $\Delta_{ii} = -\sigma_i^2 a_{x_i} U_{aa} a_{x_i}$, where $\sigma_i = \mathbf{E}[x_i^2]^{1/2}$, $a_{x_i} = \frac{\partial a}{\partial x} = -U_{aa}^{-1} U_{ax_i}$, $a = c_1^d$, $x_1 = y_1^d$ and $x_2 = r^d$, then:

$$
\begin{aligned}
\Delta_{11} &= \sigma_1^2 \frac{\left[\varepsilon\beta(1+r^d)^2\left[(y_1^d - c_1^d)(1+r^d) + y_2^d\right]^{-(1+\varepsilon)}\right]^2}{\varepsilon(c_1^d)^{-(1+\varepsilon)} + \varepsilon\beta(1+r^d)^2\left[(y_1^d - c_1^d)(1+r^d) + y_2\right]^{-(1+\varepsilon)}} \\
\Delta_{22} &= \sigma_2^2 \frac{\left[-\beta\left[(y_1^d - c_1^d)(1+r^d) + y_2\right]^{-\varepsilon}\right]^2}{\varepsilon(c_1^d)^{-(1+\varepsilon)} + \varepsilon\beta(1+r^d)^2\left[(y_1^d - c_1^d)(1+r^d) + y_2\right]^{-(1+\varepsilon)}}
\end{aligned}
$$

The agent can now compute optimal attention using Equation 12 and move to the optimal action.

The solution to the optimal consumption choice problem above gives the following Euler equation:

$$
c_1^s = \left[\frac{1}{\beta(1+r^s)}\right]^{\frac{1}{\varepsilon}} c_2^s \tag{33}
$$

By combining the Euler equation and the intertemporal budget constraint, we determine the optimal allocation of consumption in both periods for the sparse agent:

$$
c_1^s = \frac{1}{1+\beta^{\frac{1}{\varepsilon}}(1+r^s)^{\frac{1-\varepsilon}{\varepsilon}}}\left(y_1^s + \frac{y_2}{1+r^s}\right) \tag{34}
$$

$$
c_2^s = \frac{[\beta(1+r^s)]^{\frac{1}{\varepsilon}}}{1+\beta^{\frac{1}{\varepsilon}}(1+r^s)^{\frac{1-\varepsilon}{\varepsilon}}}\left(y_1^s + \frac{y_2}{1+r^s}\right) \tag{35}
$$

However, the desired optimal allocation for the sparse agent is not feasible, as it exceeds the agent's available resources. The agent, therefore, is smart enough to adjust her allocation of consumption:

$$
c_1^a = \frac{1}{1+\beta^{\frac{1}{\varepsilon}}(1+r^s)^{\frac{1-\varepsilon}{\varepsilon}}}\left(y_1^s + \frac{y_2'}{1+r^s}\right) \tag{36}
$$

$$
c_2^a = \frac{[\beta(1+r^s)]^{\frac{1}{\varepsilon}}}{1+\beta^{\frac{1}{\varepsilon}}(1+r^s)^{\frac{1-\varepsilon}{\varepsilon}}}\left(y_1^s + \frac{y_2'}{1+r^s}\right) \tag{37}
$$

In fact, the agent solves the problem defined in condition 19, so as to find the value of $y_1'$ that, given her sparse perception of wealth, exhausts the true budget constraint. In other words, $y_1'$ guarantees that the budget constraint is hit under the true levels for the interest rate ($r$) and income in period two ($y_2$). Therefore:

$$c_1^a(y_1^s, r^s, y_2') + \frac{c_2^a(y_1^s, r^s, y_2')}{1+r} = y_1 + \frac{y_2}{1+r} \tag{38}$$

In order to find the value of $y_2'$ that guarantees that condition 38 is satisfied, we substitute for $c_1^a$ and $c_2^a$ into it:

$$y_2' = \frac{(1+r)\left[1+r^s+\beta^{\frac{1}{\epsilon}}(1+r^s)^{\frac{1}{\epsilon}}\right]}{1+r+\beta^{\frac{1}{\epsilon}}(1+r^s)^{\frac{1}{\epsilon}}}\left(y_1+\frac{y_2}{1+r}\right) - (1+r^s)y_1^s \tag{39}$$

This is the value of $y_2'$ that corresponds to an optimal allocation of consumption for the sparse agent after adjustment: it accounts for the sparsity of the agent that leads her to have a wrong perception of own wealth, but it is also feasible.

Given optimal consumption for both agents determined above, we find the following relationship between the adjusted level of consumption for the sparse agent in period 1 and the consumption of the rational agent in the same period:

$$c_1^a > c_1 \iff y_2' > \frac{(1+r^s)\left[1+\beta^{\frac{1}{\varepsilon}}(1+r^s)^{\frac{1-\varepsilon}{\varepsilon}}\right]}{1+\beta^{\frac{1}{\varepsilon}}(1+r)^{\frac{1-\varepsilon}{\varepsilon}}}\left(y_1+\frac{y_2}{1+r}\right) - (1+r^s)y_1^s \tag{40}$$

**Proposition 1**: *Consider the value of $y_2'$ in Equation 39. It is trivial to show that this always satisfies the condition in Equation 40 if $r > r^s$ for any $\varepsilon > 0$.*

Summing up, by assuming a CRRA utility function, we show that the adjusted optimal consumption choice made by the biased agent leads her to consume a greater share of her wealth in period 1, compared to the rational agent, under the condition in Equation 40.

We finally compute the derivative of optimal consumption of the two types of agents in period 1 with respect to $y_1$:

$$\frac{\partial c_1^a}{\partial y_1} = \frac{1}{1+\beta^{\frac{1}{\epsilon}}\frac{(1+r^s)^{\frac{1}{\epsilon}}}{1+r}} \tag{41}$$

$$\frac{\partial c_1}{\partial y_1} = \frac{1}{1+\beta^{\frac{1}{\epsilon}}\frac{(1+r)^{\frac{1}{\epsilon}}}{1+r}} \tag{42}$$

**Proposition 2**: *Consider the derivatives in Equations 41 and 42. It is trivial to show that the biased agent has a greater propensity to consume out of positive income shocks in period 1 compared to the unbiased agent, as long as $r > r^s$, which is true by assumption.*