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MONEY ILLUSION, FINANCIAL LITERACY AND NUMERACY: EXPERIMENTAL EVIDENCE

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ABSTRACT

Money illusion is usually defined as the inability of individuals to correctly account for inflation or deflation when making decisions. Empirical evidence shows that money illusion matters in financial decisions, particularly those made by households. In this article, we analyze money illusion at the individual level within the context of financial choices and study its relationship with numeracy and financial literacy. To do so, we propose an original measure of money illusion via an experimental task. This task consists of a series of choices between a pair of simple bonds whose returns are affected only by inflation (or deflation). We provide a fine-grained measure of money illusion that is correlated with typical measures (questionnaires) of it. Moreover, we show that money illusion depends on the choice context (e.g., inflation or deflation) and participants' abilities. Individuals with financial knowledge are less sensitive to money illusion than others, while there is no evidence of an impact of numeracy.

JEL Classification code: C9; D1; E2; G4.

PsycINFO Classification code: 2260; 2340; 2343.

Keywords: Behavioral Sciences; Money Illusion; Design of Experiments; Behavioral Finance; Financial Literacy; Numeracy.

1. INTRODUCTION

Increasing empirical evidence shows that money illusion matters in different contexts. Money illusion is broadly defined as the inability of individuals to correctly account for inflation or deflation when making decisions and is usually attributed to intuitive decision-making based on more accessible information (Shafir, Diamond and Tversky 1997; Fehr and Tyran 2001; Akerlof and Shiller 2010). In particular, agents have difficulties understanding the impact of price fluctuations on revenues. Indeed, they are confused with regard to the differences between real and nominal returns or values, even when they know the inflation rate. The existence of suboptimal financial choices caused by money illusion is supported by empirical evidence. Stock market investors discount real cash flows at nominal rates (Modigliani and Cohn 1979) or compare real stock returns to nominal bond returns (Asness 2000; Cohen, Polk and Vuolteenaho 2005). Loan interest rate premiums are relatively small in times of high market interest rates and vice versa (Machauer and Weber 1998). Nominal shocks have real effects on experimental asset markets, affecting nominal price inertia and equilibrium selection (Fehr and Tyran 2001, 2007; Noussair, Richter and Tyran 2012). Intertemporal decision-making (consumption vs. saving) is strongly affected by price fluctuation (Yamamori, Iwata and Ogawa 2018).

At an individual level, money illusion has usually been measured via questionnaires (Shafir, Diamond and Tversky 1997; Shiller 1997; Cipriani, Lubian and Zago 2008; Mees and Franses 2014). More precisely, Shafir, Diamond and Tversky (1997) provide individual-level questionnaire-based evidence on money illusion by submitting hypothetical situations to lay judgments about an increase/decrease in wealth or income in inflationary and deflationary contexts. They report a serious focus on nominal values or changes that are analyzed as a framing effect, reflecting agents' preference for the nominal framework given its facility and salience. The authors also observe that agents may use a mix of both frameworks (real and nominal) and that the favored framework may vary depending on context.

However, these questionnaires capture dimensions other than financial decisions, including judgments on hypothetical situations in terms of welfare, fairness and happiness. The main weakness of these questionnaires is that they do not propose an incentivized measure of money illusion based on real decisions.

To the best of our knowledge, there is no incentivized task to measure money illusion at the individual level. Our objective is to propose a simple incentivized task to measure money illusion at the individual level in the context of financial choices.

To do so, we design and create an experiment that consists of a series of choices between two simple bonds whose returns are influenced by inflation (deflation). Participants have to choose the bond that has the higher real return; otherwise, they make an error. We think these errors reflect their failure to understand or calculate the impact of inflation on the returns of bonds and therefore express money illusion. The rate of errors made by participants can then be considered as an individual measure of money illusion.

However, we know that the level of money illusion may vary according to the context, and we need to introduce this context in our design. First, in money illusion surveys, participants' answers are more biased by money illusion when comparing deflation than inflation scenarios, and even when participants are able to select the most profitable scenario in real terms, they are not satisfied with it in deflation contexts (see Shafir, Diamond and Tversky 1997; Mees and Franses 2014; Guille and Mercier 2017). Moreover, Fehr and Tyran (2001) provide experimental evidence that money illusion has asymmetric effects on equilibrium adjustment, particularly in cases of deflation.

Second, money illusion is often presented and tested in a strict sense as a preference for the nominal value. The way in which Shafir, Diamond and Tversky (1997) identified a serious focus on the nominal value is based on the observation that participants often choose responses that correspond to a nominal preference. However, in their questionnaire, it is always the case that responses corresponding to nominal preference always differ from responses corresponding to real preference. This design feature may lead to overestimation of the importance of nominal preference. To more precisely identify a preference for the nominal value, we think it is more appropriate to test whether participants make more errors when real and nominal preferences are noncongruent than when they are congruent.

Third, Svedsäter, Gamble and Gärling (2007) show that the nominal representation of share prices influences an individual's intuitive judgments since "*any percentage price change of a stock share when presented in absolute number is perceived as smaller for smaller than for larger numbers*" (pp.700-701). This possible nominal preference for large values is consistent with the results of Weber et al. (2009) and with Lea and Webley (2006) view, that is, "*money as drug*".¹

Fourth, Shiller (2005) and Shafir, Diamond and Tversky (1997) also suggest that money illusion can be the result of computational difficulties or of a choice to disregard real reasoning when the cost of negligence is small.

¹ For an explanation of the relationship between money illusion and the perception of money, see Bourgeois-Gironde and Guille (2011).

Thus, we design our experiment such that we can explore the effect of four characteristics of financial choices on money illusion: inflation vs. deflation; congruence vs. noncongruence; values of bonds (real vs. nominal values and low vs. high values); and low vs. high differences in returns.

There is also evidence for a framing effect since alternative representations of the same situations lead to different responses by individuals (e.g., Shafir, Diamond and Tversky 1997). Moreover, in real life, choices may be more complex since the inflation rate is anticipated with some uncertainty. For these reasons, we also vary the framing of our choices and introduce uncertainty with regard to inflation rates.

Additionally, money illusion can be influenced by individual abilities. Despite the fact that Cipriani, Lubian and Zago (2008) and Chytilova (2017) show that individuals with economic literacy are still prone to money illusion, our view is that two individual abilities are central to understanding the impact of inflation on real returns, financial literacy and numeracy. Indeed, many empirical studies show that financial literacy leads to a better management of personal finances² but is unequally distributed among individuals.³ The correlation between numeracy, financial literacy and financial behavior is also well documented (Lusardi 2012). Van Rooij, Lusardi and Alessie (2011) show that numeracy and financial literacy are strongly positively correlated with participation in the stock market, while Almenberg and Widmark (2011) find that numeracy is strongly linked to participation in both the stock and housing markets. Moreover, Ghazal, Cokely and Garcia-Retamero (2014) show that numeracy is a strong and positive predictor of financial behavior and is linked to confidence and deliberation. Skagerlund et al. (2018) also predict that numeracy is the strongest predictor of financial literacy. Indeed, a proportion of financial literacy skills can be explained by numeracy skills since the conceptual understanding of inflation, interest rates or risk diversification requires simple calculation skills. Underlying this tight relationship is the issue of the difference between simple computations in a “standard environment” (numeracy) and computations in a more complex and concrete environment (financial literacy).

However, to the best of our knowledge, the relationship between money illusion, financial literacy and numeracy has not yet been explored, although some authors suggest that a lack of numeracy and financial literacy skills can at least partly explain money illusion. For instance,

² Financial literacy influences, for example, retirement planning (Ameriks, Caplin and Leahy 2003; Lusardi and Mitchell 2007) and portfolio choices (Van Rooij, Lusardi and Alessie 2011; Arrondel, Debbich and Savignac 2014; Abreu and Mendes 2010).

³ The less educated, women, young adults and elders tend to be less financially educated and to struggle with financial concepts, such as inflation, interest rates or risk diversification (Lusardi and Mitchell 2014; Grohmann 2018; Arrondel, Debbich and Savignac 2014).

Shiller (2005) noted that “*Not only are people troubled by math anxiety when doing index calculations, but also people have a difficulty with intuitive understanding of the indexation concept*” (Shiller 2005, p.245).

Therefore, we also design our experiment such that we can explore the relationships between our measure of money illusion and these two important individual abilities in the context of financial choices.

This paper is organized as follows. In section 2, we present the design of the experiment. Section 3 describes our results. Finally, section 4 provides discussion and concluding remarks. The experimental materials are given in the online appendices.

2. DESIGN OF THE EXPERIMENT

The experiment is composed of the financial task and several questionnaires and other tasks. We first present the incentivized measure of money illusion based on the financial task and then the other individual measures. Finally, we detail the procedure of the experiment.

2.1 Incentivized measure of money illusion

We propose an incentivized individual measure of money illusion based on a financial task. This task consists of a series of choices. For each choice, participants have to select one of two simple bonds to invest in for one period. Both bonds have the same initial value. They differ in their return and the inflation (deflation) rate (π) that affects this return. In each choice, one bond has the highest real value, and one bond has the highest nominal value. These two bonds can be the same (congruence of nominal and real values) or not (noncongruence).

In the main framing (*basic framing*), the return of the bonds is presented in the form of the final nominal value. We also introduce two other framings which present the return of the bonds in the form of the nominal rate (i) of return (*return framing*) or the final real value (*real framing*). The choices between both bonds are presented as choices between two countries (A or B) in which to invest. The initial values of the bonds are expressed in an experimental unit of account (ECU). Figure 1 shows the same choice presented in each framing.

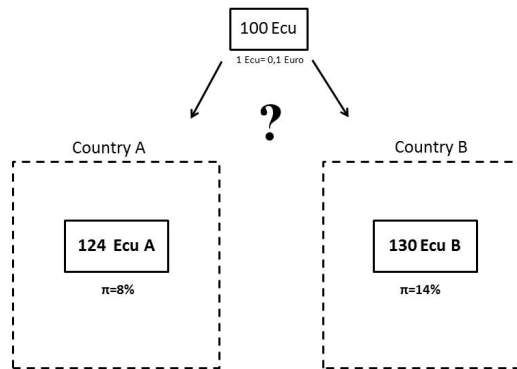


Figure 1a: *Basic* framing

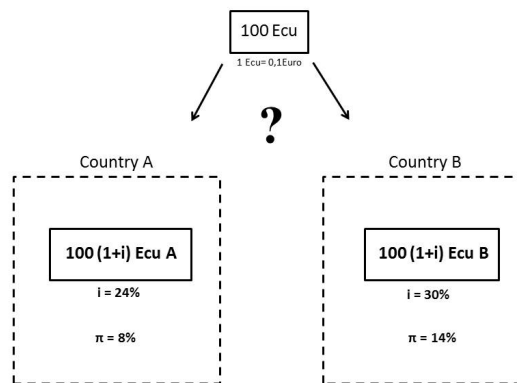


Figure 1b: *Return* framing

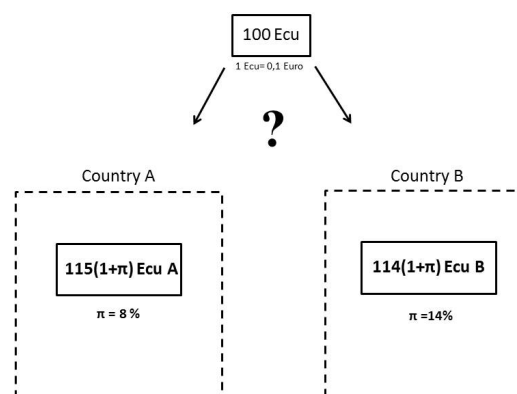


Figure 1c: *Real* framing

Figure 1: Three framings of financial choices for the same pair of bonds

Note: The nominal and real values of the country A bond are 124 ECU and 115 ECU, respectively (i.e., $124 = 115 \cdot 1.08$); the nominal and real values of the country B bond are 130 ECU and 114 ECU, respectively (i.e., $130 = 114 \cdot 1.14$).

After each choice, the participants have to answer a satisfaction question (“*Are you satisfied with your choice?*”) and a confidence question (“*Are you confident in your choice?*”) on a 10-point Likert scale.

We design the pairs of bonds according to four characteristics:

1. Price changes: The *inflation* condition involves a choice where both bonds are in an inflation context; the *deflation* condition involves a choice where both bonds are in a deflation context; the *mixed* condition involves a choice where one bond is in an inflation context but the other is in a deflation context.
2. Real and nominal values: The *congruence* condition involves a choice where the bond that has the higher final real value also has the higher final nominal value (vs. the *noncongruence* condition).
3. Initial values: The *low-value* condition involves a choice where the initial value of the bonds is equal to 100 ECU and the exchange rate between the ECU and the euro is equal to 0.1; the *high-value* condition involves a choice where the initial value is 1000 ECU and the exchange rate between the ECU and the euro is 0.01. In both cases, the initial value is equivalent to 10 euros.
4. Differences in the final real values: The *low-difference* condition involves a choice where the difference between the real values of both bonds is low (1 ECU in the *low-value* condition; 10 ECU in the *high-value* condition);⁴ the *high-difference* condition involves a choice where this difference is high (6 ECU in the *low-value* condition; 60 ECU in the *high-value* condition).⁵

Based on these characteristics, we create five blocks of 8 choices in the *basic* framing, as described in Table 1 (for a more detailed description of each block, see Online Appendix B Table B6).

⁴ 1 ECU or 10 ECU is equal to 0.10 or 0.20 euros.

⁵ 6 ECU or 60 ECU is equal to 0.60 euros.

Table 1: Description of the 8 choices of the 5 *basic* framing blocks

BLOCK	1	2	3	4	5
<i>Initial value</i>	100 ECU	100 ECU	100 ECU	1000 ECU	1000 ECU
<i>Difference in real value</i>	1 ECU 0.10 euro	6 ECU 0.60 euro	2 ECU 0.20 euro	10 ECU 0.10 euro	60 ECU 0.60 euro
<i>Price change</i> <i>*congruence</i>	4 I * NC 1 M * NC 1 D * NC 2 D * C	4 I * NC 1 M * NC 1 D * NC 2 D * C	3 I * NC 1 I * C 2 M * NC 1 D * NC 1 D * C	4 I * NC 1 M * NC 1 D * NC 2 D * C	4 I * NC 1 M * NC 1 D * NC 2 D * C
NC = noncongruence, C = congruence I = inflation, D= deflation and M= mixed					

The other two framings consist of 20 choices. The 20 choices of the *return* framing are a subset of the 40 *basic* pairs of bonds (Online Appendix B Table B3). Among the 20 choices of the *real* framing, 5 are built based on *basic* choices (Online Appendix B Table B4).

We also introduce choices between pairs of uncertain bonds in the *basic* and *real* framings. In the *basic* framing, a pair of uncertain bonds is built from two pairs of bonds that have the following characteristics: noncongruence, the same initial value and the same nominal final value in each country. The uncertainty is related only to the inflation rate, which can take two values with equal probability. Therefore, the real value of both bonds is uncertain, but one uncertain bond first-order stochastically dominates the other. Five choices were built based on 10 of the 40 certain *basic* bonds (Online Appendix B Table B2). Figure 2 shows an example of an uncertain choice in the *basic* framing. In the *real* framing, there are 3 uncertain choices (Online Appendix B Table B5).

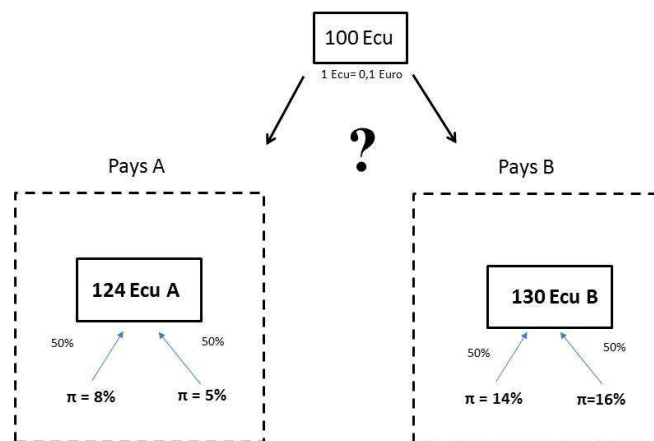


Figure 2: Example of a choice between two uncertain bonds in the *basic* framing

Note: Investing in country B maximizes the real value of the investment. The probability distribution of the real value of bond B first-order stochastically dominates that of bond A: bond B gives an equal chance of a real value of 118 ECU or 115 ECU against an equal chance of a real value of 114 ECU or 112 ECU with bond A.

Overall, participants make 88 financial choices. First, they start with the 40 certain *basic* choices. Second, the 5 uncertain *basic* choices are presented. Third, participants continue with the 20 *return* choices, the 20 certain *real* choices and the 3 uncertain *real* choices.

The order of presentation of the choices inside each framing is randomized across participants, and the display of the pair of bonds is randomized across trials. The exchange rate of the ECU in euros is always mentioned on the computer screen.

In all choices, there is a correct answer, that is, choosing the bond that has the higher real value. Otherwise, participants make an error. We propose two measures of money illusion: first, the mean individual error rate and, second, its transformation into log odds.⁶ We are also interested in confidence, satisfaction and response time data. In particular, for confidence, we define metacognitive sensitivity as the difference between the mean confidence in correct bond choices and the mean confidence in incorrect choices. The higher the difference, the better able a participant is to detect his or her errors.

2.2. Other individual measures

Financial literacy

Participants have to answer three usual questions (Arrondel and Masson 2014; Lusardi and Mitchell 2014; Arrondel, Debbich and Savignac 2014). The first two questions enable us to

⁶ Whenever the mean error rate is null or equal to 1, we replace its value with .01 or .99, respectively.

check whether they understand interest rates, and the third question measures their understanding of the inflation concept. We create a financial literacy indicator via the computation of the three answers that the participants give to these questions (0 to 3).

Money illusion

Participants have to answer 20 questions, 14 of which are based on Shafir, Diamond and Tversky (1997) problems, which deal with the impact of inflation/deflation on wages, property prices or consumer durable goods. These problems have been adapted by Guille and Mercier (2017) to minimize personal assumptions that could bias the participants' answers. In particular, participants are asked to compare and judge different hypothetical situations concerning the same person (i.e., scenarios rather than the situations of different persons). Three questions are based on a new problem added by Guille and Mercier (2017) about the impact of inflation on the return of a bond. We add a specific problem that includes 3 questions related to inflation-indexed bonds. A money illusion indicator is created according to the 20 answers that the participants give to these questions (0 to 20).

Numeracy

We create a specific numeracy test in relation to the financial task. Participants have to compare six pairs of ratios. Each ratio is created with values used in the task (see Online Appendix C). Participants earn 0.50 euros for each correct answer. We compute a score of numeracy according to the six comparisons made by the participants (0 to 6).

Risk aversion

We use a procedure by Holt and Laury (2002) to elicit risk aversion. The gains in the certain option (A) are 2 € and 1.6 €, while the gains in the risky option (B) are 3.85 € and 0.1 €. Participants make 10 choices, with the probability of high gains ranging from 10% to 100% by increments of 10%. All the choices are displayed simultaneously in one table. To avoid multiple switches between the two options, subjects can switch from option A to option B no more than once. The choices are incentivized. We measure risk aversion by the number of times the certain option is chosen.

Loss aversion

To elicit loss aversion, we follow Gaëchter, Johnson and Hermann (2007). Participants are asked to choose between a lottery ticket (A') that gives a 50% chance of winning 50 € and a 50% chance of losing 50 € and a certain outcome (B'). There are 11 choices with a certain outcome that varies from + 50 € to - 50 € by an increment of 10 €. All the choices are displayed simultaneously in one table, and multiple switches are not allowed. Participants can switch from option A' to option B' no more than once. The choices are not incentivized. We measure loss aversion by the number of times the lottery ticket is chosen.

2.3 Procedure and participants

The experiment was conducted in French at the Laboratory of Experimental Economics in Paris (LEEP). The participants were recruited using an online system (ORSEE). There were 96 participants (44 females and 52 males) aged 24.6 years, on average. Thirty participants held a master's degree, 39 held a bachelor's degree, and 27 held high school graduates. Fourteen participants were enrolled in a law degree program, and 19 were enrolled in an economics or finance degree program. Overall, 52 participants had taken at least one course in economics or finance. The experiment consisted of six sessions with 11 to 18 participants per session. The sessions averaged approximately one hour and twenty minutes in length.

The experiment is divided into 8 steps. Participants complete, in the following order, the first questionnaire, which consists of only sociodemographic questions; the first trial of choices (*basic* certain and uncertain bonds); the second questionnaire, which combines financial literacy and money illusion questions; the second trial of choices (*return* certain bonds); the third questionnaire, which combines financial literacy and money illusion questions; the third trial of choices (*real* certain and uncertain bonds); the Holt-Laury risk aversion procedure; the loss aversion measure; and, finally, the numeracy task.

The final gain is the sum of four components: the gain in euros of one randomly drawn financial choice, the outcome of the risk aversion lottery, the gain from the numeracy task and a 5-euro participation fee. The mean gain was 20.5 euros ($sd = 1.42$). The instructions are read and orally explained, projected on individual computers and printed out. No calculator is present during the entire experiment, but participants can use paper and pencil if they want to. The response time is not restricted.

3. RESULTS

We first test whether our measure of money illusion has the expected features. Then, we study the impact of framing and complexity on money illusion. Finally, we examine which individual preferences and abilities are predictive of money illusion in our task.

3.1. Performance on the financial task

We examine the performance on the 40 *basic* certain choices. On average, the participants have a mean error rate equal to 31%. Without making any error, a participant can obtain a mean return rate of 19.2%, while the mean return rate drops to 15.9% when one is wrong all the time. On average, the mean return rate is 18.3%. Data by participant are shown in Figure 3.

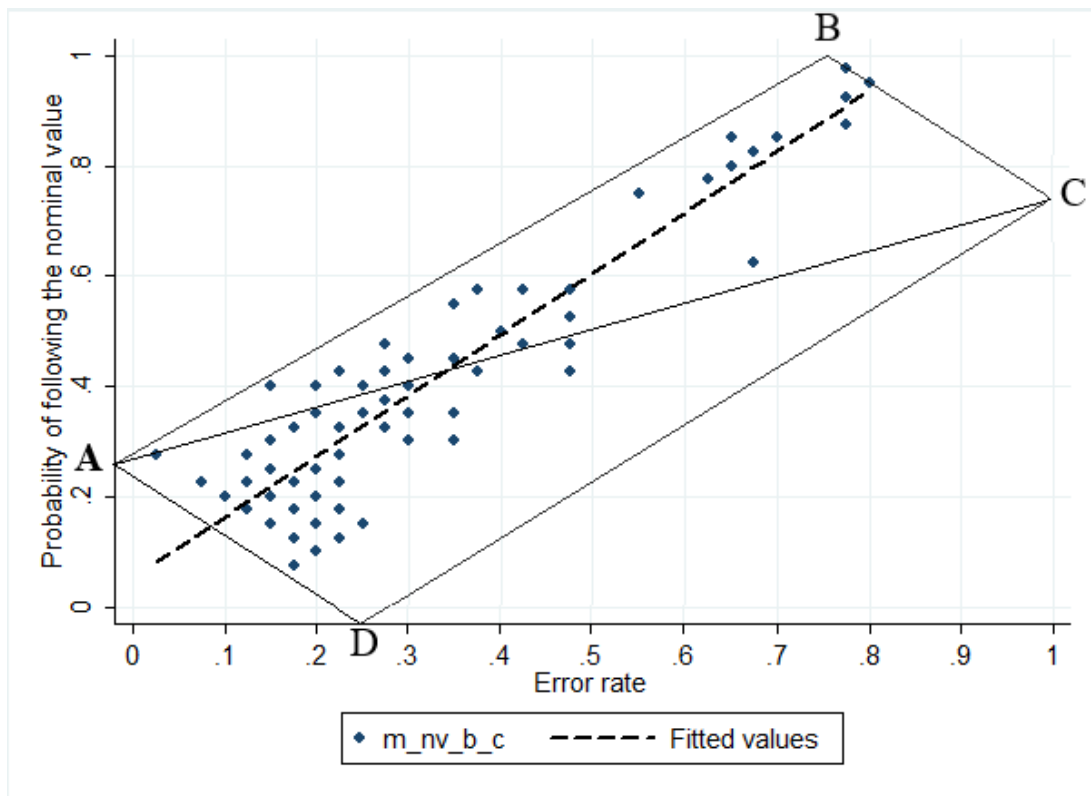


Figure 3: Mean error rate and probability of following the nominal value by participant

Note: The x axis represents the mean error rate, and the y axis represents the probability of following the nominal value (data by subject). By design, the data are in the rectangle (ABCD). A corresponds to a perfect real value maximizer. B corresponds to a perfect nominal value maximizer. In line AC, the error rate is the same in the congruent and noncongruent choices. In line AB, the error rate is zero in the congruent choices. In line DB, the probability of following the nominal value is the same in the congruent and noncongruent choices.

If all participants choose randomly between both bonds, then the mean error rate and the probability of following the nominal value will be 50%. By contrast, if they all choose the bond that has the higher nominal value, then the mean error rate will be 75%, and the probability of following the nominal value will be 100% (point B). The slope of the linear fit (dashed line in Figure 3) is higher than that of line AC, which represents data with the same error rates in the congruent and noncongruent choices. Thus, this result indicates that an increase in the error rate is related to an increased influence of the nominal value, as expected. However, this influence of the nominal value on behavior is not as strong as it could be if the participants were considering only the nominal value. Indeed, line BD, which represents the data with the same probability of following the nominal value in the congruent and noncongruent choices, is steeper than the linear fit.

In Table 2, we provide an overview of the different measures collected in the financial task.

Table 2: Task variables in the *basic* certain choices according to economic training and gender

<i>VARIABLES</i>	<i>ALL</i> (<i>n</i> =96)	<i>EcoFi</i> (<i>n</i> =52)	<i>Others</i> (<i>n</i> =44)	<i>Male</i> (<i>n</i> =44)	<i>Female</i> (<i>n</i> =52)
<i>Error rate</i>	.31 (.2)	.27 (.02)	.36 (.03)	.26 (.03)	.36 (.03)
		t(94)=2.16***		t(94)=-2.55***	
<i>Error log odds ratio</i>	-.93 (1.03)	-1.15 (.14)	-.67 (.15)	-1.24 (.14)	-.66 (.15)
		t(94)=2.34***		t(94)=-2.84***	
<i>Mean return rate</i>	18.25 (.75)	18.40 (.69)	18.07 (.80)	18.45 (.69)	18.09 (.80)
		t(94)=-2.17**		t(94)=-2.39***	
<i>Mean confidence</i>	7.17 (1.47)	7.56 (.19)	6.72 (.22)	8.00 (.19)	6.48 (.18)
		t(94)=-2.89***		t(94)=-5.81***	
<i>Mean satisfaction</i>	6.72 (1.40)	7.08 (.18)	6.30 (.21)	7.49 (.21)	6.07 (.14)
		t(94)=-2.79***		t(94)=-5.75***	
<i>Metacognition sensitivity</i>	.54 (.80)	.68 (.12)	.38 (.10)	.68 (.14)	.43 (.09)
		t(94)=1.84*		t(94)=-1.49	
<i>Mean response time</i>	12.63 (7.57)	14.88 (1.21)	9.97 (.73)	14.18 (.99)	11.32 (1.13)
		t(94)=-3.33*		t(94)=-1.87*	

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

In the financial task, participants with a background in economics and finance are more accurate. Female participants commit more errors, are less satisfied and confident and respond more quickly.

We expect our financial task to capture some typical features of money illusion found in the literature: participants should commit more errors in deflation, in noncongruent choices and when the initial value is high. Moreover, we expect more errors when the differences in real values are low. To obtain a balanced comparison of the four characteristics, we restrict our attention to the 32 certain pairs of bonds in blocks 1, 2, 3 and 4 of the *basic* framing. In Table 3, we report our regression results on errors, confidence, satisfaction and the response time.

Table 3: Impact of choice characteristics on errors, confidence, satisfaction and the response time

VARIABLES	(1)	(2)	(3)	(4)
	Errors	Confidence	Satisfaction	Response time
		(z score)	(z score)	(z score)
<i>Method</i>	<i>Logit (odds ratio)</i>	<i>OLS</i>	<i>OLS</i>	<i>OLS</i>
<i>Observations</i>	3,072	3,072	3,072	3,072
<i>R-squared</i>		0.043	0.036	0.015
<i>mixed*noncongruence</i>	1.234* (0.156)	-0.237*** (0.070)	-0.142** (0.068)	-0.037 (0.057)
<i>deflation*noncongruence</i>	2.626*** (0.397)	-0.245*** (0.061)	-0.235*** (0.067)	-0.009 (0.055)
<i>deflation*congruence</i>	1.088 (.0825)	-0.297*** (0.051)	-0.217*** (0.054)	0.042 (0.050)
<i>high-value</i>	1.332*** (0.0939)	-0.113*** (0.040)	0.113** (0.053)	0.224*** (0.037)
<i>low-difference</i>	1.312*** (0.1034)	-0.278*** (0.040)	-0.267*** (0.038)	0.078* (0.040)
constant	0.273*** (0.0494)	.321*** (0.036)	.170*** (0.040)	-0.154*** (0.031)

Choices used: 32 by subject, blocks 1, 2, 3 and 4 in the *basic* certain framing
Standard errors in parentheses (adjusted for 96 clusters by subject)
*** p<0.01, ** p<0.05, * p<0.1

First, a logistic regression analysis (Table 3, column 1) is conducted to explain the errors in the task according to the characteristics of the choices.⁷ The *inflation* and *congruence* conditions reduce the risk of error. On average, participants make fewer errors in the inflation context than in the deflation or mixed contexts and when the final real and nominal values of bonds are congruent. By contrast, the choices in the *high-value* and *low-difference* conditions increase the mean error rate. To account for individual differences in the use of the satisfaction or confidence scales or in the response times, we standardize the variables and run three ordinary least squares (OLS) regressions (Table 3, columns 2, 3 and 4). Our results show that participants are more confident in their choices in the *inflation* condition (than in the *deflation* or *mixed* conditions) and less confident in the *high-value* and *low-difference* conditions. Satisfaction follows an equivalent pattern of results for all choice characteristics, except for the initial values of the bonds. Interestingly, participants are more satisfied in the

⁷ The same results are obtained with a probit regression.

high-value condition. Additionally, the response time is higher in the *high-value* and *low-difference* conditions.

Overall, our financial task makes it possible to reproduce what has been observed in the literature.

3.2. Complexity and framing

We expect participants to commit more errors in uncertain financial choices because of the increased complexity of the choices. To test the influence of uncertainty, we calculate the difference in the error log odds ratio between certain and uncertain choices. We consider only pairs of bonds in the *basic* framing that are used both in certain and uncertain choices (10 certain vs. 5 uncertain choices). Surprisingly, participants make significantly fewer errors (mean difference in log odds ratio = -1.38, $t(1)=-7.55$, $p<0.001$) in uncertain choices ($M=-2.35$, $sd=2.49$) than in certain choices ($M=-0.97$, $sd=1.63$). Confidence is not significantly different, while satisfaction is significantly higher in uncertain financial choices (mean difference = 0.18, $t(1)= 1.77$, $p = 0.04$).

Conversely, we expect subjects to make fewer errors in the *return* and *real* framings than in the *basic* framing. In particular, in *real* framing, choosing the bond with the higher real value is trivial once it is understood that calculations are unnecessary since the actual values appear directly on the screen. The existence of a framing effect is tested by comparing participants' errors and perceptions in two sets of common choices presented in the *basic* framing, comparing first to the *return* framing and second to the *real* framing. The difference between the *basic* and *return* framings is based on the 20 common choices. The error log odds ratio in the *return* framing ($M=-1.14$, $sd=.12$) is positively correlated ($r=0.60$, $p<0.01$) with the error log odds ratio in the *basic* framing ($M=-1.18$, $sd=0.09$). The difference between the two error log odds ratios is not significant (mean difference=0.04, $t(1)= 0.43$, $p = 0.33$). The mean values of satisfaction and confidence are also not significantly different. The difference between the *basic* and *real* framings is based on 5 common choices. The error log odds ratio in the *real* framing ($M=-1.56$, $sd=0.26$) is positively correlated ($r=0.32$, $p<0.01$) to the error log odds ratio in the *basic* framing ($M=-1.55$, $sd=0.30$). The difference between the two error log odds ratios is not significant (mean difference=-0.01, $t(1)= -0.03$, $p = 0.49$). The mean values of satisfaction and confidence are also not significantly different.

3.3. Performance in the task and individual characteristics

In Table 4, we report the descriptive results for other individual measures.

Table 4: Individual measures according to economic training and gender

<i>VARIABLES</i>	<i>ALL</i> (<i>n</i> =96)	<i>EcoFi</i> (<i>n</i> =52)	<i>Others</i> (<i>n</i> =44)	<i>Male</i> (<i>n</i> =44)	<i>Female</i> (<i>n</i> =52)
<i>Numeracy</i>	4.30 (1.58)	4.63 (.20)	3.91 (.25)	4.68 (.20)	3.98 (.23)
		t(94)=-2.28***		t(94)=2.2***	
<i>Financial literacy</i>	2.34 (.82)	2.59 (.09)	2.04 (.13)	2.63 (.09)	2.1 (.12)
		t(94)=-3.46***		t(94)=3.39***	
<i>Money illusion questionnaire</i>	10.96 (3.88)	9.46 (.56)	12.73 (.42)	9.57 (.63)	12.13 (.44)
		t(94)=4.51***		t(94)=-3.40***	
<i>Loss aversion</i>	4.78 (2.42)	4.85 (.30)	4.70 (.41)	4.81 (.36)	4.75 (.34)
		t(94)=0.28		t(94)=-0.12	
<i>Risk aversion</i>	6.18 (2.07)	6.33 (.26)	6.00 (.34)	6.34 (.27)	6.04 (.31)
		t(94)=0.77		t(94)=-0.71	

Standard errors in parentheses
 *** p<0.01, ** p<0.05, * p<0.1

On average, participants perform reasonably well on the numeracy and financial literacy tests. They obtain an average score of 4.30 in numeracy (based on a scale of 0 to 6) and of 2.34 in financial literacy (0 to 3). By contrast, their results in the money illusion questionnaire are less satisfying since the average score is only 10.86 (0 to 20), with an important dispersion ($sd=3.88$). For these three measures, there are significant differences between males and females and between participants who had taken at least one course in economics or finance and others; however, there are no significant differences with regard to loss aversion and risk aversion.

How are these measures related to performance in the financial task? In Table 5, we report the Pearson correlations between the main variables.

Table 5: Pearson correlations for the main variables

Measures	1	2	3	4	5	6	7	8
(1) Error rate	-							
(2) Error log odds ratio	.98***	-						
(3) Metaco. Sensitivity	-.55***	-.55***	-					
(4) Money illusion questionnaire	.37***	.39***	-.25***	-				
(5) Numeracy	-.13	-.12	.04	-.30***	-			
(6) Financial literacy	-.36***	-.37***	.22**	-.48***	.33***	-		
(7) Loss aversion	.04	.05	.04	.02	.29***	.09	-	
(8) Risk aversion	.06	.05	-.06	.04	.14	.08	.20**	-

N=96 (*p<0.10; **p<0.05; ***p<0.01)

The error rate, the error log odds ratio and metacognitive sensitivity in the financial task are significantly and positively (negatively for metacognitive sensitivity) correlated with the measure of money illusion in the questionnaire. Hence, the error rate in the task can be considered as an individual measure of money illusion in a financial context.

Among the measures of numeracy, financial literacy, loss aversion and risk aversion, only financial literacy presents significant correlations with performance in the task. Financially literate participants make fewer errors in the task and are better able to detect their errors. They also have a lower score on the money illusion questionnaire. Surprisingly, our measure of numeracy does not significantly correlate with performance on the financial task.

To investigate whether participants are sensitive to the characteristics of choices according to their individual characteristics, we compute the difference in the error log odds ratio between two sets of balanced choices for each choice characteristic. We observe that participants make more errors in the non-inflation (*deflation* and *mixed* conditions), *noncongruence*, *high-value* and *high-difference* conditions than in the respective opposite conditions. Only financial literacy presents a significant correlation with some of these differences: the *noncongruence* vs. *congruence* in deflation difference ($r=0.34$, $p<0.001$) and the *low-difference* vs. *high-difference* difference ($r = 0.29$, $p = 0.004$). More precisely, we perform a median split of the participants according to their financial literacy (*Median* = 3). A total of 52 out of 96 participants have a score of 3 on the financial literacy questionnaire and are considered highly

financially literate (54%). Figure 4 shows how these two types of participants differ in their sensitivity to the *congruence* (vs. *noncongruence*) and the (*low* vs. *high*) *difference* conditions.

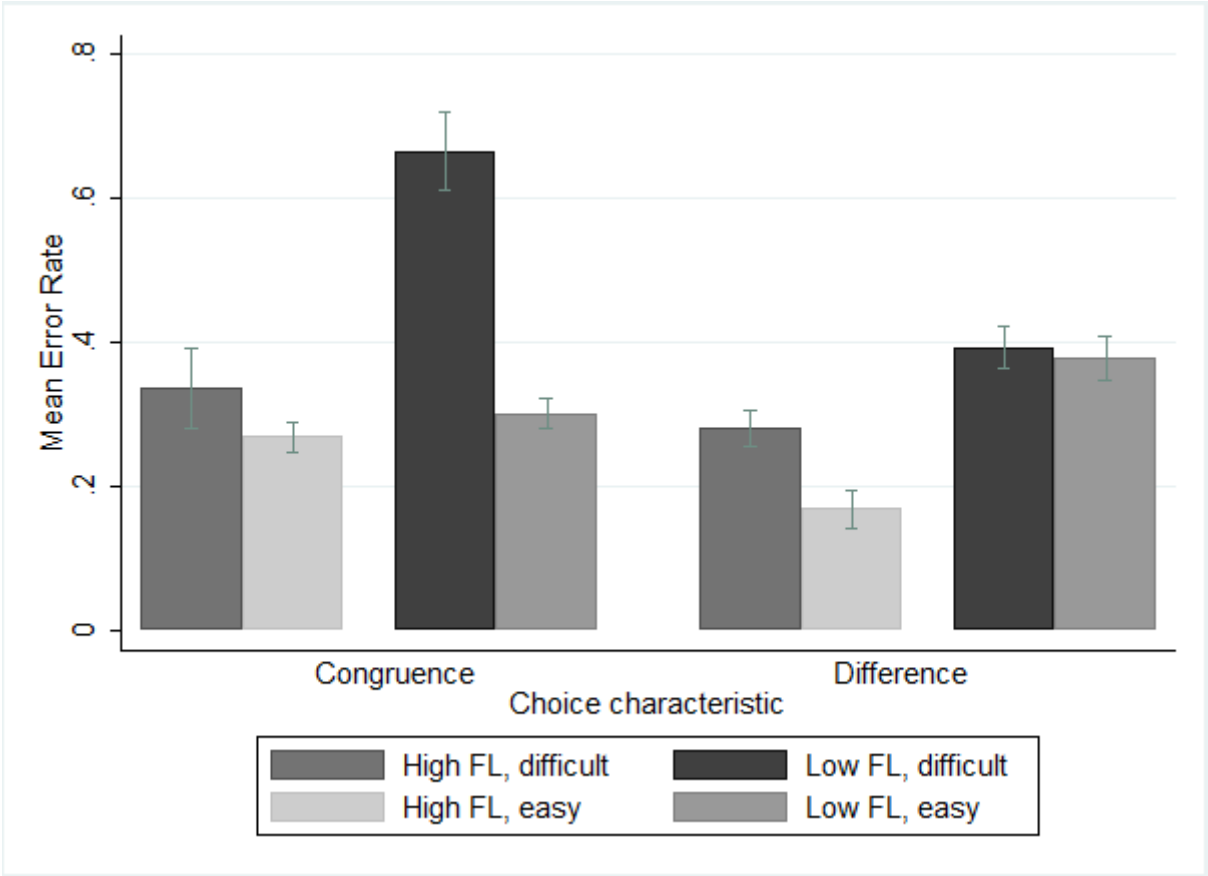


Figure 4: Mean error rate by difficulty and financial literacy level for the *congruence* (vs. *noncongruence*) and *low-difference* (vs. *high-difference*) conditions

Note: Difficult is for the *noncongruence* and *low-difference* conditions; easy is for the *congruence* and *high-difference* conditions. High FL means highly financially literate participants; low FL means participants with low financial literacy.

We observe that highly financially literate participants are insensitive to the *congruence* condition (*noncongruence* vs. *congruence*: $M= 0.34, sd= 0.35$ vs. $M= 0.27, sd= 0.16, t(51)= -1.19, p=0.12$) but are sensitive to the *low-difference* condition (*low-difference* vs. *high-difference*: $M= 0.28, sd= 0.16$ vs. $M= 0.17, sd= 0.19, t(51)= -6.37, p<0.001$). This result shows that these participants do not think in nominal terms and that they seek to maximize the real value with more or less success, depending on the difficulty of finding this value. Conversely, participants with low financial literacy are very sensitive to the nominal value (*noncongruence* vs. *congruence*: $M= 0.66, sd= 0.37$ vs. $M= 0.30, sd= 0.18, t(43)= -5.05, p<0.001$) but not to the difference of return (*low-difference* vs *high-difference*: $M= 0.39, sd= 0.20$ vs. $M= 0.38, sd= 0.26, t(43)= -0.62, p=0.27$).

Once again, we find surprising results for numeracy since there is no significant correlation with any of these differences. In particular, we would have expected numeracy to help maintain performance in the *low-difference* condition.

4. DISCUSSION

The objectives of this experiment were as follows: first, to provide an individual measure of money illusion in the context of simple financial choices using an experimental task and to analyze the effects of the characteristics of choices; second, to investigate the impact of financial literacy and numeracy abilities on money illusion in this context.

Regarding the first objective, our results show that our measure of money illusion is consistent with previous findings supporting the existence of serious money illusion bias. Indeed, participants make frequent errors in the task. On average, the error rate equals 31% in the *basic* framing, which means that many participants do not correctly take inflation (deflation) into account when choosing between two simple bonds. Moreover, their mean error rate is positively correlated with their individual score in the money illusion questionnaire.

Errors are affected by the characteristics of choices: money illusion is higher in deflation, noncongruence, high-value and low-difference choices. The asymmetry between inflation and deflation replicates previous results. The fact that there are more errors in noncongruent than in congruent choices is a new way to show the existence of nominal preference. Our approach to contrasting the differences between noncongruence and congruence choices is a direct test of nominal preference. The positive impact of high value on errors (and satisfaction) provides original evidence in favor of a nominal preference for high value. Indeed, this hypothesis predicts that the nominal values of high-value bonds should tend to increase money illusion bias. Finally, it has been hypothesized that money illusion can be the result of computational difficulties. The observation that low differences in the returns between two bonds tend to increase money illusion proves that computational difficulties matter.

Furthermore, we observe two unexpected results. First, participants make fewer errors when financial choices become uncertain. This result might be explained by the design of the uncertain choices themselves since the lottery with the lower inflation rate always corresponds to the right answer. Participants who do not know how to choose between the two lotteries or who have a preference for low inflation may then adopt this simple rule of decision: choose the lottery ticket with the lowest inflation and then obtain the right answer. Second, there is no difference between the error rates in the *basic* framing and the other two

framings (*return* and *real*). Hence, participants neither benefit from nor are disadvantaged by any framing interventions, contrary to what we expected. In particular, in the *real* framing, there is no issue with computing the real value, and participants who understand the meaning of real value should succeed easily, which is not the case.⁸ Participants are equally affected by money illusion in all framings. This absence of a framing effect suggests that money illusion can be a deep-rooted bias and therefore be difficult to reduce.

Regarding the impact of individual characteristics on money illusion, we observe two main findings. The first, which is related to the negative impact of financial literacy on money illusion, is in line with our expectations. The second, which is more surprising, concerns the other characteristics, particularly numeracy. Indeed, the relationship with numeracy skills is not significant, nor are the relationships with loss aversion and risk aversion. Numeracy skills do not seem to help participants calculate in a financial environment, which is surprising because the calculations required to compare the two bonds are the same as those in the numeracy questionnaire.

These findings shed light on the potential sources of money illusion. In the literature, various mechanisms have been proposed to explain money illusion: nominal reasoning (preference), miscalculations that may come from computational difficulties, a misunderstanding of real value (the calculation of which has to be performed). Nominal preference may be one – but not the only – explanation of money illusion. The fact that there are more errors in noncongruent than in congruent choices is clearly in favor of the presence of a nominal preference. However, we also observe that the probability of following the nominal value is lower in noncongruence choices than in congruent choices, which shows that there is also a preference for real value. Furthermore, nominal preference is absent among financially literate participants. The asymmetry between inflation and deflation can be explained by the fact that participants are more familiar with inflation than deflation, but it can also illustrate a possible nominal loss aversion (in deflation, nominal values decrease). This second explanation is not supported by our results (absence of an impact of loss aversion on the money illusion score). The higher error rate in low-difference choices can be the result of a choice to disregard real reasoning when the cost of negligence is small, as suggested by Shafir, Diamond and Tversky (1997). However, our evidence does not support this explanation. Indeed, highly financially literate participants do not make more errors in noncongruent than in congruent choices, but they are sensitive to computational difficulties, while the sensitivity pattern is completely

⁸ By contrast with previous results, for instance, Fehr and Tyran (2001) find nominal inertia is higher in nominal than real framings.

inverted for participants with low financial literacy. The hypothesis of computational difficulties seems to be better grounded, but the absence of any effect of numeracy on errors or on the *low-difference* vs. *high-difference* difference of errors is puzzling and should be further studied. This result suggests that money illusion bias cannot be confined to simple mistakes in the computation of real values from nominal values. However, participants could have used other processes to compute real values, for instance, approximation by subtracting inflation to the real rate of return. Hence, the influence of other measures of numeracy can be further investigated (e.g., the Berlin Numeracy Test).

Overall, our results show that money illusion is a complex bias deriving from several sources, notably a greater familiarity with inflation, a preference for nominal values (rather than real values) and for large values (rather than small values) and miscalculation. This issue appears to be serious and difficult to solve, as shown by the absence of any framing effect. This result may explain the lack of success observed for inflation-indexed bonds (Shiller, 2005). Furthermore, our findings support the idea that money illusion bias goes beyond a problem of knowledge of the financial environment (the persistence of money illusion with financial literacy skills) and of computing abilities (the absence of an effect of numeracy). This raises the issue of a possible debiasing of money illusion through specific financial education programs.

In conclusion, we propose a simple, incentivized and precise individual measure of money illusion in a financial context. The main advantages of our measure are its abilities to provide a large quantity of individual data in a short period of time, to confer greater flexibility by varying the parameters of choices or analyzing the impact of individual characteristics, and to build subscores of money illusion depending on these parameters as well as its greater proximity to financial behavior compared to judgments on scenarios because this measure is based on real and incentivized decisions. It provides a good tool for further studies that intend to more precisely identify the main sources of money illusion bias.

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