MONEY ILLUSION, FINANCIAL LITERACY AND NUMERACY: EXPERIMENTAL EVIDENCE

Darriet Elisa [a1], *Guille Marianne* [a], *Vergnaud Jean-Christophe* [b]

and Shimizu Mariko [a]

ABSTRACT

Money illusion is usually defined as the inability of individuals to correctly account for inflation or deflation when making decisions. Individuals affected by money illusion are no longer rational as defined by economic theory. 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 and precise measure of money illusion via an experimental task and analyze the effects of financial literacy and numeracy via the usual measures. This task consists of a series of choices between a pair of simple bonds whose returns are only affected by inflation (or deflation). This task provides a fine measure of money illusion that is correlated with its usual measures (questionnaires). Moreover, we show that money illusion depends on the context of the choices and participants 'skills. Individuals with financial knowledge are less sensitive to money illusion than others, while numeracy has no impact.

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

PsycINFO Classification code: 2260; 2340; 2343.

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

[a] LEMMA, Université Paris 2 Panthéon-Assas & Labex MME-DII, 4 rue Blaise Desgoffe, 75006 Paris, France.

[b] CES, Université Paris 1 Panthéon-Sorbonne, 106-112 bd de l'Hôpital, 75013 Paris, France.

[1] Corresponding author, +33(0)170232006 darriet.elisa@gmail.com, LEMMA, Université Paris 2 Panthéon-Assas, 4 rue Blaise Desgoffe, 75006 Paris, France.

1. INTRODUCTION

In the current context of increasingly complex financial markets, households need to have a certain degree of financial understanding (Campbell 2006) to make good financial decisions throughout their life time. Numerous articles (Lusardi and Mitchell 2011; Van Rooij, Lusardi and Alessie 2011a, 2011b; Arrondel, Debbich and Savignac 2014) have studied the issue of households' financial choices and raised the issue of inequalities in financial outcomes, mainly due to individuals' abilities, such as financial literacy. Financial literacy can be defined as a *life skill* (Skagerlund, Lind, Strömbäck, Tinghög, and Västfjäll 2018; Lusardi 2012) and leads to the better management of finances (propensity to have a pension plan, portfolio diversification, participation in financial markets, financial wealth, etc.). Using sample surveys, Arrondel, Debbich and Savignac (2014) show that financial literacy affects households' portfolio composition. Indeed, the more financially literate households are, the more likely they are to hold stocks in their portfolio. However, the allocation of the portfolio itself (the shares invested in stocks and in other assets) is mainly influenced by the expected returns and risks of assets and by each household's risk aversion. Consequently, the issue of understanding the expected return and risk of assets is crucial.

One of the problems faced by households is the need to understand the impact of inflation on these returns. Indeed, households can have difficulties distinguishing real returns or values of assets from nominal ones, even if they know the inflation rate. These difficulties can lead to sub-optimal financial choices. In this case, households are not fully rational. Households tend to suffer from money illusion. Commonly defined as agents' tendency to think in nominal rather than real terms, money illusion 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). The effect of the money illusion bias can be crucial in financial markets, leading to suboptimal portfolio choices between stocks and bonds (Modigliani and Cohn 1979), disinterest in inflation indexed-bonds (Shiller 2005), interest rate smoothing (Machauer and Weber 1998), and an inadequate pension structure (Bodie and Crane 1997). The existence of these suboptimal financial behaviors caused by money illusion are supported by experimental evidence (Fehr and Tyran, 2001). However, these results have been obtained at an aggregate level. At an individual level, money illusion is only measured by questionnaires (Shafir, Diamond and Tversky 1997). There is no individual measure based on financial choices.

Consequently, the aim of this paper is twofold. First, we propose a simple incentivized task to measure money illusion at the individual level in the context of financial choices and to

compare this measure with those based on questionnaires. Second, we explore the relationships between our measure of money illusion and two important cognitive abilities in this context: financial literacy and numeracy.

This paper is organized as follows. We begin with a literature review providing an overview of money illusion, financial literacy and numeracy in a financial context as well as descriptions of our hypotheses. In section 2, we present the methodology of the experiment. Section 3 describes our results. Finally, section 4 provides discussion and concluding remarks. Experimental materials are given in the appendices.

1.1. MONEY ILLUSION

Money illusion is a complex phenomenon that has long been recognized. Fisher first defined money illusion as the "*failure to perceive that the dollar, or any other unit of money, expands or shrinks in value"* (1928, p. 4) and "*the tendency of people to think of money in nominal, rather than real terms"* (1928, p.4). More generally, Keynes (1936) considered that money illusion occurs when "*individuals do not accurately take inflation into account*". In this broad sense, money illusion was resumed by Patinkin (1956) as *"any deviation from real decision-making*", which constitutes a violation of what Leontief (1936) called the "*homogeneity postulate*" extended to real balances. Indeed, rational agents make their decisions in the absence of money illusion when their net demand functions are homogeneous of degree zero in all nominal prices and wealth.

Empirical evidence shows that money illusion matters in different contexts, in particular, in financial choices. 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, which affect nominal price inertia and equilibrium selection (Fehr and Tyran 2001, 2007; Noussair, Richter and Tyran 2012).

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 scenarios to lay judgments about the increase/decrease of wealth or income in inflationary and deflationary contexts. They report a serious focus on nominal values or changes, which are analyzed as a framing effect reflecting agents' preference for the nominal framework given its facility and salience. However, the

authors observe that agents may use a mix of both frameworks (real and nominal) and that the favored framework may vary depending on the context. Agents are, for instance, more likely to use the real framework in case of hyperinflation. *De facto*, when inflation is high, its effects are easy to identify and agents are willing to be protected against it. On the contrary, when inflation is low, it is more difficult to appreciate the erosion in the real value of money, especially over long periods of time. Thus, money illusion can be interpreted as a form of bounded rationality, especially in financial markets: investors are more subject to money illusion in their decision-making processes when the cost of negligence is small (in a low-inflation context, for example). Nevertheless, these questionnaires capture dimensions other than financial decisions, including judgments on hypothetical scenarios in terms of welfare, fairness and happiness. Moreover, the scenarios do not strictly refer to financial choices, although money illusion seems to have specific effects on financial choices that need to be precisely measured at an individual level.

Among the studies on money illusion's consequences on financial choices, an important area of research has focused on inflation-indexed bonds. Early on, Fisher (1928) argued that the prevalence of money illusion justifies the need for this type of bond to provide a protection against the risk of inflation and increase portfolio diversification. Yet, the history of inflation-indexed bonds is not as successful as could have been expected. According to Shiller (2005), the world's first known inflation-indexed bonds were issued by the state of Massachusetts during the American Revolution (1780), but this experience was very limited. It was only in 1945 that Finland, then followed by several other countries, introduced indexed-bonds (the UK, 1975; the USA, 1997; France, 1998…), but these bonds still represent a small share of these countries' national debt.

Money illusion may be an explanation. For instance, Shiller (1997) finds that, although most of the respondents to his questionnaire in the US and Turkey were able to deal with the concept of indexation, some of them would nonetheless prefer not to invest in inflation-linked assets even though no logical argument for resisting indexation was provided. One of the respondents said: *"I want to know how much money I will be getting*". This statement may capture the basic misunderstanding of the evolution of money value through time, or the desire of money for its own sake. As Bourgeois-Gironde and Guille (2011) note, money illusion is linked to the perception of money and may particularly be related to this desire for money regardless of its purchasing power, which is called *money as drug* opposed to *money*

as tool by Lea and Webley (2006). [1] Another possible reason for the scarce success of indexed bonds may be related to the difficulties that a less-educated population would have with indexed number calculations. As noted by Shiller about the Massachusetts experience*: "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).

It seems, therefore, that the money illusion bias in financial choice, and its consequences, as incorrect choices or a reluctance for inflation-indexed bonds, can be influenced by cognitive abilities. Our view is that two cognitive abilities are central to understanding the impact of inflation on real returns: numeracy and financial literacy.

1.2. COGNITIVE ABILITIES: FINANCIAL LITERACY AND NUMERACY

As defined by the OECD (2005), *"[f]inancial education is the process by which individuals improve their understanding of financial products and concepts; and through information, instruction and/or objective advice develop the skills and confidence to become more aware of financial risks and opportunities, to make informed choices, to nowhere to go for help, and to take other effective actions to improve their financial well-being and protection"*. Empirical studies on the influence of financial literacy on households' financial choices and outcomes are numerous, and all agree on the fact that it leads to a better management of personal finances but is unequally distributed among individuals. Differences in financial literacy have been found across subpopulations: 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).

The link between financial literacy and financial behavior has been investigated by a large number of empirical studies across the world. Financial literacy skills have an influence on retirement planning (Ameriks, Caplin and Leahy 2003; Lusardi and Mitchell 2007; Bucher-Koenen and Lusardi 2017; Van Rooij, Lusardi and Alessie 2011a). Lusardi and Mitchell (2011), for example, show that American adults with some degree of financial literacy are more willing to plan for retirement. Moreover, financially literate individuals are more likely to invest in stocks (Van Rooij, Lusardi and Alessie 2011b, Arrondel, Debbich and Savignac 2014) and are willing to increase their portfolio diversification (Abreu and Mendes 2010).

[1] Lea and Webley (2006) suggest that money may exert action at a neurochemical level to produce reinforcing effects similar to drug use and not only as a medium of exchange or store of value as in the usual instrumental view. This hypothesis is consistent with the results of Weber et al. (2009) and Miyapuram et al. (2012), which support the existence of money illusion by identifying a specific impact of pure nominal changes on the brain's reward circuit using advanced techniques of brain imagery.

Moreover, Huston (2012) highlights a negative relationship between financial literacy and the cost of financial borrowing, whatever the channel used: credit cards or loans. Households with financial knowledge are more likely to have lower borrowing costs than other households. Van Rooij, Lusardi and Alessie (2012) found positive relationships between financial knowledge, pension plans and household wealth. They show that financial literacy can increase households' wealth via two mechanisms: increasing their propensity to invest in equity markets and to therefore benefit from equity; increasing their likelihood to have a retirement plan and to therefore have pension income during their retirement.

As Skagerlund et al. (2018) highlight, the causality link between financial literacy and having better financial behavior can be less narrow than it appears. The correlation between numeracy, financial literacy and financial behavior is already well known and documented (Lusardi 2012). Van Rooij, Lusardi and Alessie (2011b) show that numeracy and financial literacy are strongly positively correlated with participation in the stock market. More importantly, Almenberg and Widmark (2011) find that numeracy is strongly linked to participation in both the stock and housing markets in Sweden. Gerardi, Goette and Meier (2013) show that numerical ability is negatively associated with mortgage delinquency and default. 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 the financial literacy skills can be explained by numeracy skills since the conceptual understandings of inflation, interest rates or risk diversification requires simple calculation skills. Behind this tight relationship between financial literacy and numeracy there is the issue of the difference between simple computation in a "standard environment" (numeracy) and computations in a more complex and concrete one (financial literacy).

1.3. HYPOTHESES

In this study we analyze the influence of financial literacy and numeracy on money illusion at an individual level. To do so, we design and create an experiment using an individual incentive choice task to measure money illusion. This task consists of a series of choices between a pair of simple bonds whose returns are influenced by inflation (deflation).

1.3.1 Error rate and choice characteristics

We consider participants who do not choose the right bond (having the best real return) as making errors when calculating bonds' real values or returns and thus as suffering from

money illusion. This incorrect choice can occur when, faced with nominal decision-making, participants only take into account nominal values or rates of return or take into account the inflation rate but do so inaccurately. We also relate our task to a money illusion questionnaire close to that of Shafir, Diamond and Tversky (1997). We make the following hypothesis (*hypothesis 1*): the error rate (number of errors in choices) is an individual measure of money illusion, and participants who have high scores of money illusion in the money illusion questionnaire have high error rates in our task.

Then, we design our experiment such that we can control the effect of different contexts on money illusion. Hence, we vary four important choice characteristics between both bonds: price change (inflation or deflation), initial value (high or low), difference of final real values (high or low), and respective rankings of real and nominal final values (congruent or not). Consequently, we assumed that (*hypothesis 2)*: error rate increases in a deflation context; when nominal bonds' values are high; when bonds' return difference is low; when the rankings of the bonds' real and nominal final values are not congruent.

1.3.2 Error rate and individual characteristics

The errors – money illusion – may be influenced by individual characteristics, such as financial literacy (misunderstanding of the nature of assets or of the impact of inflation on the value or the return of assets) and numeracy (miscalculation), as well as loss aversion and risk aversion attitudes. We assume *(hypothesis 3)*: that money illusion decreases with financial literacy and with numeracy skills. We do not make any assumptions concerning loss aversion and risk aversion.

1.3.3 *Effects of the complexity of the task*

First, we introduce uncertainty into some financial choices regarding bonds' returns and hypothesize (*hypothesis 4a*): that error rate is higher in uncertain situations.

Second, we instruct participants to make financial choices via two other framings. First, rather than displaying final nominal values (the *basic* framing), the nominal returns of the bonds is presented (the *return* framing). The *return* framing is more closely related to the usual presentation of bonds. We assume (*hypothesis 4b*) that money illusion decreases in the *return* framing since real returns are easier to compute and compare than final real values. Indeed, to compute real returns, participants just have to subtract inflation to nominal returns, whereas in the *basic* framing, they have to make divisions to calculate real values. Second, in the other framing (*real*), no calculation is required to determine bonds' real value since the framing

presents real rather than nominal values. This enables us to test the influence of nominal vs. real presentation. We assume (*hypothesis 4c*): that money illusion decreases in the *real* framing.

2. METHOD

2.1 PARTICIPANTS AND PROCEDURE

The experiment was conducted in French at the Laboratory of Experimental Economics in Paris (LEEP). Subjects were recruited using an online system (ORSEE). There were 96 participants (44 females and 52 males), aged 24.6 years on average. 30 participants held a master's degree, 39 a bachelor's degree and 27 were high school graduates. 14 participants were enrolled in a law degree program and 19 in an economics or finance degree program. Overall, 52 participants had at least one course in Economics or Finance. The experiment consisted of six sessions with 11 to 18 participants per session. Sessions averaged approximately one hour and twenty minutes in length.

The experiment was divided into 8 steps. Participants had to answer, in the following order, a first questionnaire that consisted only of sociodemographic questions, a first trial of choices (*basic* certain and uncertain bonds), a second questionnaire mixing financial literacy and money illusion questions, a second trial of choices (*return* certain bonds), a third questionnaire mixing financial literacy and money illusion questions, a third trial of choices (*real* certain and uncertain bonds), the Holt-Laury aversion procedure, a loss aversion measure and finally a numeracy task.

The final gain is the sum of four components: the gain in euros of one randomly drawn choice, the outcome of the risk aversion lottery, the gain in the numeracy task and a 5 euros participation fee. The mean gain was 20.5 euros (*sd* = 1.42).

Instructions were read and orally explained, projected on individual computers and printed out.

2.2. DESIGN AND MEASURES

2.2.1. Financial task

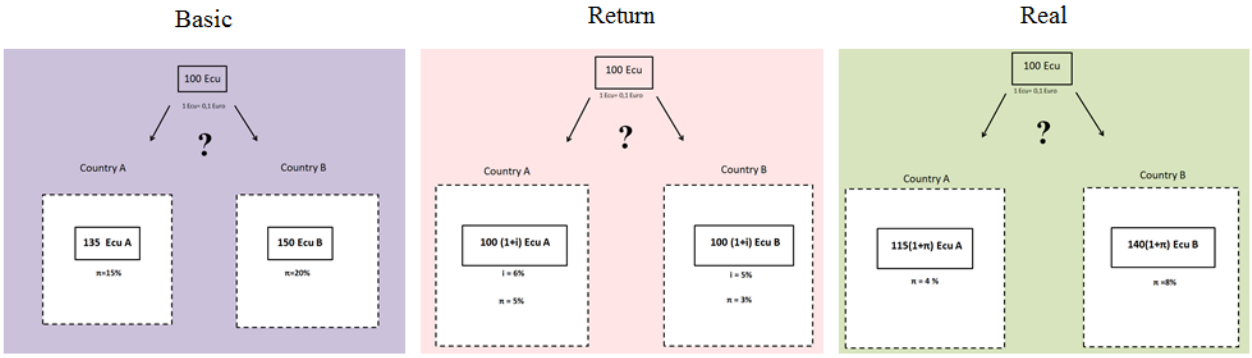
Participants had to make 88 financial choices. We introduced an experimental unit of account (ECU) to process to these choices. The exchange rate of the ECU in euros was always mentioned and depended on the inflation (deflation) rate. For each choice, participants had to choose between two simple bonds (A or B) to invest in for one period. Both bonds had the same initial value (ECU 100 or 1000). They differed in their return and the inflation

(deflation) rate that affects this return, as if participants had to choose between two countries (A and B) in which to invest. Bonds' return was presented in the form of final nominal value, nominal rate of interest or final real value depending on the framing, as already mentioned (see Figure 1 and Appendix A for a more detailed description of the three framings used and of the instructions). The order of presentation of choices inside each framing was randomized across participants, and the display of the pair of bonds was randomized across trials.

The three framings presented the inflation (deflation) rate (π) with a particular presentation of both bonds: the *basic* framing presented their final nominal values (*NV*), the *return* framing their nominal rates of return (*NR*) and the *real* framing their final real values (*RV*).

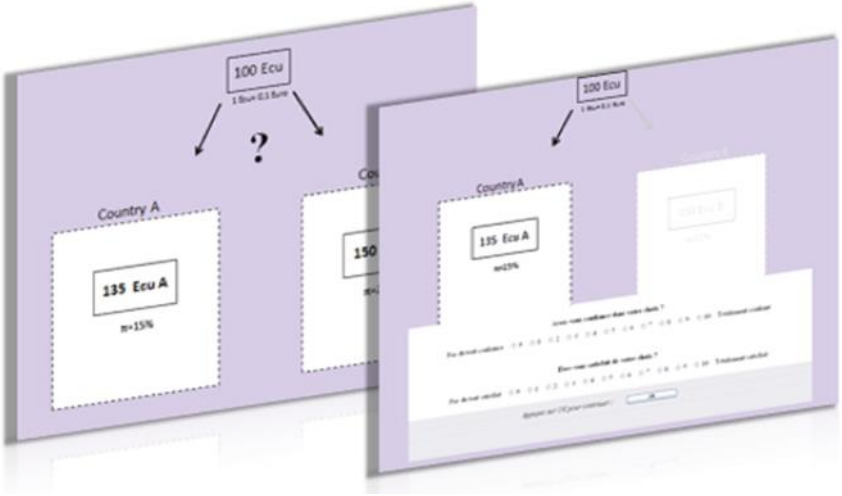
To give a correct answer, participants had to choose the bond with the higher real value (or return). Otherwise, their choice was an error. We first compute the mean individual error rate and transform it into log odds. Whenever the mean error rate is null or equal to 1, we replace its value by .01 or .99.

Figure 1: Three framings of financial choices



Once subjects have chosen the bond to invest in, they had 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 (See Figure 2). We compute the mean of confidence and satisfaction. We define metacognitive sensitivity as the difference between the mean confidence in correct choices of bonds and the mean confidence in incorrect choices. The higher the difference, the more able a subject is to detect his errors. For each choice, the time of response (seconds) of each participant was recorded.

Figure 2: Example of choice in the *basic* framing



First, subjects have to select the bond in which they want to invest; second, they have to indicate the level of satisfaction and confidence they have with the bond they have chosen.

Basic framing

The *basic* framing was presented first. 40 certain pairs of bonds were presented to participants along with 5 uncertain ones (built upon 10 certain pairs of bonds). All these choices are described in Appendix B (Tables B1 and B2).

We designed the *basic* pairs of bonds according to 4 characteristics:

1. Price changes: the *inflation*-condition refers to a choice where both bonds were in an inflation context; the *deflation*-condition to a choice where both bonds were in a deflation context; and the *mixed*-condition to a choice where one bond was in an inflation context, and the other in deflation.

2. Real and nominal values: the *congruency*-condition refers to a choice where the bond having the higher final real value also had the higher final nominal value (*vs*. the *non-congruent*-condition).

3. Initial value: the *low-value* condition refers to a choice where the bonds' initial value was equal to 100 ECU and the exchange rate between the ECU and the euro was equal to 0.1; the *high-value* condition refers to a choice where the initial value was equal to 1000 and the exchange rate between the ECU and the euro was equal to 0.01. In both cases, the initial value was equivalent to 10 euros.

4. Difference in final real values: the *low-difference* condition refers to a choice where the difference between the real values of both bonds was low (1 ECU in the *low-value* condition; 10 ECU in the *high-value* condition)[2]; the *high-difference* condition refers

[2] 1 ECU or 10 ECU is equal to 0.10 or 0.20 euro.

to a situation where this difference was high (6 ECU in the *low-value* condition; 60 ECU in the *high-value* condition)[3].

Based upon these characteristics, we created five blocks of 8 choices, which are described in Table 1 (for a more detailed description of each block see Appendix B table B6).

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

Block	1	2	3	4	5
initial value	100 ECU	100 ECU	100 ECU	1000 ECU	1000 ECU
Difference in real value	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
Price change *congruency	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 = Non-Congruent, C = Congruent
I = Inflation, D= Deflation and M= Mixed

Return framing

The *return* framing was the second framing presented and was composed of 20 choices. The 20 pairs of bonds were designed based on certain *basic* pairs of bonds (Appendix B Table B3).

Real framing

The *real* framing was the last framing presented and consisted of 20 certain and 3 uncertain choices. Of the 20 certain choices, 5 were built upon *basic* choices. (Appendix B Tables B4 and B5). We have common pairs of bonds in the three framings.

2.2.2. Individual measures based on questionnaires

Financial literacy

4 questions were asked to the participants. Three of them were already used to study financial literacy (Arrondel and Masson 2014; Lusardi and Mitchell 2014; Arrondel, Debbich and Savignac 2014). The first two questions enable us to check whether participants understand interest rates, the third one measures their understanding of the inflation concept. We added a fourth question related to our experimental task: "*What will be the real value of an investment of 1000 invested for a year at the rate of 10% for an inflation rate of 5%?*"). We created a financial literacy indicator via the computation of the four answers the participants gave to these questions (0 to 4).

[3] 6 ECU or 60 ECU is equal to 0.60 euro.

Money illusion

20 questions were asked to the participants. 14 questions are based on Shafir, Diamond and Tversky (1997)'s 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 answers. In particular, respondents were asked to compare and judge different hypothetical situations concerning the same person (i.e., scenarios rather than the situations of different persons). 3 questions are based on a new problem added by Guille and Mercier (2017) about the impact of inflation on a bond's return. We added a specific problem including 3 questions related to inflation-indexed bonds. A money illusion indicator was created according to the 20 answers participants gave to these questions (0 to 20).

Numeracy

We created a specific numeracy test in relation to the financial task. Participants had to compare six pairs of ratios. Each ratio was created with values used in the task. Participants earned 0.50 euro for each correct answer. We computed a score of numeracy according to the six comparisons made by participants (0 to 6).

2.2.3 Measures of risk and loss aversion

Risk aversion

Risk aversion was elicited through a Holt and Laury (2002) procedure. The gains in the sure option (A) were 2 € and 1.6 €, while the gains in the risky option (B) were 3.85 € and 0.1 €. Subjects had to make ten choices with the probability of high gains ranging from 10% to 100% by increments of 10%. All the choices were displayed simultaneously in one table. To avoid multiple switches between both options, subjects could switch from option A to option B one time at most. The choices were incentivized. We measure risk aversion by the number of times the sure option was chosen.

Loss aversion

To elicit loss aversion, subjects were asked to choose between: a lottery ticket (A') which gives a 50% chance of winning 50 € and a 50% chance of losing 50 €, and a sure outcome (B'). There were eleven choices with a sure outcome varying from + 50 € to – 50 € by an increment of 10 €. All the choices were displayed simultaneously in one table and multiple switches were not allowed. Subjects could switch from option A' to option B' one time at most. The choices were not incentivized. We measure loss aversion by the number of times the lottery ticket was chosen

3. RESULTS

3.1. DESCRIPTIVE RESULTS

3.1.1. Individual characteristics and financial tasks

See Appendix C, Table C1 and Table C2 for an overview of all measures.

Table 2: Mean errors and T-test of variables according to economic training and gender

	VARIABLES	EcoFi (n=52)	Others (n=44)	Male (n=44)	Female (n=52)
Individual measures	*Numeracy*	4.63	3.91	4.68	3.98
		(.20)	*(.25)*	*(.20)*	*(.23)*
		t(94)=-2.28***		t(94)=2.2***	
	Financial literacy	3.15	2.52	3.27	2.5
		(.13)	*(.16)*	*(.13)*	*(.15)*
		t(94)=-3.08***		t(94)=3.76***	
	Money illusion	9.46	12.73	9.57	12.13
		(.56)	*(.42)*	*(.63)*	*(.44)*
		t(94)=4.51***		t(94)=-3.40***	
	Loss aversion	4.85	4.70	4.81	4.75
		(.30)	*(.41)*	*(.36)*	*(.34)*
		t(94)=0.28		t(94)=-0.12	
	Risk aversion	6.33	6.00	6.34	6.04
		(.26)	*(.34)*	*(.27)*	*(.31)*
		t(94)=0.77		t(94)=-0.71	
Financial task measures	*Error ratio*	.27	.36	.26	.36
		(.02)	*(.03)*	*(.03)*	*(.03)*
		t(94)=2.16***		t(94)=-2.55***	
	Error log odds ratio	-1.15	-.67	-1.24	-.66
		(.14)	*(.15)*	*(.14)*	*(.15)*
		t(94)=2.34***		t(94)=-2.84***	
	Mean confidence	7.56	6.72	8.00	6.48
		(.19)	*(.22)*	*(.19)*	*(.18)*
		t(94)=-2.89***		t(94)=-5.81***	
	Mean satisfaction	7.08	6.30	7.49	6.07
		(.18)	*(.21)*	*(.21)*	*(.14)*
		t(94)=-2.79***		t(94)=-5.75***	
	Metacognition sensitivity	.68	.38	.68	.43
		(.12)	*(.10)*	*(.14)*	*(.09)*
		t(94)=1.84*			
	Mean response time	14.88	9.97	14.18	11.32
		(1.21)	*(.73)*	*(.99)*	*(1.13)*
		t(94)=-3.33*		t(94)=-1.87*	

Standard errors in parentheses

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

For financial literacy, numeracy, money illusion questionnaire and measures in the financial task, there are significant differences between males and females and between participants who declared to follow economics or finance lectures and others, but none for loss aversion and risk aversion (Table 2). In particular, participants with a training in economics or finance had a better performance in the financial task, the numeracy task, financial literacy and money illusion questionnaires.

3.2 TESTS OF MAIN HYPOTHESES

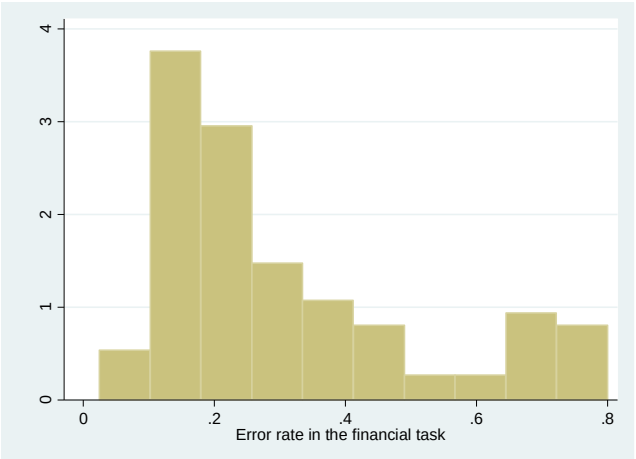
3.2.1 Error rate (Hypothesis 1)

The mean error rate is measured based on the 40 *basic* certain choices. On average, participants had a rate of error equal to 31% (*sd*= .2, see Appendix C, table C1). Hence, participants chose the wrong bond in three out of ten choices. If they had chosen randomly between both bonds, the mean error rate would be 50%, while if they had chosen the bond having the higher nominal value, the mean error rate would be 75% (see Figure 3 for the actual distribution of errors).

The error rate and the error log odd ratio in the financial task are significantly and positively correlated with the measure of money illusion in the questionnaire (r=.37 and r=.39, respectively, p<0.01, see Appendix C, table C2).

These results support our hypothesis 1 and are consistent with previous results pointing to a significant prevalence of money illusion. Hence, the error rate in the task can be considered as an individual measure of money illusion in a financial context.

Figure 3: Histogram of the error rate in the financial task (*basic* framing)



3.2.2 Influence of choice characteristics (Hypothesis 2)

We then analyze the effect of choice characteristics on errors: price change, congruency, initial value, and difference in real value. 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.

First, a logistic regression analysis (Table 4, column 1) was conducted to explain the errors in the task according to choices' characteristics. Inflation and congruent conditions reduced the mean error rate (e.g., on average, participants made fewer errors in inflation rather than in deflation or mixed contexts, as well as when bonds' final real and nominal values were congruent). On the contrary, choices in *high-value* and *low-difference* conditions increased the mean error rate.

Second, three OLS regressions (Table 4, columns 2, 3 and 4) were conducted on confidence, satisfaction and response time. Our results show that participants were more confident in their choices in *inflation*-condition (rather than in *deflation* or *mixed* ones) and less confident *in high-value* and *low-difference* conditions. Satisfaction follows an equivalent pattern of results for all choice characteristics, except for the bonds' initial values. Interestingly, participants were more satisfied in *high-value* condition. Response time was lower in the *mixed*-condition and higher in *high-value* and *low-difference* conditions.

Table 4: Choice characteristics of the mean error rate, confidence, satisfaction and response time

VARIABLES	(1) Error	(2) Confidence	(3) Satisfaction	(4) Response time
Method	*Logit (odds ratio)*	*OLS*	*OLS*	*OLS*
Observations	*3,072*	*3,072*	*3,072*	*3,072*
R-squared		0.020	0.016	0.009
*mixed*non-congruent*	1.234*	-0.400***	-0.206**	-2.020***
	(0.156)	(0.1022)	(0.094)	(0.646)
*deflation*non-congruent*	2.626***	-0.374***	-0.292***	0.275
	(0.397)	(0.0845)	(0.0874)	(0.763)
*deflation*congruent*	1.088	-0.403***	-0.303***	0.132
	(.0825)	(0.0722)	(0.080)	(0.894)
high-value	1.332***	-0.150***	0.175**	2.434***
	(0.0939)	(0.0522)	(0.071)	(0.577)
low-difference	1.312***	-0.363***	-0.332***	1.262**
	(0.1034)	(0.0564)	(0.0532)	(0.533)
constant	0.273***	7.634***	6.926***	11.18***
	(0.0494)	(0.155)	(0.159)	(0.821)

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

3.2.3 Influence of individual characteristics (Hypothesis 3)

Five OLS regressions (Table 5) were conducted to study the influence of individual characteristics (numeracy, financial literacy, loss aversion and risk aversion) on performance, confidence, satisfaction and metacognition sensitivity in the task and money illusion score in the questionnaire

We only found one significant decreasing relation between the rate of error and financial literacy; the other characteristics had no impact on it (Table 5, column 1). Interestingly, we also found an increasing relation between financial literacy and mean confidence, mean satisfaction and metacognition (Table 5, columns 2, 3 & 4). Overall, financially literate participants made fewer errors in the task, were more confident in their choices, more satisfied and more able to detect their errors. They also had a lower score in the money illusion questionnaire. Consequently, financially literate participants were less affected by money illusion bias.

Note that training in economics or finance and gender are not significant when introduced in the regressions.

Table 5: Individual characteristics over errors, confidence, satisfaction and metacognition in the task and money illusion score

VARIABLES	(1) Error log odds ratio	(2) Mean confidence	(3) Mean satisfaction	(4) Metacognition sensitivity	(5) MI-Question.
Method	*OLS*	*OLS*	*OLS*	*OLS*	*OLS*
Observations	*96*	*96*	*96*	*96*	*96*
R-squared	*0.217*	*0.136*	*0.112*	*0.089*	*0.302*
Numeracy	-0.0331	0.0593	0.01081	-0.0153	-0.574**
	(0.0648)	(0.0977)	(0.0943)	(0.0544)	(0.231)
Fin.lit.	-0.4440***	0.4156***	0.3329**	0.226***	-1.700***
	(0.0944)	(0.1426)	(0.1376)	(0.0794)	(0.337)
loss_aver	0.0241	-0.0870	-0.0953	0.0213	0.127
	(0.0418)	(0.0630)	(0.0608)	(0.0351)	(0.149)
risk_aver	0.0520	0.0100	0.1087	-0.0405	0.216
	(0.0520)	(0.0716)	(0.0691)	(0.0399)	(0.169)
Constant	0.0513	5.5251***	5.5039***	0.110	16.35***
	(0.0513)	(0.6406)	(0.6180)	(0.357)	(1.515)

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

To investigate whether participants were sensitive to choice characteristics 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 made more errors in the non-inflation (*deflation* and *mixed* conditions), *non-congruent*, *high-value* and *high-difference* conditions than in the respective second one. We explain these differences

of individual characteristics using OLS regressions (Table 6). We remark that only financial literacy has a significant impact: it reduced the difference in the error rate between *non-congruent* and *congruent* choices in deflation conditions, but slightly increased this difference between *non-inflation* and *inflation* conditions and *low-* vs. *high-difference* conditions. In other words, participants with high financial literacy were more sensitive to *non-inflation* and *low-difference* conditions and less sensitive to *non-congruency* in *deflation* conditions. These results support the hypothesis that highly financially literate participants tried to maximize their real returns, while the less financially literate ones were more influenced by nominal returns.

Table 6: Influence of individual characteristics on the differences in the error log odds ratio

VARIABLES	(1)	(2)	(3)	(4)
Difference in mean error log odds ratio	*non-inflation vs. inflation*	*non-congruent vs. congruent in deflation*	*high-value vs. low-value*	*low-difference vs. high-difference*
Method	*OLS*	*OLS*	*OLS*	*OLS*
Observations	*96*	*96*	*96*	*96*
R-squared	*0.075*	*0.214*	*0.029*	*0.108*
Numeracy	-0.052	-0.312	0.061	0.086
	(0.109)	(0.236)	(0.065)	(0.072)
Fin.lit.	0.386**	-1.397***	0.097	0.292***
	(0.158)	(0.344)	(0.095)	(0.106)
Loss_aver	-0.072	0.083	-0.002	-0.026
	(0.070)	(0.152)	(0.042)	(0.047)
Risk_aver	-0.013	0.395**	0.011	-0.031
	(0.080)	(0.173)	(0.048)	(0.053)
Constant	0.171	3.691**	-0.107	-0.350
	(0.711)	(1.546)	(0.429)	(0.477)

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

3.2.4 Influence of complexity (Hypothesis 4)

The uncertainty effect. To test the influence of uncertainty, we calculate the difference in the error log odds ratio between certain and uncertain choices. We only consider pairs of bonds in the *basic* framing that were used both in certain and uncertain choices (10 certain *vs.* 5 uncertain choices). Surprisingly, participants made 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=-.97, *sd*=1.63). Confidence was not significantly different, while satisfaction was significantly higher in uncertain financial choices (mean difference = 0.18, t(1)= 1.77, p = 0.04). These results do not support our *hypothesis 4a*.

The framing effect. The existence of a framing effect was tested by comparing participants' errors and perceptions in two sets of common choices presented in the *basic* and *return* framings and in the *basic* and *real* framings.

The difference between the *basic* and *return* framings was based on 20 common choices. The error log odds ratio in the *return* framing (M=-1.14, sd=.12) is positively correlated (r=.60, p<0.01) with the error log odds ratio in the *basic* framing (M=-1.18, sd=.09). The difference between the two error log odds ratios is not significant (mean difference=0.04, t(1)= 0.43, p = 0.33). Mean satisfaction and confidence are also not significantly different between the framings. We found no relation between individuals' characteristics and the difference in mean errors between both framings.

The difference between the *basic* and *real* framings was based on 5 common choices. The error log odds ratio in the *real* framing (*M*=-1.56, *sd*=.26) is positively correlated (r=.32, p<0.01) to the error log odds ratio in the *basic* framing (*M*=-1.55, *sd*=.30). The difference between the two error log odds ratios is not significant (mean difference=-.01, t(1)= -0.03, p = 0.49). Mean satisfaction and confidence are also not significantly different between the framings. These findings do not support our hypotheses *4b* and *4c*.

4. DISCUSSION

The objectives of the current study were, first, to provide an individual measure of the money illusion bias in the context of simple financial choices using an experimental task and to analyze the effects of choices' characteristics; and second, to investigate the impact of financial literacy and numeracy skills on the money illusion bias in this context.

First, participants made frequent errors in the task. On average, the rate of errors equals 31% in the *basic* framing, which means many participants did not correctly take inflation (deflation) into account when choosing between two simple bonds. Moreover, the participants' mean error rate is positively correlated with their individual score in the money illusion questionnaire.

This result is consistent with previous findings and supports the existence of a serious money illusion bias. Clearly, some participants chose the bond having the higher nominal rather than real value. These errors may be due either to nominal reasoning (preference) or to miscalculations that may come from computational difficulties or a misunderstanding of the real value (the calculation of which has to be performed).

Our results are also consistent with previous findings in the literature regarding the asymmetry between inflation and deflation contexts. Participants made more errors in

deflation than in inflation contexts, as shown in the money illusion surveys. Indeed, participants' answers were more biased by money illusion when comparing deflation than inflation scenarios, and even when participants were able to select the most profitable scenario in real terms they were not satisfied with it in deflation conditions (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. We also observe more errors in non-congruent than congruent choices. This result shows that nominal preference may be one – but not the only – explanation of money illusion. Indeed, if all participants were driven by nominal or real preferences, the rate of errors in congruent choices would tend to zero. Moreover, this rate of errors depends on two other choice characteristics (value and difference). High bonds' nominal values and low differences of return between both bonds tend to increase money illusion bias. These findings support the hypothesis of a complex bias deriving from several sources. The first effect suggests a possible nominal preference, consistent with Lea and Webley (2006)'s view, namely money as drug, while the second effect indicates 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, as suggested by Shafir, Diamond and Tversky (1997). The fact that response time was longer in *high-value* and *low-difference* choices supports the hypothesis of computational difficulties.

Regarding the effect of individual characteristics, we only observe a decreasing and significant relationship between the error rate and success in the financial literacy questionnaire. This relation was expected since one of the items of the financial literacy questionnaire measures the ability to calculate a real value. In contrast, the relationship with numeracy skills is not significant, as well as those with loss aversion and risk aversion. Numeracy skills do not seem to help participants to calculate in a financial environment, which is surprising because the calculus required to compare the two bonds is the same as that in the numeracy questionnaire. This result suggests that the money illusion bias cannot be confined to simple mistakes of real values' computation from nominal values.

We observe two other 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 did not know how to choose between both lotteries, or who had a preference for low inflation, could then have adopted 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 rates of error in the *basic* framing and the other framings. Hence, participants are not benefitted or disadvantaged by any framing interventions, contrary to what we expected. Particularly, in the *real* framing, there was no issue with computing the real value, and participants who understood the meaning of real value should have succeeded easily, which was not the case. Participants were equally affected by money illusion in all framings.

Overall, our results show that the main source of money illusion in financial decisions is the understanding of real value. This issue appears to be serious and difficult to solve, as was shown by the absence of any framing effect. This result can be an explanation of the lack of success observed for inflation-indexed bonds. Furthermore, our findings support the idea that the money illusion bias goes beyond a problem of financial environment knowledge (persistence of money illusion with financial literacy skills) and of computing abilities (absence of an effect of numeracy). Consequently, the money illusion bias may be an important source of suboptimal choices in households' financial behavior. This observation raises the issue of a possible debiasing of money illusion by specific programs of financial education.

However, there is a real difficulty in improving the financial behavior of households, as shown by the obstacles encountered by financial literacy education programs implemented in recent years (Grohmann 2018; Fernandes, Lynch and Netemeyer 2014). Skagerlund et al. (2018) explain these failures with a potential endogeneity in the relationship between financial literacy and financial behavior caused by unobserved variables, such as numeracy. As a component of numeracy skills, money illusion could be an ability essential to making optimal financial choices. Mak and Braspenning (2012) argue that the current regulation in the EU consumer credit market (MiFID II) does not guarantee the complete protection of consumers, and they advocate that this regulation should pay more attention to consumer groups who have low financial literacy skills. In addition, Altman (2012) notes that households with low financial literacy have a "trust heuristics", which means that they have a higher propensity to trust their financial advisor (see Carmel et al. 2015). Consequently, and in the light of our results, programs and consumer protection regulation could add a component dedicated to money illusion. The relevance of this type of program could be tested in further studies since money illusion matters in many financial decisions, particularly long-term ones (savings, pensions, loans or real estate decisions).

While our results highlight the complexity of money illusion, further studies need to be performed to identify more precisely the sources of the money illusion bias (miscalculation,

misunderstanding and nominal preference) according to the context of choices and individual abilities. For example, it would also be useful to investigate the possibility of decreasing the money illusion bias by implementing a lecture on real and nominal values before the task. It would also be interesting to further explore the absence of a relationship between money illusion and numeracy. Our numeracy task was built on division used in the financial task since we expected participants to use division to calculate real values. Yet, they could have used other processes to compute real values, for instance approximation by subtracting inflation to the real rate of return. Hence, other measures of numeracy could be added to the experiment, for instance more standard ones (e.g., the Berlin Numeracy Test).

In conclusion, we propose a simple, incentivized and precise individual measure of money illusion bias. This experimental measure is correlated with the usual measures of money illusion based on questionnaires. On average, according to this measure, thirty percent of participants were affected by money illusion. Participants were highly sensitive to the contexts of the financial choices they faced. Particularly, they were more affected by money illusion in deflation than in inflation situations, which is consistent with previous findings. Moreover, money illusion decreases with financial literacy skills, but there is no effect of numeracy. More generally, these findings should lead to further studies on the possibilities and tools that could improve financial behavior and reduce money illusion bias.

REFERENCES

Abreu, M., & Mendes, V. (2010). Financial literacy and portfolio diversification. *Quantitative Finance, 10*(5), 515-528.

Akerlof, G., & Shiller, R. (2010). *Animal spirits: How human psychology drives the economy, and why it matters for global capitalism*. Princeton University Press.

Almenberg, J., & Widmark, O. (2011). Numeracy, financial literacy and asset market participation. *Journal of Pension Economics and Finance*, 10, 585-598.

Altman, M. (2012). Implications of behavioural economics for financial literacy and public policy. *The Journal of Socio-Economics*, 41(5), 677-690.

Ameriks, J., Caplin, A., & Leahy, J. (2003). Wealth accumulation and the propensity to plan. *The Quarterly Journal of Economics*, 118(3), 1007-1047.

Arrondel, L., & Masson, A. (2014). Mesurer les préférences des épargnants: comment et pourquoi (en temps de crise)?. *Economie et Statistique*, 467(1), 5-49.

Arrondel, L., Debbich, M., & Savignac, F. (2014). Financial literacy and financial planning in France. *Numeracy*, 6(2), 8.

Asness, C. (2000). Stocks versus bonds: explaining the equity risk premium. *Financial Analysts Journal*, 56(2), 96-113.

Bodie, Z., & Crane, D. (1997). Personal Investing: Advice, Theory, and Evidence. *Financial Analysts Journal*, 53(6), 13-23.

Bourgeois-Gironde, S., & Guille, M. (2011). Keynes's animal spirits vindicated: an analysis of recent empirical and neural data on money illusion. *Journal of Post Keynesian Economics*, *34*(2), 331-352.

Bucher-Koenen, T., Lusardi, A., Alessie, R., & Van Rooij, M. (2017). How financially literate are women? An overview and new insights. *Journal of Consumer Affairs*, *51*(2), 255-283.

Campbell, J. (2006). Household finance. *The Journal of Finance, 61*(4), 1553-1604.

Carmel, E., Carmel, D., Leiser, D., & Spivak, A. (2015). Facing a biased adviser while choosing a retirement plan: the impact of financial literacy and fair disclosure. *Journal of Consumer Affairs*, *49*(3), 576-595.

Cipriani, G., Lubian, D., & Zago, A. (2008). Money Illusion: Are Economists Different?. *Economics Bulletin*, 1(3), 1-9.

Cohen, R., Polk, C., & Vuolteenaho, T. (2005). Money illusion in the stock market: The Modigliani-Cohn hypothesis. *The Quarterly Journal of Economics*, *120*(2), 639-668.

Fehr, E., & Tyran, J. (2001). Does money illusion matter? *American Economic Review*, *91*(5), 1239-1262.

Fehr, E., & Tyran, J. (2007). Money illusion and coordination failure. *Games and Economic Behavior*, *58*(2), 246-268.

Fernandes, D., Lynch Jr, J., & Netemeyer, R. (2014). Financial literacy, financial education, and downstream financial behaviors. *Management Science*, *60*(8), 1861-1883.

Fisher, I., (1928). *The Money Illusion*, New York: Adelphi Company.

Gerardi, K., Goette, L., & Meier, S. (2013). Numerical ability predicts mortgage default. *Proceedings of the National Academy of Sciences*, *110*(28), 11267-11271.

Ghazal, S., Cokely, E., & Garcia-Retamero, R. (2014). Predicting biases in very highly educated samples: Numeracy and metacognition. *Judgment and Decision Making*, 9(1), 15–34.

Grohmann, A. (2018). Financial literacy and financial behavior: Evidence from the emerging Asian middle class. *Pacific-Basin Finance Journal*, *48*, 129-143.

Guille, M. and Mercier, F. (2017). Money-illusion: Does an advanced training in economics make a difference?, *Working paper LEMMA.*

Holt, C., & Laury, S. (2002). Risk aversion and incentive effects. *American Economic Review*, *92*(5), 1644-1655.

Huston, S. (2012). Financial literacy and the cost of borrowing. *International Journal of Consumer Studies*, *36*(5), 566-572.

Keynes, J. (1936). *The General Theory of Employment, Interest and Money*. United Kingdom, Palgrave Macmillan.

Lea, S., & Webley, P. (2006). Money as tool, money as drug: The biological psychology of a strong incentive. *Behavioral and Brain Sciences*, *29*(2), 161-209.

Leontief, W. (1936). The fundamental assumption of Mr. Keynes' monetary theory of unemployment. *The Quarterly Journal of Economics*, *51*(1), 192-197.

Lusardi, A. (2012). Numeracy, financial literacy, and financial decision-making. *Numeracy*, 5(1), 1-12.

Lusardi, A., & Mitchell, O. (2007). Financial literacy and retirement preparedness: Evidence and implications for financial education. *Business Economic*s, *42*(1), 35-44.

Lusardi, A., & Mitchell, O. (2011). Financial literacy and retirement planning in the United States. *Journal of Pension Economics & Finance*, *10*(4), 509-525.

Lusardi, A., & Mitchell, O. (2014). The economic importance of financial literacy: Theory and evidence. *Journal of Economic Literature*, *52*(1), 5-44.

Machauer, A., & Weber, M. (1998). Bank behavior based on internal credit ratings of borrowers. *Journal of Banking & Finance*, *22*(10-11), 1355-1383.

Mak, V., & Braspenning, J. (2012). Errare humanum est: Financial literacy in European consumer credit law. *Journal of Consumer Policy*, *35*(3), 307-332.

Mees, H., & Franses, P. (2014). Are individuals in China prone to money illusion? J*ournal of Behavioral and Experimental Economics*, 51, 38-46.

Miyapuram, K., Tobler, P., Gregorios-Pippas, L., & Schultz, W. (2012). BOLD responses in reward regions to hypothetical and imaginary monetary rewards. *Neuroimage*, 59(2), 1692-1699.

Modigliani, F., & Cohn, R. (1979). Inflation, rational valuation and the market. *Financial Analysts Journal*, *35*(2), 24-44.

Noussair, C., Richter, G., & Tyran, J. (2012). Money illusion and nominal inertia in experimental asset markets. *Journal of Behavioral Finance*, *13*(1), 27-37.

Organization for Economics Co-operation and Development (2005). *Improving Financial Literacy: Analysis of Issues and Policies*, Paris, France.

Patinkin, D. (1965). *Money, interest, and prices; an integration of monetary and value theory*. New York, Harper & Row.

Shafir, E., Diamond, P., & Tversky, A. (1997). Money illusion. *The Quarterly Journal of Economics*, *112*(2), 341-374.

Shiller, R. (1997). Why do people dislike inflation?. In Romer, C. & Romer, D. (Ed.), *Reducing inflation: Motivation and Strategy* (pp. 13-70). University of Chicago Press.

Shiller, R. (2005). The Invention of Inflation-Indexed Bonds in Early America. In Goetzmann W. N. and Rouwenhorst G. K., (Ed.), *The Origins of Value: The Financial Innovations that Created Modern Capital Markets* (pp. 239-248). Oxford: Oxford University Press,

Skagerlund, K., Lind, T., Strömbäck, C., Tinghög, G., & Västfjäll, D. (2018). Financial literacy and the role of numeracy–How individuals' attitude and affinity with numbers influence financial literacy. *Journal of Behavioral and Experimental Economics*, *74*, 18-25.

Van Rooij, M., Lusardi, A., & Alessie, R. (2011a). Financial literacy and retirement planning in the Netherlands. *Journal of Economic Psychology*, *32*(4), 593-608.

Van Rooij, M., Lusardi, A., & Alessie, R. (2011b). Financial literacy and stock market participation. *Journal of Financial Economics*, *101*(2), 449-472.

Van Rooij, M., Lusardi, A., & Alessie, R. (2012). Financial literacy, retirement planning and household wealth. *The Economic Journal*, *122*(560), 449-478.

Weber, B., Rangel, A., Wibral, M., & Falk, A. (2009). The medial prefrontal cortex exhibits money illusion. *Proceedings of the National Academy of Sciences*, *106*(13), 5025-5028.

APPENDICES

Appendix A: Experimental Material

Figure A1a: *Basic* framing, certain financial choices

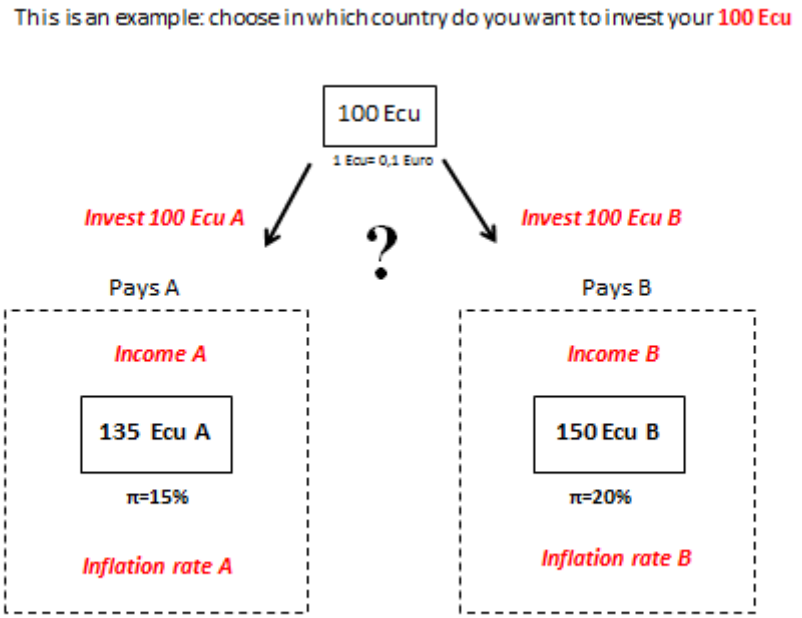


Figure A1: *Basic* framing, gain outline with certain choices

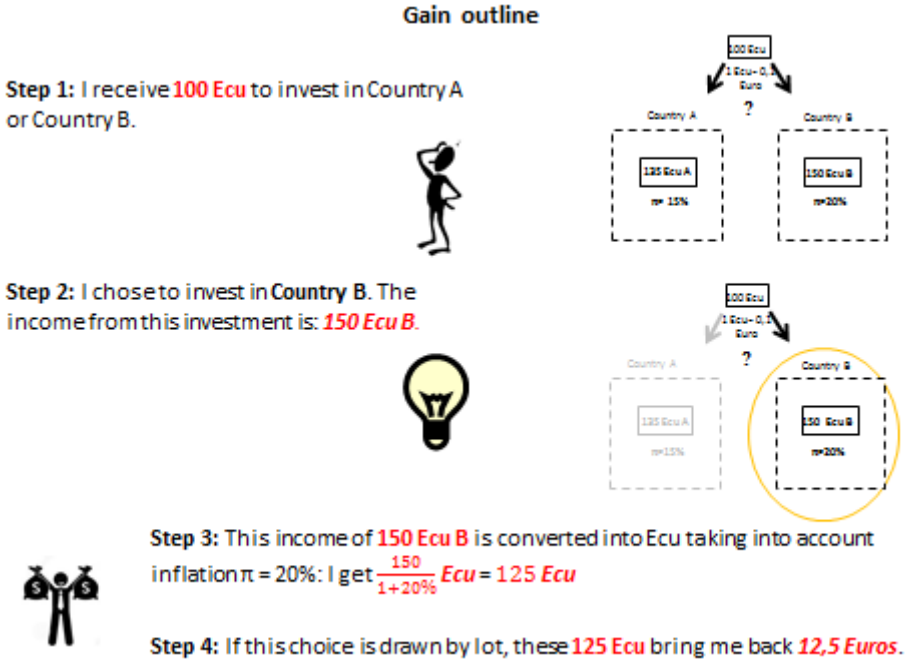


Figure A2a: *Basic* framing, uncertain financial choices

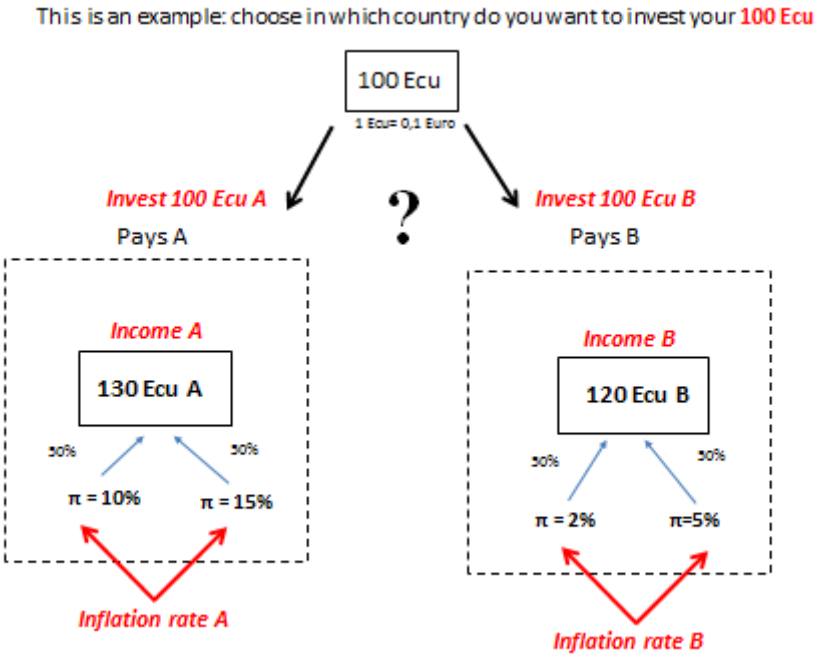


Figure A2b: *Basic* framing, gain outline with uncertain choices

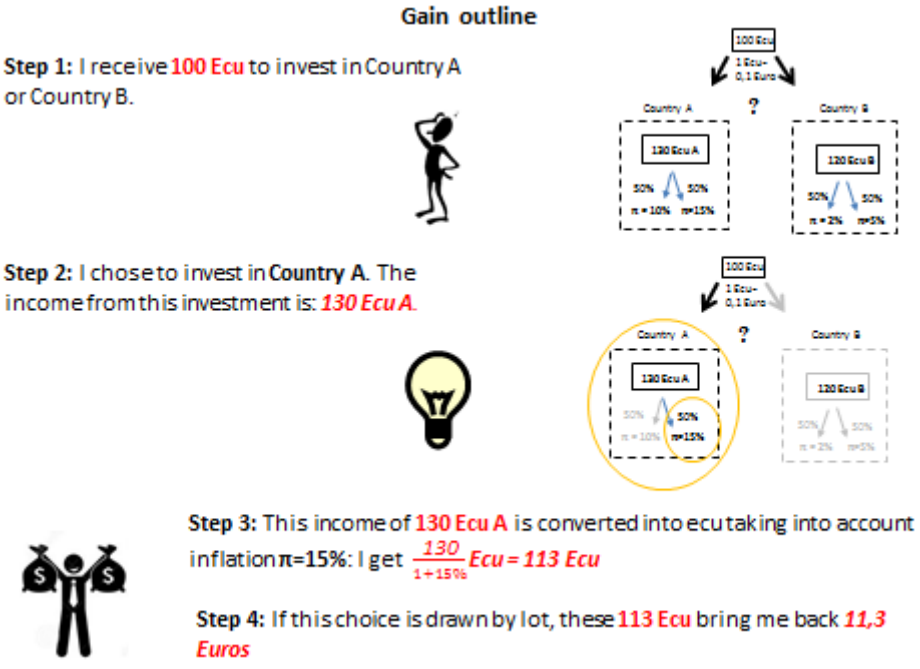


Figure A3a: *Return* framing, certain financial choices

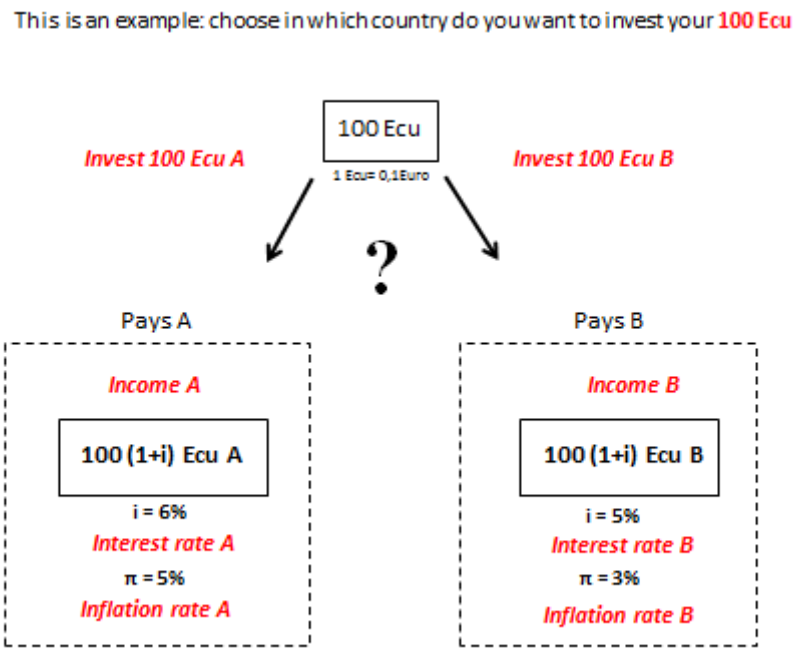


Figure A3b: *Return* framing, gain outline with certain choices

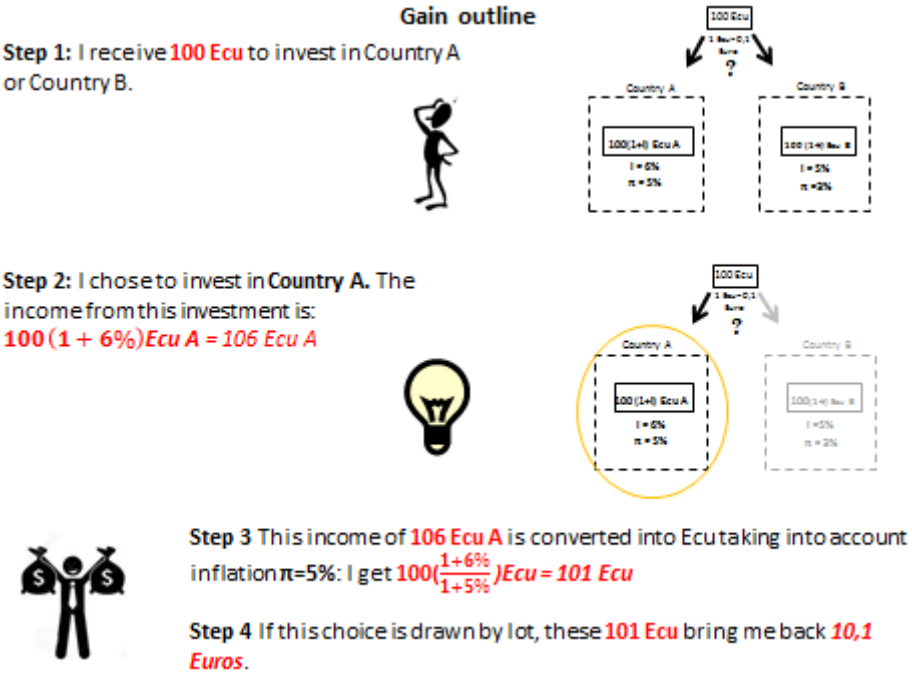


Figure A4a: *Real* framing, certain financial choices

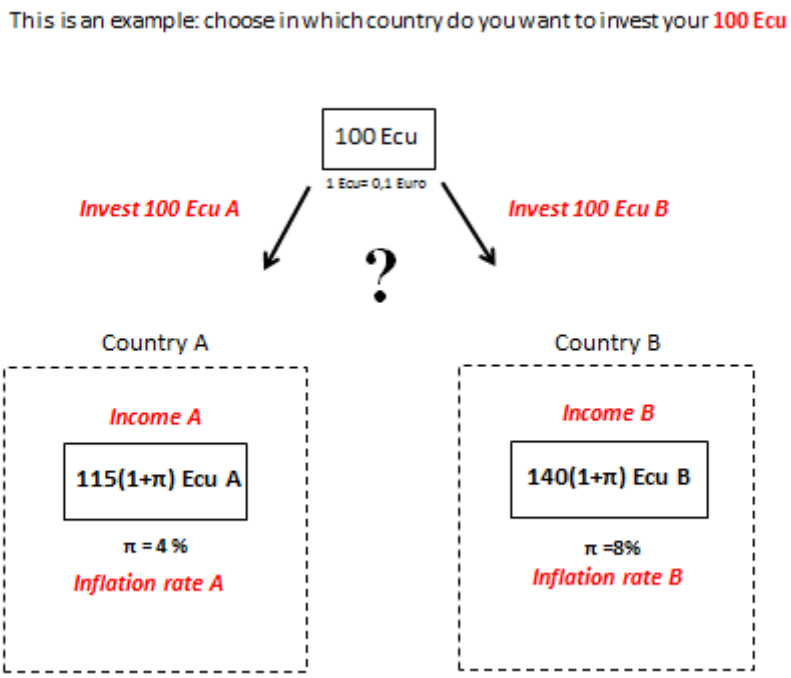


Figure A4b: *Real* framing, gain outline with certain choices

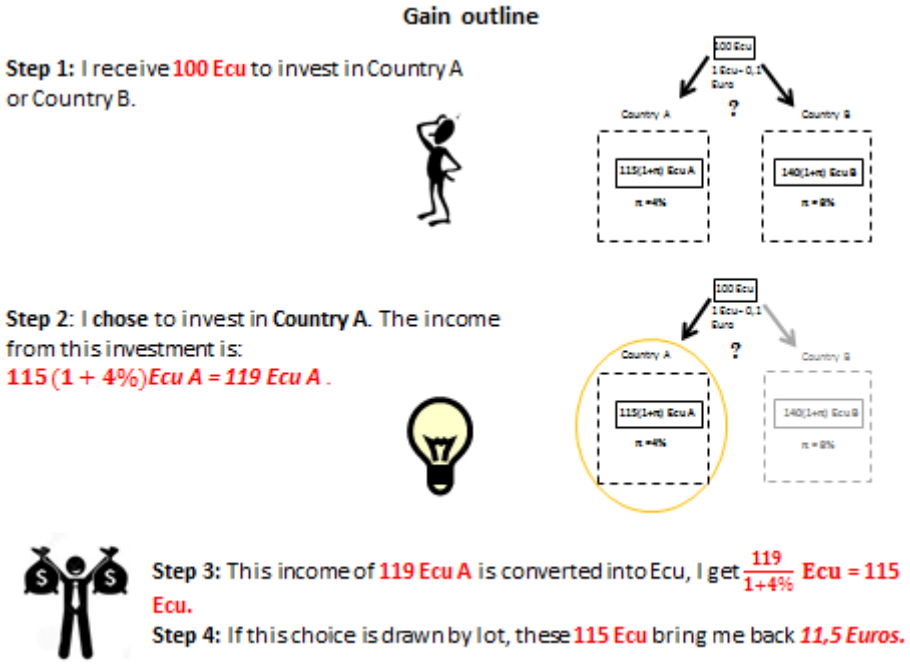


Figure A5a: *Real* framing, uncertain financial choices

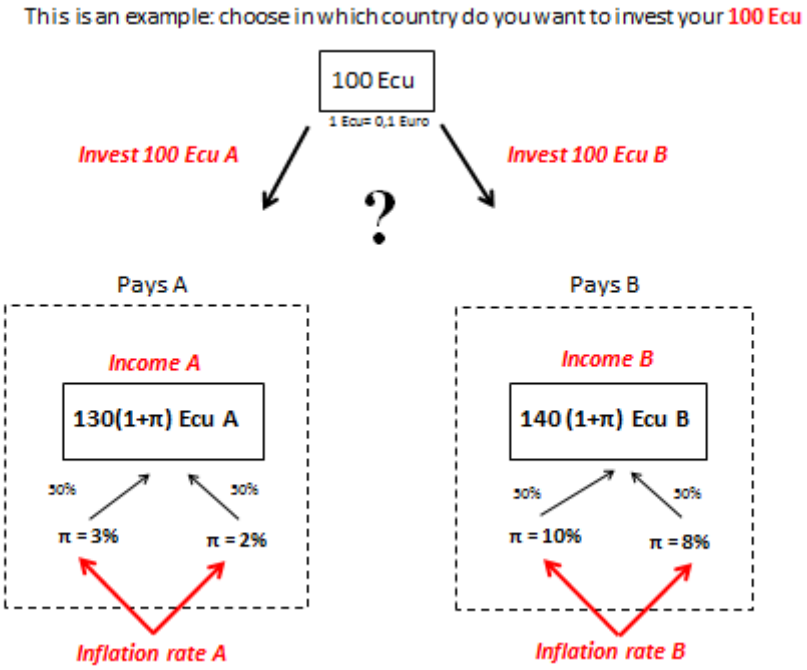
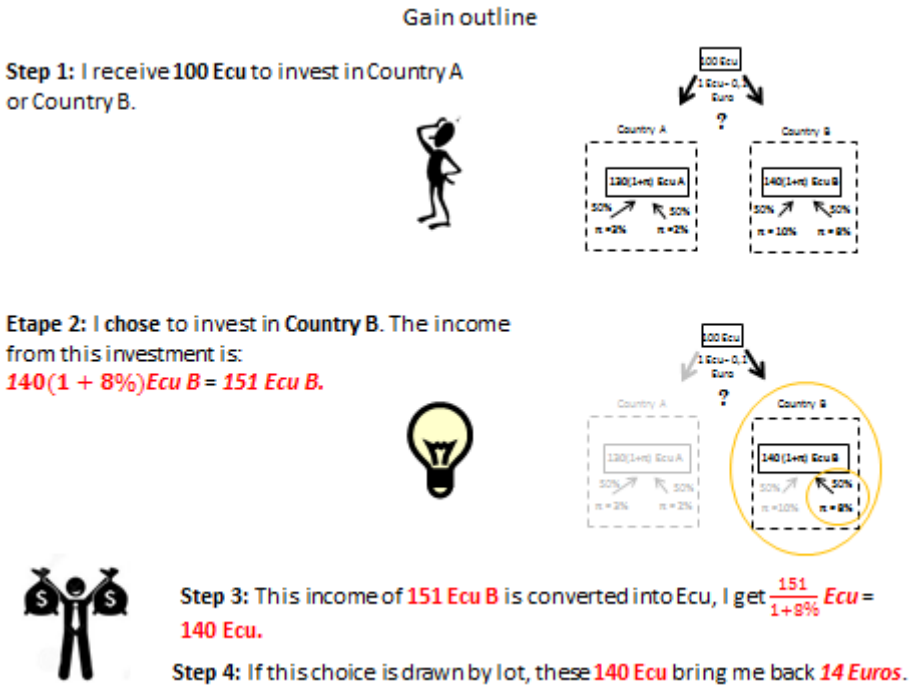


Figure A5b: *Real* framing, gain outline with uncertain choices



Appendix B: Description of financial pairs of bonds

Table B1: *Basic* framing, certain choices

	Inflation A	Inflation B	NV_A	NV_B	RV_A	RV_B
b1	8%	14%	124	130	115	114
b2	1%	14%	116	130	115	114
b3	8%	11%	124	127	115	114
b4	1%	3%	116	117	115	114
b5	-1%	3%	114	117	115	114
b6	-1%	-3%	114	111	115	114
b7	-8%	-3%	106	111	115	114
b8	-8%	-10%	106	103	115	114
b9	7%	15%	126	129	118	112
b10	0%	11%	118	124	118	112
b11	5%	16%	124	130	118	112
b12	0%	6%	118	119	118	112
b13	-4%	4%	113	116	118	112
b14	-3%	-1%	114	111	118	112
b15	-10%	-1%	106	111	118	112
b16	-10%	-12%	106	99	118	112
b17	9%	16%	142	148	130	128
b18	1%	16%	131	148	130	128
b19	9%	3%	142	132	130	128
b20	1%	3%	131	132	130	128
b21	-1%	3%	129	132	130	128
b22	-3%	1%	126	129	130	128
b23	-9%	-3%	118	124	130	128
b24	-9%	-11%	118	114	130	128
b25	8%	14%	1242	1300	1150	1140
b26	1%	14%	1162	1300	1150	1140
b27	8%	11%	1242	1265	1150	1140
b28	1%	3%	1162	1174	1150	1140
b29	-1%	3%	1139	1174	1150	1140
b30	-1%	-3%	1139	1106	1150	1140
b31	-8%	-3%	1058	1106	1150	1140
b32	-8%	-10%	1058	1026	1150	1140
b33	7%	15%	1263	1288	1180	1120
b34	0%	11%	1180	1243	1180	1120
b35	5%	16%	1239	1299	1180	1120
b36	0%	6%	1180	1187	1180	1120
b37	-4%	4%	1133	1165	1180	1120
b38	-3%	-1%	1145	1109	1180	1120
b39	-10%	-1%	1062	1109	1180	1120
b40	-10%	-12%	1062	986	1180	1120

Table B2: *Basic* framing, uncertain choices

	Inflation A 1	Inflation A 2	Inflation B 1	Inflation B 2	NV_A	NV_B
b1-b11	8%	5%	14%	16%	124	130
b7-b15	-8%	-10%	-3%	-1%	106	111
b6-b14	-1%	-3%	-3%	-1%	114	111
b10-b23	0%	-9%	11%	-3%	118	124
b9-b22	7%	-3%	15%	1%	126	129

Table B3: *Return* framing, certain choices

	Inflation A	Inflation B	NV_A	NV_B	RV_A	RV_B
b1	8%	14%	124	130	115	114
b2	1%	14%	116	130	115	114
b3	8%	11%	124	127	115	114
b4	1%	3%	116	117	115	114
b5	-1%	3%	114	117	115	114
b6	-1%	-3%	114	111	115	114
b7	-8%	-3%	106	111	115	114
b8	-8%	-10%	106	103	115	114
b17	9%	16%	142	148	130	128
b18	1%	16%	131	148	130	128
b19	9%	3%	142	132	130	128
b20	1%	3%	131	132	130	128
b33	7%	15%	1263	1288	1180	1120
b34	0%	11%	1180	1243	1180	1120
b35	5%	16%	1239	1299	1180	1120
b36	0%	6%	1180	1187	1180	1120
b37	-4%	4%	1133	1165	1180	1120
b38	-3%	-1%	1145	1109	1180	1120
b39	-10%	-1%	1062	1109	1180	1120
b40	-10%	-12%	1062	986	1180	1120

Table B4: *Real* framing, certain choices

	Inflation A	Inflation B	NV_A	NV_B	RV_A	RV_B
b1	8%	14%	124	130	115	114
b10	0%	11%	118	124	118	112
b23	-9%	-3%	118	124	130	128
b26	1%	14%	1162	1300	1150	1140
b34	0%	11%	1180	1243	1180	1120
d1	1%	14%	113	127	112	111
d2	-1%	-3%	116	113	117	116
d3	-8%	-3%	100	105	109	108
d4	8%	3%	120	113	111	110
d5	0%	15%	117	128	117	111
d6	7%	6%	127	120	119	113
d7	0%	6%	116	117	116	110
d8	9%	3%	141	131	129	127
d9	1%	3%	132	133	131	129
d10	-1%	3%	125	128	126	124
d11	-6%	-3%	120	122	128	126
d12	8%	3%	1253	1185	1160	1150
d13	1%	3%	1151	1164	1140	1130
d14	8%	15%	1296	1369	1200	1190
d15	-8%	-2%	1086	1147	1180	1170

Table B5: *Real* framing, uncertain choices

	Inflation A 1	Inflation A 2	Inflation B 1	Inflation B 2	NV_A	NV_B
b1-b4	8%	1%	14%	3%	124	130
b9-b15	7%	-10%	15%	-1%	106	111
b21-b24	-1%	-9%	3%	-11%	114	111

Table B6: Detailed description of the five blocks of certain choices in the *basic* framing

Block	b1-b8	b9-b16	b17-b24	b25-b32	b33-b40
High Value	no	no	no	yes	yes
High difficulty	yes	no	yes	yes	no
Inflation	4 NC : b1; b2; b3; b4	4 NC : b9; b10;b11; b12	3 NC:b17; b18; b20 1 C : b19	4 NC : b25; b27; b26; b28	4 NC : b33; b34; b35; b36
Mixed	1 NC : b5	1 NC : b13	2 NC : b21; b22	1 NC : b29	1 NC: b37
Deflation	1 NC : b7 - 2 C : b6 ; b8	1 NC : b15 - 2 C: b14; b16	1 NC :b23 - 1 C : b24	1 NC : b31 - 2 C : b30; b32	1 NC : b39 - 2 C : b38; b40

NC = non congruent, C = congruent

Appendix C: measures and correlations of variables

Table C1: Measures (means, standard deviation and range)

Measures		Mean	SD	Range
Individual measures	Financial literacy	*2.86*	1.04	0-4
	Numeracy	*4.30*	1.58	0-6
	Loss aversion	*4.78*	2.42	0-10
	Risk aversion	*6.18*	2.07	0-10
	Money illusion questionnaire	*10.96*	3.88	20-0
Financial measures	Error rate	*.31*	.2	0-1
	Error log odds ratio	*-.93*	1.03	$-\infty, +\infty$
	Satisfaction	*6.72*	1.40	0-10
	Confidence	*7.17*	1.47	0-10
	Metacognition sensitivity	*.54*	.80	-10-10
	Response time	*12.63*	7.57	$0-+\infty$

Table C2: Pearson correlations for all the variables

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
(1) Financial literacy	1	+0.23 **	+0.03	+0.13	-0.49 ***	-0.45 ***	-0.45 ***	+0.27 ***	+0.32 ***	+0.28 ***	+0.32 ***
(2) Numeracy		1	+0.29 ***	+0.14	-0.30 ***	-0.13	-0.12	+0.04	+0.11	+0.04	+0.32 ***
(3) Loss aversion			1	+0.20 **	+0.02	+0.04	+0.05	-0.12	-0.09	+0.04	+0.09
(4) Risk aversion				1	+0.04	+0.06	+0.05	+0.16	+0.16	-0.06	-0.01
(5) Money illusion questionnaire					1	+0.37 ****	+0.39 ***	-0.21 **	-0.25 **	-0.25 **	-0.39 ***
(6) Error rate						1	+0.98 ***	-0.19 *	-0.13	-0.55 ***	-0.39 ***
(7) Error log odds ratio							1	-0.21 **	-0.15	-0.55 ***	-0.41 ***
(8) Satisfaction								1	+0.78 ***	+0.13	+0.05
(9) Confidence.									1	+0.08	+0.06
(10) Metacognition sensitivity										1	+0.19 *
(11) Response time											1

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