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TITLE: "The Influence of Executive Functions and Intelligence Quotients on Time Preferences, Risk Aversion, and Ambiguity Aversion"

STUDENT NAME: Isabel Avendano Ibanez

STUDENT ID NUMBER: 511146

SUPERVISOR: Peter Wakker

SECOND ASSESSOR: Xiao Yu

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By Isabel Avendano Ibanez

Abstract

The present study extends the literature on cognitive skills and economic decision-making in a new direction. We explore how the relationship between economic decisions vary according to cognitive ability. This paper investigates whether behaviors as regards risk aversion, ambiguity aversion, and impatience are systematically related with cognitive ability, using a sample of 98 young adults. Experimental measures include certainty equivalents (CEs) and matching probabilities within the framework of the Ellsberg choice task for measuring risk and ambiguity aversion, respectively, and trade-offs between immediate rewards and rewards available at different points in time for measuring impatience. Measures of cognitive ability include a short version of the Wechsler Adult Intelligence Scale (WAIS-IV) and a Stroop task to obtain Intelligence Quotient (IQ) and Executive Function (EF) scores, respectively. Our findings highlight a comparison between the influence of IQ and EF skills on economic choices. We introduce noteworthy associations between EF and decision-making, unveiling the potential influence of self-regulating skills on economic behavior. The findings on the relationship between risk aversion, ambiguity aversion and impatience with cognitive ability are consistent with findings in psychological and economic studies. Our results support evidence on the dual system theory and have relevant implications for both theoretical and empirical research in behavioral economics.

I. Introduction

A recent and growing literature has demonstrated a relevant association between cognitive ability and economic decision-making. Previous studies reveal that higher levels of cognitive ability have an influence on economic outcomes (Burks et al., 2009). Modern economic analyses usually rely on the assumption that human beings are fully informed and that they take action based on rational thinking of the information available. However, deviations from this standard assumption corroborate the existence of disparities in individual understanding and processing of information when revealing the true preferences of economic agents. Prior studies find that some people are more prone to making mistakes than others in integrating future objectives with current goals, which highlights cognition as a latent influential component of economic behavior (Tversky & Kahneman, 1981; Read et al. 1999; Reyna et al., 2009; Cokely and Kelley, 2009). The evidence of a more rational judgment by individuals with higher cognitive abilities reveals that acknowledging cognitive skills as a strong determinant of behavior may result in advances in economic models. For example, to capture the true preferences and in understanding the strategic behavior of people.

In the literature, Intelligence Quotient (IQ) tests have received significant consideration in studies on the relationship between cognitive ability and decision-making. A potential reason for this is that IQ tests measure major components of cognition, such as verbal comprehension, perceptual reasoning, working memory and speed processing. These components have a strong influence on critical decision-making to achieve expected goals in the short and long term. Although IQ measurements are broadly used, it is not an exclusive determinant of cognitive ability.

Other fundamental aspects of cognition noteworthy to economic behavior are captured by individual executive functioning, which has been found associated with academic performance and economic success (Denckla, 1994). The term Executive Functions (EF), also referred to as cognitive control or self-regulation skills, is defined as a set of cognitive processes necessary for selecting and accomplishing goal-directed behaviors (Best, 2010). Executive functions encompass brain skills such as inhibition and interference control, working memory, and mental flexibility (Miyake et al., 2000; Diamond, 2013). According to the Center on the Developing Child at Harvard University (2011), a distinctive feature of a superior EF is the ability to manage information, focus attention and filter distractions. Interestingly, human beings are not born with EF skills but with the potential to develop them. Furthermore, previous findings show an association between executive functions and superior problem-solving, attention maintenance, interference resistance, and multitasking (Chan et al., 2008; Burgess et al., 2000; Grafman & Litvan, 1999; Stuss et al., 1995). Although little exploration has been done to explain the influence of executive functions in economic decision-making, these cognitive processes are relevant for the regulation of social behavior and goal-oriented choices (Bechara et al., 1999; Bechara et al., 1996; Grafman & Litvan, 1999; Najdowsk et al. 2014).

Behavioral economic theories provide sufficient evidence to expect a significant relationship between risk-aversion, ambiguity-aversion, and impatience, on the one hand and cognitive ability on the other. Previous findings show that individuals who perform better on cognitive tests are more likely to behave patiently and to overcome the average lack of self-control (Shoda et al., 1990; Warner & Pleeter, 2001; Dohmen et al., 2010). The relationship between risk and ambiguity attitudes and cognitive ability is however mixed (Dohmen et al., 2010; Andersson et al., 2016).

The purpose of this paper is to investigate whether behaviors on people's willingness to take risks, to avoid ambiguous situations, and to wait for superior rewards are systematically related to cognitive ability. To examine this, 98 participants completed a controlled experiment that measures levels of cognition and decision-making over time, under risk and under ambiguity. Experimental measures include certainty equivalents (CEs) and matching probabilities within the framework of the Ellsberg two- and three-color choice task to provide measures of risk and ambiguity aversion, respectively. For impatience, measures include trade-offs between immediate rewards and rewards available at different points in time. In addition to this, measures of cognitive ability include a short IQ test version from the Wechsler Adult Intelligence Scale (WAIS) and a Stroop task to obtain EF levels.

Our findings extend the literature on cognitive skills and economic decision-making in a new direction. We explore how the relationship between economic decisions vary according to cognitive ability. This study also highlights a comparison between cognitive capacities, such as IQ and EF, and their relation to economic behavior. Additionally, new noteworthy associations between EF and decision-making are revealed, which unveils the potential influence of self-regulating skills on economic behavior. Our findings on the relationship between risk aversion and impatience with cognitive ability are consistent with findings in psychological and economic studies. For ambiguity aversion, results display a positive correlation with cognitive ability, which goes against previous cognitive hypotheses (Machina & Siniscalchi, 2014). Our results underline a substantial connection between EF and economic choices. The study introduces empirical evidence of the comparability between cognitive skills on their influence on decision-making.

II. Literature Review

According to Tversky and Kahneman (1992), economic behavior is strongly shaped by attitudes towards risk and ambiguity, impatience and different behavior for gains and losses. Prior studies have shown that decision-making under risk, under ambiguity, and over time are impacted by cognitive ability, skills necessary to achieve tasks i.e. problem solving, learning, memory, and attention (Tymula et al., 2012). Economic models have been slowly incorporating types of cognitive abilities to answer questions on whether levels of cognition have a significant influence on economic behavior. The idea that superior cognitive abilities are related to a lower error in decision making emerges from the belief that choices are made by individual information processing. Therefore, those with outstanding cognitive ability levels should be less prone to making mistakes in the process of translating true preferences into choices (Burks et al., 2009).

Linking differences in cognition to factors that influence decision-making supports the principle of a dual system theory, broadly found in psychological, economic and sociological models. Botdorf et al. (2017), explained that engaging in irrational behavior comes from the individual capacity for self-control. Findings in the literature link irrational choices to cognitive skills, such as memory attention (Potrafke, 2019; Boy G. A., 2005; Huck and Weizsäcker, 1999). This suggests that the extent to which cognitive ability is developed in a person plays a crucial role in behavior. Authors such as Hinson et al. (2003) and Shiv and Fedorikhin (1999) show that higher cognitive load leads to a raise in impulsive behaviors and that differences in working memory levels are correlated with preferences of short over long-term outcomes. It has been found that high performance on cognitive tests enhances a more patient and higher risk-seeking behavior (Frederick, 2005; Dohmen et al., 2010; Burks et al., 2009; Shamosh & Grey, 2008; Shapiro et al, 2013). Hence, as optimal decision-making requires proper information processing (Nagel, 1988), understanding the reach of mental capabilities appears to be essential for developing a strong and predictive economic model.

Since cognitive abilities can influence consistency in choices and in revealing true preferences (Shapiro et al. 2013), it is possible then to assume that the sum of individual differences in cognition can work as proof of the effects of biased behavior in society. For simplicity, throughout this paper, the following terminology will be used: (i) risk attitude is defined as the willingness to accept a lottery when all possible probabilities for obtaining it are known, (ii) ambiguity attitude is defined as the willingness to accept an act when probabilities for obtaining it are unknown (iii) impatient behavior is defined as the unwillingness to wait for better outcomes in the future as compared to present ones (Shamosh & Grey, 2008; Tymula et al., 2012; Rohde, 2018).

Theories of behavioral economics provide enough arguments to expect that risk and ambiguity attitudes, and impatient behavior are influenced by cognitive abilities. Economic theories such as the dual-system approach, anomalous preferences, and choice bracketing reinforce the belief that people fail to assess their choices when it comes to translating their true preferences (Benjamin et al., 2013; Dunhan et al., 2010; Read et. al, 1999). These models are based on the scheme that optimal decision-making is a perfectly patient and has an expected wealth maximization behavior, however, deviations from this are found in all kinds of fields in which individual choices happen. As mentioned by Asparouhova et al. (2009), the existence of cognitive biases emerges when a person under- or overweights information. Furthermore, prior research has shown that poor cognitive skills, such as executive functions, have a negative impact on decision-making (West, 1996; Raz et al., 1998; Bayer & Osher, 2018). Therefore, strengthening the cognitive system should lessen deviations from the optimal and lead to superior decision-making.

Prior studies on the effects of cognitive abilities on time preferences show fairly homogeneous results. The assumptions of neoclassical economic theory are based on the idea that individuals have a stronger preference for immediate outcomes over larger ones in the future (Cruz & Muñoz, 2016). However, previous findings show that higher performance on cognitive tests are related to lower levels of impatience (Potrafke, 2019; Frederick, 2005; Dohmen et al., 2010; Burks et al., 2009; Shamosh & Gray, 2008; Shoda et al., 1990; Warner & Pleeter, 2001; Steinberg et al., 2009; Benjamin et al., 2013). Additionally, Bayer & Osher (2018) stated that overcoming preferences for instant rewards requires self-regulation, which makes use of certain levels of cognitive resources. Additionally, they found that better scores in the Stroop task, a widely used test to measure executive functions, were related to more patient behavior and that poor executive functions reduce the ability to overcome the classic tendency to prefer present outcomes. Supporting this, studies carried out by Mischel, Shoda, and Rodriguez (1989) and Reynolds et al., (2008) note that impatience has been linked to a lack of self-control and impulsive behavior in children and adolescents and that these findings can predict social behavior later in life. Research on young people exhibit that students with higher grades are found to be more patient and that females tend to be more patient as compared to males for high stakes conditions, results are however mixed when it comes to low stakes conditions (Shutter et al., 2010; Steinberg et al., 2009; Castillo et al., 2011).

Decisions under uncertainty are found in a wide range of stages of economic decision-making. In this study, uncertainty is referred to as scenarios with all known (risk) and unknown probabilities (ambiguity) as part of individual choices. The literature suggests that risk and ambiguity attitudes vary among individuals with different cognitive skills and that the difficulty of the choice problem has a strong influence on decision-making (Huck & Weizsäcker, 1999). Previous studies hold mixed evidence of a relationship between individual differences in the capacity of self-regulation and cognition with risk and ambiguity aversion.

Cognitive limitations are found to affect how people process information under risky situations (Viscusi & Magat, 1992). According to Potrafke (2019) countries with higher IQ scores appear to be more risk-averse as compared to countries with lower scores. However, extensive research on individual differences shows that people with lower cognitive ability are more risk-averse (Dohmen et al. 2010; Andersson et al. 2016; Frisell et al., 2012; Jaeger et al., 2010; Benjamin et al., 2013). Authors such as Whitney, Rinehart, and

Hinson (2008) explained that more cognitive load increases risk-aversive behavior, proposing that individuals with superior cognitive abilities that deal with higher loads of information have a lower risk-aversive behavior. Interestingly, when it comes to gender, women are more risk-averse than men with the same intellectual capacity (Croson and Gneezy, 2009; Sutter et al., 2010; Hartog et al., 2002; Powell and Ansic, 1997). Nonetheless, authors like Andersson et al. (2013) argue that cognitive abilities are not related to risk aversion but to random decision-making because controlling for factors that influence risk attitudes is a difficult task. In general, the predominant literature states that risk aversion is negatively related to cognitive ability (Frisell et al., 2012; Jaeger et al., 2010).

The literature on the effects of cognitive ability on ambiguity aversion appears to be less explored than the relationship with risk aversion. Ambiguity aversion represents a willingness to pay extra to avoid unknown risks (Ellsberg, 1961). Various studies suggest that poor mental skills assessing probabilities or performing difficult computations translate into ambiguity aversion (Asparouhova et al., 2009; Fox and Tversky, 1995). Heath and Tversky (1991), Fox and Weber (2002), and Chow and Sarin (2002) found a negative relationship between people's knowledge of the stock market and ambiguity aversion. Additionally, Dimmock et al. (2016) found higher ambiguity aversion among higher educated than lower educated. Supporting this, Dimmock, Kouwenberg, and Wakker (2015) show that ambiguity aversion is positively related to being male, old, and college-educated. Furthermore, Tymula et al. (2012) found that adolescents find situations under ambiguity more desirable as compared to adults, revealing the potential influence of risk-taking behavior and cognition of adolescents on ambiguity aversion. For gender differences, prior discoveries show that women are more ambiguity averse than men in fields related to investment decisions (Schubert et al. 1999; Powell and Ansic, 1997; Gysler et al., 2002). In spite of the findings demonstrating the link between cognition and ambiguity aversion, Andersson et al. (2016) proposes that ambiguity aversion and cognitive ability tests, such as Numeracy Test and CRT scores, does not appear to have a meaningful relationship.

In recognition of the relevance that cognitive processes have on decision-making, the application of cognitive tests has become more prevalent in economic models. Correlations between economic decision-making and cognitive ability are relevant for both theoretical and empirical economic research. However, the literature on the relationship between risk aversion, ambiguity aversion, and impatience with cognitive ability is still scarce. The present study will examine the possibility of any correlation between performance on Intelligence Quotient (IQ), Executive Functions (EF), and a combined measure of both with decision making under risk, ambiguity and at different points in time. The intention of this work is to build on previous findings on the relationship between cognitive ability, such as IQ, on decision making and provide preliminary insights on its comparability with EF. Additionally, we seek to assess whether a combined measure of IQ and EF unfolds noteworthy features of economic behavior. To our knowledge, no comparison or combination of these two cognitive tests on its effects on economic behavior has been investigated in the literature. Findings could demonstrate significant differences between cognitive traits on decision-making and scrutinize the influence of self-regulation on rational choices. By this, our evidence supports the existence of a dual system model and explicates the phenomena of incomplete preferences.

III. Data Description

The dataset was collected using an online survey between June 14 and June 26, 2019. The participants' pool consisted mainly of young adults with ages ranging from 19 to 32 years, residing in 7 different countries. In total, 98 participants completed the survey.

Participants conducted the survey through a computer or a mobile device without special assistance. The experiment design consisted of five sections completely in the English language. Section 1 focused on the measurement of cognitive abilities, where participants were administered with a short version of the current design of the Wechsler Adult Intelligence Scale (WAIS-IV) and a Stroop Task, to measure Intelligence Quotient (IQ) and Executive functions (EF), respectively. The second section concerned a questionnaire on decision-making under risky and ambiguous situations with the use of the Ellsberg Paradox. Section 3 covered three questions to measure the time-preferences of participants. Lastly, section 4 was a questionnaire to obtain demographic information of the participants. Throughout this paper, the focus is on gain outcomes only. Additionally, to increase the number of people that complete the experiment, each participant received the opportunity to participate in a lottery to win a €10 Amazon voucher once the experiment was finished.

A. MEASURES OF COGNITIVE ABILITY

To measure cognitive abilities, two different tests were administered. First, participants were presented with a short questionnaire based on the latest version of the Wechsler Adult Intelligence Scale (WAIS-IV), one of the most commonly used adult IQ tests for measuring intelligence (Dohmen et al, 2010). In this experiment, participants were presented with a 25-question IQ test with a 6-minute test timer. Once the timer was over, all 25 questions on the test were submitted. In order to generate an accurate IQ score, participants were told not to use calculators or any other assistance from any other source in answering the questions. This section assessed major components of cognition, such as verbal comprehension, perceptual reasoning, working memory and processing speed by testing material based on similarities, vocabulary, comprehension, arithmetic, digit span and logical reasoning.

Second, participants were administered with the Stroop Color-Word Task, first used by Ridley Stroop in 1935, a reliable and widely used method in psychology to measure executive functioning (Lezak, Howieson, & Loring, 2004). This measure of cognitive ability is included due to positive outcomes that come from a superior executive functioning on decision-making and to account for additional skills not measured by the WAIS-IV test. The term executive functions refer to brain processes that control other brain processes (Najdowski et al., 2014), which are involved in the accomplishment of goal-directed behavior for short and long-term social and economic success (Denckla, 1994).

For this section of the survey, participants were presented with four different words of color names (red, green, blue, yellow) in different print colors. They needed to respond to the print color of the word associated with that word. In the task, participants had two different types of question, a congruent option (a word that matches the color print) and incongruent (a word that did not match the color print), i.e. for the incongruent kind if a participant was presented with the word "GREEN" the color was any other but green, assume the word was in a red print, then he or she needed to choose the associated option for the color red. Therefore, for the congruent kind if a participant was presented with the word "GREEN" the print color was also green, then he or she needed to choose the option for color green. Participants were asked to respond forty questions to complete this task, 13 congruent and 27 incongruent scenarios. For each question, participants had a maximum of 3 seconds before the answer was automatically submitted, followed by the next color-word question.

The relevance of this task lies in the presence of incongruence in the color-word scenario, this causes an increase in the average time for naming colors compared to the congruent scenario (Stroop,1935). The extra time spent in naming the color comes from the strong automaticity that the process of reading has in the brain, thus, inhibiting such a process represents a high cognitive effort. As a result of such a process, it is possible to obtain the called Interference Score (IS). This score is obtained by dividing the average time to read color names in incongruent colored ink by the average time to read in a congruent color ink (Troyer et al., 2007; Campanholo et al., 2014; Hankee et al., 2016; Tremblay et al., 2016; Scarpina & Tagini, 2017). Lower scores represent better attention and inhibition control, hence, superior executive functioning (EF). For simplicity, however, the scale was transformed to obtain an increasing scale, meaning that higher scores translate into a superior EF. The new scale will be represented by the name Executive Function Score during the course of this analysis.

It is important to note that, whereas both cognitive tests assess working memory and speed processing, they differ mainly in perceptual reasoning and verbal comprehension for the WAIS-IV test, and attention and inhibition control, and motor planning for the Stroop Task. The assessment of these skills

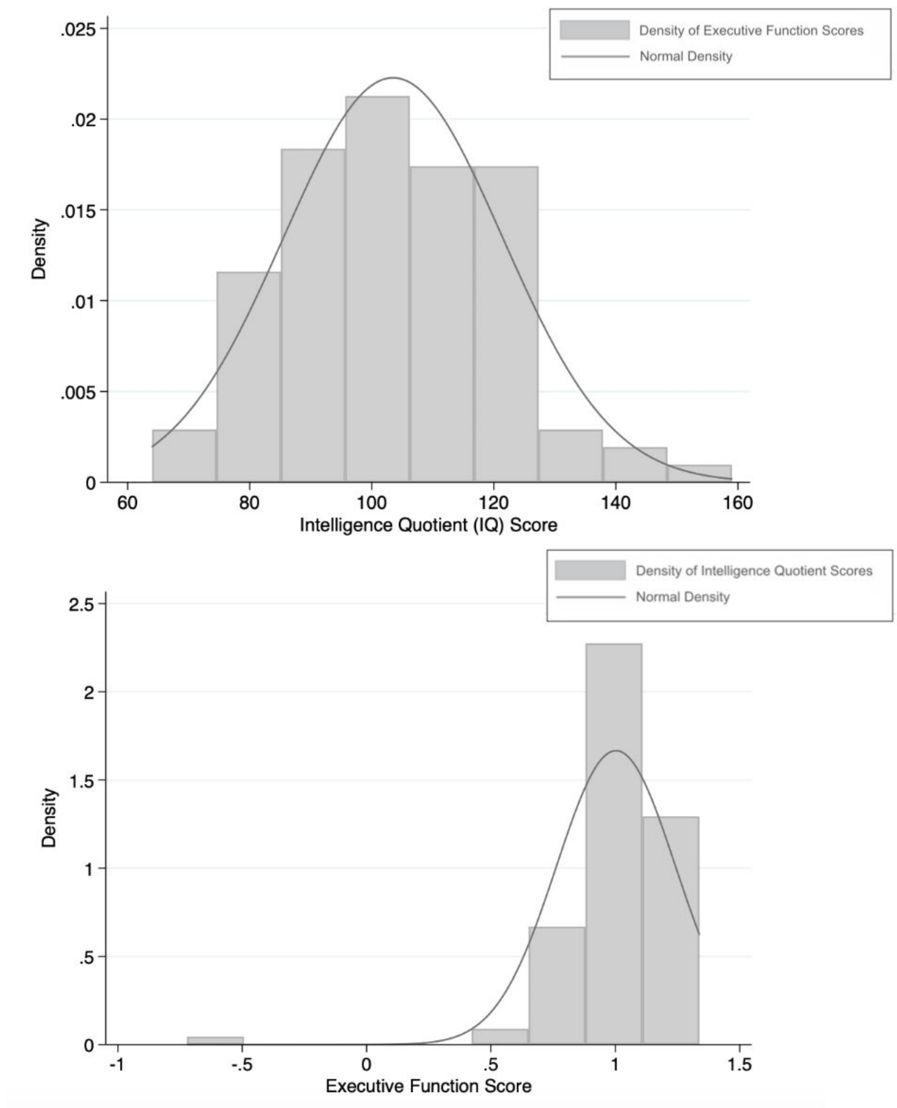

FIGURE 1. DISTRIBUTION OF SCORES IN COGNITIVE TESTS

combined grant a broader understanding of the intellectual degree and cognitive capability of each participant in this experiment. The combined measure of cognitive ability encompasses further brain skills than studies in the literature, such as cognitive control and attention flexibility. Hence, possible findings of its correlation with economic behavior can lead to economic research towards a new direction.

Figure 1 shows the distribution of results of both cognitive tests. The upper graph shows the score in the Intelligence Quotient test overlaid with a normal density function with the same variance and means as the estimated density. Both densities appear to be close to each other, which follows previous results in the literature. The lower graph shows the Executive Function score ratio of the incongruent and congruent color task in the Stroop test. The normal density function is also overlaid.

Similarly to Dohmen et al. (2010) and given our normality assumption, both IQ and EF scores were standardized to obtain zero means and standard deviations of one. The standardization process eases the interpretation of the coefficients of the dependent variables because changes will be related to the same level in means and standard deviations on both measures of cognitive ability. By this, the Spearman correlation between IQ and EF scores is 0.09, meaning that both variables have a weak correlation. This confirms the belief that both measures underline different aspects of cognition. For this reason, deriving a combined measure of cognitive ability from both scores provide a more reliable estimation of cognitive ability. The combined measure of cognitive encompasses further brain skills than what is found in the economic literature.

Conversely, comparing both IQ and EF scores, separately, enables a juxtaposition between a variable broadly analyzed with economic behavior (such as IQ) and one with a scarce examination in economic models (such as EF). Also, as EF is extensively analyzed in psychological models, this study connects insights from both economic and psychology literature. In this paper, all measures of cognitive ability (IQ scores, EF scores, and the combined measure of cognitive ability) will be used to compare significant differences between cognitive traits and decision making. The results of the standardized measures remain similar to the ones without.

All of three cognitive ability: i) IQ scores ii) EF scores and iii) Combined measure of cognitive ability exhibit a slight U-shape age pattern that decreases around age 25 and then begins to increase until 30, yet, the rise at later age does not reach the same level as younger ages. The pattern, however, is not relevant for this study because the age in the sample pool is fairly homogeneous.

B. Risk and Ambiguity Attitudes

Risk and ambiguity attitudes were obtained by eliciting preferences in lottery-choice tasks. The section consisted of six questions in total, three for measuring risk and three for measuring ambiguity attitudes. To measure the willingness to take risks, participants had the option to choose between a paid lottery or different safe payments. Participants were presented to three choice lists with 21 rows each. Each row showed two options, a safe payment option, and a lottery. In the lottery, they could win €100 with 50%, 30% and 15% probability to win or nothing otherwise. Each question with the respective probability had exactly the same lottery, however, the safe option increased from row to row. The safe option ranged from €0 in the first row and €100 in the last one, with the addition of €5 euros per row.

To assess ambiguity attitudes, participants had the option to choose between two lotteries. Participants were presented to three choice lists with 24 rows each. Each row showed the two lottery options. In lottery 1, participants could win €100 if a black ball was drawn from the urn, with no specification on the probability to win. Lottery 2 showed different probabilities for winning €100. Probabilities increased from row to row, ranging from 0% to 100%, with a 5% increment per row. For study purposes, probabilities between 0-5% and 95-100% were increased on a smaller scale. In this section, two questions centered on two-color (black and red) and three-color (black red and yellow) choice urn with unknown proportions. The remaining question showed a three-color choice urn with 40% with red balls and 60% with black and yellow balls.

For this experiment, each urn is considered a source of uncertainty, all coming from the same random mechanism (Tversky & Fox, 1995). By this, participants show their preference towards probabilities from two different sources. Because of symmetry, these probabilities can be matched to the subjective probabilities of an ambiguity-neutral attitude (Dimmock, Kouwenberg & Wakker, 2016). The matching probability method is more convenient when it comes to translating subjective into objective probabilities

(Baillon et al., 2018). The divergence between risk and ambiguity in the experimental conditions is driven by the information available to make a decision.

C. Time Preferences

To measure the willingness to wait, participants were given options to choose between receiving money at different points in time. This section of the experiment consisted of three questions with a scenario of receiving an amount of money for free at the current time or a higher amount in the future. A 21-row choice list with two options per row was presented. The free money at the present time remained unchanged while the amount of money to be received in the future points in time (3, 6 and 12 months) increased from row to row, ranging from €100 to €250 with an increment of €7.5 for each row. This section draws the level of impatience of decision-makers coming from the rate of discounting on future outcomes.

IV. Results

In the raw data, the relationship with cognitive ability and the dependent variables appear to be at variance with previous findings. The Spearman correlation between cognitive ability and risk-aversion is 0.13, for ambiguity aversion 0.04, and for impatience -0.16. This is translated into consistent results with the literature for impatience, evidencing that higher levels of cognition are related to less impatience. However, this does not hold true for risk and ambiguity aversion. Our results exhibit a positive correlation between cognitive ability and both dependent variables, meaning that superior cognitive skills are related to higher levels of risk aversion and ambiguity aversion.

Table 1 analyses if the relationship between the measures of cognitive ability and the 3 dependent variables (risk aversion, ambiguity aversion, and impatience) holds significant with results of correlation of the raw data. Table 1 also allows comparing differences between cognitive ability measurements and the experimental measurements for decision-making. The three columns for each of the dependent variables show their relationship with the standardized IQ score, the standardized EF score and the combined measure of cognitive ability.

TABLE 1. RELATIONSHIP BETWEEN COGNITIVE ABILITY, RISK AVERSION, AMBIGUITY AVERSION, AND IMPATIENCE

Dependent Variables	Risk Aversion (experimental measure)			Ambiguity Aversion (experimental measure)			Impatience (experimental measure)		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Standardized IQ score	0.006 [0.014]			-0.002 [0.018]			-0.004* [0.002]		
Standardized EF score		-0.006 [0.012]			0.027** [0.013]			-0.003* [0.002]	
Standardized average cognitive ability score			0.001 [0.014]			0.017 [0.016]			-0.005*** [0.002]
Constant	0.019 [0.013]	0.019 [0.013]	0.019 [0.013]	-0.019 [0.017]	-0.019 [0.017]	-0.019 [0.018]	0.033*** [0.002]	0.032*** [0.002]	-0.033*** [0.002]
Observations	98	98	98	98	98	98	98	98	98
R-squared	0.003	0.002	0.000	0.000	0.023	0.010	0.028	0.020	0.048

Notes: The dependent variable in columns 1 to 3 is the risk premium obtained from the switching row in the lottery experiment. The dependent variable in columns 4 to 6 is the level of ambiguity aversion obtained from the switching row from the matching probability lottery experiment. The dependent variable in columns 7 to 9 is the level of impatience obtained in the intertemporal choice experiment. Scores on the IQ test and Stroop task are measures of cognitive ability, that have been standardized to produce means equal to 0 and standard deviations equal to 1. The combined measure is the standardized average score on standardized IQ and EF scores. Robust standard errors in brackets.

*** Significant at the 1 percent level.
** Significant at the 5 percent level.
* Significant at the 10 percent level.

The dependent variable in columns 1 to 3 is the risk premium obtained from the lottery-choice experiments. This score tells how much of the Expected Value (EV) a person is willing to give up to get rid of the risk. The risk premium is calculated by obtaining switching row between the lottery and the money for sure, also called certainty equivalent (CE), and subtracting this CE from the EV of the lottery. A higher switching row means a higher certainty equivalent. Hence, a higher CE than EV results in a low or even negative risk premium, which is translated into a risk-seeking attitude. On the contrary, a high risk premium is translated into a risk-averse attitude.

The columns 4 to 6 display the level of ambiguity aversion obtained from the matching probabilities between the two lotteries in the Ellsberg choice urn. The point of indifference between the two lotteries in the experiment is translated into the level of ambiguity tolerance. To obtain the level of ambiguity aversion, the ambiguity tolerance score is subtracted from the probability of winning the lottery. Hence, a high ambiguity tolerance level results in a low or even negative rate of ambiguity aversion, meaning that the participant has an ambiguity-seeking behavior. On the contrary, a positive rate is translated into ambiguity-averse behavior.

Lastly, columns 7 to 9 exhibit the level of impatience obtained from the intertemporal choice experiment. The switching row in the experiment indicates the additional amount of money in the future to drop the immediate offer and wait for the higher reward. A higher value on the switching row represents greater impatience, which arises the rate of discounting for future outcomes. A higher rate of discounting translates into a more impatient behavior.

Columns 1 to 3 evidence a mixed correlation between cognitive ability measurements and risk premium. For IQ scores and the combined measure of cognitive ability, the relation appears consistent with previous findings that show higher cognitive related to a more risk-averse behavior. However, for the standardized executive function (EF) score the correlation is negative, meaning better executive functions, are associated with less risk aversion. These correlations, however, are not significant at the 10 percent level, for all measures of cognitive ability.

Columns 4 to 6 also indicate mixed correlations between cognitive ability measurements and ambiguity aversion. For standardized EF scores and the combined measure of cognitive ability, the correlation is positive. This implies that higher cognitive ability is associated with higher ambiguity aversion, opposite to findings in the literature in which the cognitive ability has a negative relationship with ambiguity aversion (Fox & Weber, 2002; Chow & Sarin, 2002). In contrast, similar to previous findings, results show that higher levels of IQ are associated with less ambiguity aversion. This is significant at the 5 percent level

TABLE 2. THE LINK BETWEEN COGNITIVE ABILITY, RISK AVERSION, AMBIGUITY AVERSION, AND IMPATIENCE BY GENDER

Dependent Variables	Risk Aversion (experimental measure)		Ambiguity Aversion (experimental measure)		Impatience (experimental measure)	
	Male (1)	Female (2)	Male (3)	Female (4)	Male (5)	Female (6)
Standardized average cognitive ability score	-0.004 [0.025]	0.005 [0.019]	0.005 [0.031]	0.021 [0.017]	-0.003 [0.003]	-0.006*** [0.019]
Constant	0.014 [0.016]	0.028 [0.022]	-0.002 [0.019]	-0.041 [0.032]	0.030*** [0.003]	0.036*** [0.004]
Observations	57	41	57	41	57	41
R-squared	0.001	0.002	0.001	0.015	0.012	0.075

Notes: The dependent variable in columns 1 and 2 is the risk premium obtained from the switching row in the lottery experiment. The dependent variable in columns 3 and 4 is the level of ambiguity aversion obtained from the switching row from the matching probability lottery experiment. The dependent variable in columns 5 and 6 is the level of impatience obtained in the intertemporal choice experiment. The independent variable is the combined measure of the standardized average score from standardized IQ and EF scores. Robust standard errors in brackets.

*** Significant at the 1 percent level.
** Significant at the 5 percent level.
* Significant at the 10 percent level.

that higher levels of IQ are associated with less ambiguity aversion. This is significant at the 5 percent level for standardized EF scores and not significant at the 10 percent level for standardized IQ scores and the combined measure of cognitive ability.

Ultimately, columns 7 to 9 evidence a negative relationship between cognitive ability and impatience. Consistent with the literature, the standardized IQ scores, EF scores and the combined measure of cognitive ability exhibit a negative correlation with impatience, meaning that higher cognitive ability is associated with less discount rate per month, thus, less impatient behavior. This is significant at the 10 percent level for the standardized IQ and EF scores and significant at the 1 percent level for the combined measure of cognitive ability.

Table 2 shows the relationship between cognitive ability and risk aversion, ambiguity aversion and impatience by gender subpopulations to observe if there is any significant difference among these groups.

Columns 1 and 2 exhibit the correlation between cognitive ability and risk aversion for males and females, showing a negative relation for males and positive relation for females, however, both are not significant at the 10 percent level. Columns 4 and 5 reveal that cognitive ability is positively correlated to ambiguity aversion, also not significant at the 10 percent level. Lastly, column 7 and 8 evidence that a higher level of cognitive ability is negatively correlated with impatience, meaning that better scores on cognitive tests are associated with less impatience for both genders. This is significant at the 1 percent level for females only and not significant at the 10 percent level for males.

In summary, risk aversion does not have a significant relationship with any cognitive ability measurement obtained from the sample. The opposite is found for impatience: higher levels of cognitive ability are associated with less impatience during the experiment. This is highly significant for females only. Regarding ambiguity aversion, executive functions appear to be the only relevant cognitive ability. Higher executive functioning is associated with more ambiguity averse behaviors. This is true for females only with a stronger correlation coefficient of 0.032 and a robust standard error of 0.019, significant at the 10 percent level.

V. ROBUSTNESS

In this section, we focus on the internal validity of the results on the correlation between cognitive ability and risk aversion, ambiguity aversion, and impatience. First, controlling the variation of specific characteristics of the sample pool, such as marital status, education, and employment, allows investigating the partial correlations of the 3 dependent variables and cognitive ability. Controlling for this and performing additional robustness checks is crucial for observing whether partial correlations of our dependent variables with cognitive ability remain significant and behave according to the findings in the literature.

Columns 1 to 9 of Table 3 display regressions controlling for single, unemployed and with a maximum education of high school degree, decreasing the sample significantly to 14 observations. These variables are included as they have been found to be factors of influence in decision making under risk,

TABLE 3. ROBUSTNESS CHECKS

Dependent Variables	Risk Aversion (experimental measure)			Ambiguity Aversion (experimental measure)			Impatience (experimental measure)		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Standardized average cognitive ability score	0.012 [0.057]	-0.047 [0.052]	-0.082 [0.066]	0.200** [0.083]	0.231*** [0.039]	0.223** [0.066]	-0.012* [0.007]	-0.007 [0.006]	-0.012 [0.009]
Male		0.178** [0.074]	0.166 [0.096]		0.189* [0.093]	0.234* [0.114]		-0.023 [0.015]	-0.020 [0.021]
Age		3.113** [0.991]	3.705** [1.329]		-2.388** [0.987]	-1.928 [1.403]		-0.122 [0.165]	-0.002 [0.239]
Age Squared		-0.073** [0.023]	-0.088** [0.032]		0.056** [0.023]	0.046 [0.033]		0.003 [0.004]	-0.000 [0.006]
Residence country			0.037 [0.040]			-0.001 [0.035]			0.005 [0.005]
Country of origin			-0.001 [0.010]			0.017 [0.010]			0.001 [0.002]
Constant	--0.008 [0.045]	-32.891** [10.476]	-39.177** [14.075]	-0.098 [0.071]	24.857** [10.369]	19.870 [14.860]	0.028*** [0.007]	1.291 [1.724]	0.005 [2.503]
Additional Controls									
Never married	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Undergraduate degree	No	No	No	No	No	No	No	No	No
Employed	No	No	No	No	No	No	No	No	No
Observations	14	14	14	14	14	14	14	14	14
R-squared	0.004	0.610	0.650	0.379	0.774	0.807	0.185	0.422	0.495

Notes: The dependent variable in columns 1 to 3 is the risk premium obtained from the switching row in the lottery experiment. The dependent variable in columns 4 to 6 is the level of ambiguity aversion obtained from the switching row from the matching probability lottery experiment. The dependent variable in columns 7 to 9 is the level of impatience obtained in the intertemporal choice experiment. The independent variable is the combined measure of the standardized average score from standardized IQ and EF scores. The variable "Country of origin" refers to the country in which the participant was born and the variable "Residence country" refers to the current living location. The variable "Employed" refers to a full-time job position only. Robust standard errors in brackets.
*** Significant at the 1 percent level.
** Significant at the 5 percent level.
* Significant at the 10 percent level.

ambiguity and on time preferences (Dohmen et al., 2010; Andersson et al., 2016; Falk et al., 2018). Participants outside these 3 stated specifications do not show significant results. Columns 1, 4 and 7 show regressions for risk aversion, ambiguity aversion, and impatience, respectively, with the cognitive ability for this group. Results in column 1 point that a higher level of cognitive ability is positively correlated with risk aversion, however, this is not significant at the 10 percent level. Column 4 reveal a positive relationship between ambiguity aversion and cognitive ability, meaning that superior cognitive abilities are related to higher degrees of ambiguity aversion for single, unemployed people with highschool degree only, this is significant at the 5 percent level. Column 7 gives evidence of a negative relationship between impatience and cognitive ability. Similar to findings in the literature, greater levels of cognitive ability is related to less impatience, this is significant at the 10 percent level.

Columns 2, 5 and 8 show regressions controlled by gender and age. The quadratic expression of age is added to control for the possible nonlinear relationship that age has with the dependent variables. Results from column 2 explain that by adding these controls, the relationship between the combined measure of cognitive ability and risk aversion becomes negative, yet, this is insignificant at the 10 percent level. It is interesting to observe that for this subject group being male is related to higher levels of risk aversion as compared to females, opposite to the findings in Table 2. Column 8 shows a similar correlation between cognitive ability and impatience with a slightly smaller coefficient as the one stated in column 7, however, this becomes insignificant at the 10 percent level when extra controls are added. Contrasting this, column 5 reveals that the relationship between ambiguity aversion and cognitive ability becomes stronger and highly significant at the 1 percent level after the inclusion of gender and age. Interestingly, gender has a similar effect for ambiguity aversion as compared to the one in column 2 for risk aversion. Being male is linked to higher levels of ambiguity aversion in comparison to females in the partial sample, this is significant at the 10 percent level.

Columns 3, 6 and 9, include extra controls for geographical characteristics, such as residence country and country of origin. These traits are included because previous studies have found a geographical location to be associated with risk aversion and impatience, together with cognitive ability (Potrafke, 2019). Risk aversion and impatience, in columns 3 and 9 respectively, are again not significant, by controlling for these additional characteristics. Column 6 shows that the relationship between ambiguity aversion and cognitive

TABLE 4. ROBUSTNESS CHECKS WITH IQ SCORES

Dependent Variables	Risk Aversion (experimental measure)			Ambiguity Aversion (experimental measure)			Impatience (experimental measure)		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Standardized IQ score	0.004	-0.006	0.029	0.159***	0.225**	-0.033	-0.003	-0.016	-0.010*
	[0.022]	[0.094]	[0.039]	[0.044]	[0.087]	[0.032]	[0.004]	[0.012]	[0.005]
Male	0.166**	0.157	-0.031	0.277**	0.362**	-0.043	-0.025	-0.029	-0.008
	[0.063]	[0.096]	[0.055]	[0.107]	[0.131]	[0.057]	[0.014]	[0.021]	[0.009]
Age	2.735**	2.871	-0.433	-1.676*	-2.466	-0.287	-0.152	0.076	0.022
	[0.940]	[2.128]	[0.272]	[0.907]	[1.615]	[0.308]	[0.154]	[0.242]	[0.009]
Age Squared	-0.064**	-0.068	0.008	0.039*	0.058	0.005	0.004	-0.002	-0.000
	[0.022]	[0.050]	[0.005]	[0.022]	[0.039]	[0.006]	[0.004]	[0.006]	[0.001]
Country of origin		-0.001	0.004		0.015	0.007		0.001	-0.002
		[0.009]	[0.016]		[0.011]	[0.016]		[0.001]	[0.002]
Residence country		0.010	-0.002		-0.074	-0.042		0.012	0.000
		[0.086]	[0.034]		[0.061]	[0.043]		[0.010]	[0.006]
Constant	-29.031**	-30.471	6.000	17.489*	25.791	3.767	1.601	-0.835	-0.226
	[10.066]	[22.691]	[3.682]	[9.530]	[16.960]	[4.127]	[1.613]	[2.550]	[0.530]
Additional Controls									
Never married	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Undergraduate degree	No	No	Yes	No	No	Yes	No	No	Yes
Employed	No	No	Yes	No	No	Yes	No	No	Yes
Observations	14	14	43	14	14	35	14	14	35
R-squared	0.709	0.572	0.119	0.716	0.763	0.166	0.397	0.525	0.151

Notes: The dependent variable in columns 1 to 3 is the risk premium obtained from the switching row in the lottery experiment. The dependent variable in columns 4 to 6 is the level of ambiguity aversion obtained from the switching row of the matching probability lottery experiment. The dependent variable in columns 7 to 9 is the level of impatience obtained in the intertemporal choice experiment. Scores on the IQ test is a measure of cognitive ability, that have been standardized to produce mean equal to 0 and standard deviation equal to 1. The variable "Country of origin" refers to the country in which the participant was born and the variable "Residence country" refers to the current living location. The variable "Employed" refers to a full-time job position only. Robust standard errors in brackets.
*** Significant at the 1 percent level.
** Significant at the 5 percent level.
* Significant at the 10 percent level.

ability is somewhat smaller than the regression controlling for gender and age only. However, adding the geographical traits to ambiguity aversion and cognitive ability generates a stronger relationship than the one that regression without any trait to control. The coefficient on the cognitive ability for ambiguity aversion is significant at the 5 percent level despite the reduction in the sample size. Due to the weak correlation between all the controls included in this model with cognitive ability and the dependent variables, it is possible to assume that the results in Table 3 are likely to account for unobserved heterogeneity.

Another aspect of our results is to analyze internal validity per cognitive test. Tables 4 and 5 exhibit regressions using the standardized IQ and EF measures, respectively. The aim is to explore the partial correlations between risk aversion, ambiguity aversion and impatience per cognitive test and to investigate significant differences between the cognitive skills from each test. In table 4, columns 1, 4 and 7 show regressions for risk aversion, ambiguity aversion, and impatience, respectively, with IQ scores, controlling for gender and age, focused on unmarried and unemployed participants with high school degrees only.

The results for risk aversion (column 1) show that the relationship with the standardized measure of IQ is positive yet not significant at the 10 percent level. However, gender roles appear to be influential when it comes to risk-aversive behavior. For ambiguity aversion, cognitive abilities measured by IQ tests relate to more ambiguity aversion, with a 1 percent level of significance. Similar to results for risk aversion and also significant at the 5 percent level, males are more ambiguity averse than females in the sample. Lastly, column 7 exposes a low, negative and not significant relationship between IQ scores and gender with impatience.

Columns 2, 5 and 8 of Table 4 consider the country of origin and residence as additional controls. Results for risk aversion and impatience (column 2 and 8, respectively) are not significant at the 10 percent level. However, column 5 shows similar results as column 4 after adding these controls, yet the coefficient of IQ lose slight significance.

Results from columns 3, 6 and 9 of Table 4, control for unmarried participants working full-time with an undergraduate degree. Columns 3 and 6, show results for risk aversion and ambiguity aversion, respectively, to be not significant at the 10 percent level for this group. However, column 9 evidence a negative correlation between IQ and impatience with a 10 percent level of significance. Both coefficients and robust standard errors for the combined measure of cognitive ability and IQ exhibit similar levels on the

TABLE 5. ROBUSTNESS CHECKS WITH EF SCORES

Dependent Variables	Risk Aversion (experimental measure)			Ambiguity Aversion (experimental measure)			Impatience (experimental measure)		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Standardized EF score	-0.041	-0.105*	-0.116	0.195***	0.058	0.142	-0.015*	-0.005	-0.005
	[0.090]	[0.053]	[0.069]	[0.058]	[0.086]	[0.088]	[0.007]	[0.008]	[0.010]
Male		0.222**	0.229*		0.224	0.167		-0.022	-0.019
		[0.080]	[0.114]		[0.187]	[0.170]		[0.017]	[0.024]
Age		3.186***	3.043***		-0.870	0.246		-0.152	-0.129
		[0.660]	[0.748]		[1.520]	[1.749]		[0.165]	[0.224]
Age Squared		-0.075***	-0.072***		0.020	-0.007		0.004	0.003
		[0.016]	[0.018]		[0.036]	[0.041]		[0.004]	[0.005]
Country of origin			-0.002			0.017			0.001
			[0.009]			[0.015]			[0.002]
Residence country	-0.025		-0.014	0.147***		0.108**	-0.002		-0.001
	[0.033]		[0.035]	[0.023]		[0.039]	[0.003]		[0.004]
Constant	0.106	-33.695***	-32.111***	-0.668***	9.382	-3.056	0.035**	1.594	1.340
	[0.160]	[7.015]	[7.951]	[0.087]	[15.955]	[18.572]	[0.015]	[1.722]	[2.354]
Additional Controls									
Never married	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Undergraduate degree	No	No	No	No	No	No	No	No	No
Employed	No	No	No	No	No	No	No	No	No
Observations	14	14	14	14	14	14	14	14	14
R-squared	0.050	0.709	0.720	0.575	0.419	0.672	0.172	0.398	0.420

Notes: The dependent variable in columns 1 to 3 is the risk premium obtained from the switching row in the lottery experiment. The dependent variable in columns 4 to 6 is the level of ambiguity aversion obtained from the switching row of the matching probability lottery experiment. The dependent variable in columns 7 to 9 is the level of impatience obtained in the intertemporal choice experiment. Scores on the Stroop task is a measure of cognitive ability, that have been transformed to obtain the EF score and standardized to produce mean equal to 0 and standard deviation equal to 1. The variable "Country of origin" refers to the country in which the participant was born and the variable "Residence country" refers to the current living location. The variable "Employed" refers to a full-time job position only. Robust standard errors in brackets.

*** Significant at the 1 percent level.

** Significant at the 5 percent level.

* Significant at the 10 percent level.

effects on impatience levels, which is in accordance with the theory that higher cognitive skills are related to less impatience. Now considering results from Table 5 for unmarried, unemployed with a high school degree, the standardized measure of executive functions display a positive correlation with ambiguity aversion (column 4) and a negative correlation with impatience (column 7) with residence as the only control in the regressions, these are significant at the 1 percent and 10 percent level respectively. A potential explanation on similarities between coefficients of ambiguity aversion and impatience linked to both IQ and EF test could be due to comparable cognitive traits that both tests analyze, previously stated as working memory and speed processing. Interestingly, column 4 displays that the country of residence is related to greater ambiguity aversion at a 1 percent level of significance. This could indicate significant differences between countries as influential variables on decision-making under ambiguity. Moreover, the relationship between risk aversion and executive functions stated in column 1 is not significant controlling country of residence on this aggrupation. However, introducing gender and age as only controls (column 2) for this group of participants reveal a significant, negative correlation between EF and risk aversion (at the 10 percent level).

While results stated in Tables 1 to 4 on the relationship between risk aversion and cognitive ability are not meaningful, analyzing executive functions independently confirms the influence of cognitive skills on decision-making under risk. Similar to the literature, higher levels of cognitive skills (expressed by EF scores in this example) are related to lower levels of risk aversion (Dohmen et al., 2010; Andersson et al., 2016; Frisell et al., 2012; Jaeger et al., 2010; Benjamin et al., 2013). Near to the results in table 4 and contrary to the stated literature that females are more risk-averse than males with the same cognitive skills, column 2 of Table 5 shows that males are significantly more risk-averse than women at the 5 percent level. These findings are limited to positive, small-stakes only. Furthermore, gender and age as additional controls generate a loss on the coefficients and the significance for ambiguity aversion and impatience with EF in columns 5 and 8, respectively. In addition to this, columns 3, 6, and 9 exhibit a similar pattern by adding geography controls, as coefficients of cognitive ability in table 3 and 4. Interestingly, the country of residence appears to have a significant correlation to ambiguity aversion in this model.

TABLE 6. ROBUSTNESS CHECKS WITH COGNITIVE ABILITY SCORES AND GEOGRAPHICAL TRAITS

Dependent Variables	Risk Aversion (experimental measure)			Ambiguity Aversion (experimental measure)			Impatience (experimental measure)		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Standardized average cognitive ability score	-0.025 [0.044]			-0.005 [0.066]			-0.011*** [0.004]		
Standardized IQ score		-0.034 [0.031]			-0.045 [0.046]			-0.006** [0.003]	
Standardized EF score			0.033 [0.041]			0.119** [0.048]			-0.011* [0.006]
Constant	0.033 [0.026]	0.036 [0.025]	0.032 [0.027]	0.015 [0.041]	0.021 [0.042]	0.019 [0.038]	0.027*** [0.003]	0.027*** [0.004]	0.026*** [0.003]
Additional Controls									
Residence abroad	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	27	27	27	27	27	27	27	27	27
R-squared	0.023	0.065	0.020	0.001	0.051	0.121	0.234	0.115	0.133

Notes: The dependent variable in columns 1 to 3 is the risk premium obtained from the switching row in the lottery experiment. The dependent variable in columns 4 to 6 is the level of ambiguity aversion obtained from the switching row from the matching probability lottery experiment. The dependent variable in columns 7 to 9 is the level of impatience obtained in the intertemporal choice experiment. Scores on the IQ test and Stroop task are measures of cognitive ability, that have been standardized to produce means equal to 0 and standard deviations equal to 1. The combined measure is the standardized average score on standardized IQ and EF scores. The variable "Residence abroad" refers to the country of residence being different from the country in which the participant was born. Robust standard errors in brackets.

*** Significant at the 1 percent level.
** Significant at the 5 percent level.
* Significant at the 10 percent level.

To explore the potential influence of geographical traits on the relationship between the dependent variables and cognitive ability, regressions in Table 6 control for participants that reside in a different location from their country of origin. Controlling for this characteristic assess 27 observations from the participants' pool. Columns 1 to 3 analyze the partial correlation of the 3 measures of cognitive ability previously obtained with risk aversion, resulting in a mixed relationship between cognitive ability and decision-making under risk similar to findings in tables 1 to 5, all measures of cognitive ability are not significant at the 10 percent level. Columns 4 to 6 analyze these partial correlations with ambiguity aversion, results show that the only significant (at the 5 percent level) measure of cognitive ability on the relationship with ambiguity aversion is EF. The results demonstrate a positive correlation, meaning that for people in the sample living abroad higher executive functioning is related to ambiguity averse behavior. This finding could unfold the idea that cognitive traits analyzed by EF tests, such as attention and inhibition control, account for more accuracy in decision-making under ambiguous situations for people living abroad. Columns 7 to 9 evidence that all coefficients of cognitive ability have a negative correlation with impatience, consistent with previous findings. It is important to note that all traits of cognition examined to lead to the same relationship on time preferences.

Potential confounds in this study could arise from the experimental design and test-taking strategy. A considerable portion of the participants are non-native English speakers, meaning that native English speakers might have an advantage in time-pressuring tests to measure cognitive abilities. Additionally, a potential concern in the accuracy of cognitive scores is associated with the user's test-taking device, participants using mobile devices could be at a disadvantage in obtaining a higher score in the cognitive tests. However, we assume that participants selection in the test-taking device is associated with their preference in test execution and hence, with expected performance.

VI. Summary of Results

The present study is one of the first to analyze the links of a combined measure of cognitive ability that includes self-regulating skills and IQ. The goal of creating this combined measure is to incorporate additional traits of cognition into an integrated and more reliable unit of cognition. Additionally, our findings explore a juxtaposition between IQ and EF scores and their influence on economic choices.

First, our findings on the relationship between the combined measure of cognitive ability and the 3 dependent variables indicate a strong association with impatience mainly. The results of Tables 1 reveal a negative correlation between cognitive ability and impatience. Interestingly, results in Table 2 exhibit this negative relationship only significantly for females. Both coefficients in Tables 1 and 2 are relatively small but they show a strong significance. Also, findings in Table 3 maintain the same link between cognitive ability and impatience, for unmarried and unemployed participants with a high school degree only. Moreover, for this same group of participants, the correlation between the combined measure of cognitive ability and ambiguity aversion becomes significant and greater than its correlation with impatience. Table 3 reveals that higher levels of cognition are associated with more ambiguity averse behavior, consistent with findings of Dimmock et al. (2016) and Dimmock, Kouwenberg, and Wakker (2015). Furthermore, the results in Table 6 reveal a negative correlation between cognitive ability and impatience for participants that are residing abroad from their country of origin.

Second, findings on the relationship between IQ and the 3 dependent variables appear to be telling a similar story like the one from the associations found between the combined measure of cognitive ability and economic behavior. For risk aversion, no significant results are found related to IQ. However, for impatience and ambiguity aversion, results exhibit a similar trail than those for the combined measure of cognitive ability. Impatience is negatively correlated with IQ levels. Interestingly, for employed non-married participants holding an undergraduate degree, the degree of the negative correlation becomes stronger than for the rest of the participants. Findings on the links between ambiguity aversion and IQ show a positive correlation for unmarried and unemployed participants with a high school degree only. The coefficients of both IQ and the combined measure of cognitive ability related to ambiguity aversion display a similar size. For participants residing abroad, the relationship between impatience and IQ is also negative, however, the degree of the coefficient is mild.

Third, the relationship between Executive Functions and economic behavior is relevant for all three dependent variables. Tables 1, 5 and 6 display a negative correlation between EF and impatience. Higher levels of executive functioning are linked to more patient behavior, which is consistent with the findings in the literature related to cognitive ability and impatience. These results support the evidence that self-regulation skills are translated into more willingness to wait for better outcomes in the future (Mischel et al., 1989; Reynolds et al., 2008). Furthermore, our findings on the relationship between EF and ambiguity aversion reveal a positive correlation. Tables 1, 5 and 6 show that superior executive functioning is related to a higher degree of ambiguity aversion. This suggests that people with higher inhibition control are more prone to avoid situations where probabilities are unknown, similar to findings from Dimmock et al. (2015) and Dimmock et al. (2016). Moreover, our results show one significant correlation between EF and risk aversion, unlike IQ and the combined measure of cognitive ability. The outcomes of Table 5 reveal a negative correlation between EF and risk aversion for unmarried and unemployed participants with a high school degree only. Our findings unveil a solid influence of EF on risk aversion, as compared to IQ and the combined measure of cognitive ability. Interestingly, results in Table 5 suggest that males have a higher degree of risk aversion than women in the sample.

VII. Conclusion

The goal of this study is to explore whether cognitive ability is a potential determinant of behaviors on decision-making under risk, under ambiguity and over time. This research explores these relationships by using for the first time the combination of executive function and intelligence quotient scores to create a new measure of cognitive ability. This measure encompasses greater traits of cognition, creating a more reliable estimation of cognitive ability. Additionally, the present study is the first one to scrutinize the comparability among particular characteristics from IQ and EF scores. The main findings are that people with higher cognitive abilities are more patient, more ambiguity-averse, and less risk-averse. This is demonstrated using a series of robustness checks and while controlling for personal characteristics, education, marital status, geographical traits, and employment.

These links complement findings on the dual system theory and have relevant implications for both theoretical and empirical research in behavioral economics. First, our evidence identifies both IQ and EF to be essential for rational decision-making and economic success. Consequently, reinforcing educative systems is vital for the preparation and adaptability of the future workforce cognitive skills. By improving the education level, we can assume that biased preferences and deviations from the full-information rational-expectations hypothesis will decrease. Additionally, developing a strong foundation for these essential skills foster social connection and reduces stress later in life.

Second, our findings suggest a direct relationship between cognitive ability and poverty. Empirical evidence shows that lower levels of cognition are associated with a higher probability of error in choices, hence, inferior economic outcomes. However, developments in decision-making towards more rational behavior are related to improved standards later in life (Nagel, 1988; Denckla, 1994; Burks et al., 2009). Social policies that combine attention to cognitive ability and reduce sources of toxic stress, such as violence and malnutrition, could improve the likelihood of success later in life.

Third, our findings display the relevance in human capital investments to lessen impulsive and persistent errors in decision-making. Addressing the source and helping them learn how to cope with irrational behaviors could increase productivity in the workplace Programs focused on job-skills training that by design builds cognitive skills, such as self-regulation, can help human capital to become more economically secure. Also, these strategies could lead to less stress-related environments and greater work participation. Additionally, based on the correlation between less risky and more patient behavior with benefits on retirement savings and financial accumulation, programs that boost cognitive ability invigorates sustainable economic strategies.

Lastly, our findings on the relevance of geographical backgrounds on decision-making could unlatch potential thrives in the development of migration schemes. Structural models for migrating populations can incorporate traits on risk aversion, ambiguity aversion and impatience for upcoming screening and design policies.

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