Gender, Personality Traits and the Ellsberg Paradox[1,2]

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Abstract
This paper analyzes gender differences in ambiguity and whether they can be explained by differences in personality traits. In an experiment with 347 high school students, we investigate choices under ambiguity and link ambiguity to cognitive and personality traits. Participants value ambiguity less than risk. Women are more risk averse, while men are more ambiguity averse than women. Conditioning on risk aversion, the gender gap in ambiguity vanishes. Results for a representative sample of experimenters differ from results using a subset of volunteers. Psychometric measures are more strongly related to risk than to ambiguity. Conditioning on these measures explains roughly 20% of the difference in ambiguity aversion between men and women.

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[2] Additional information about the experiment is available in Borghans et al. (2009).
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1. Introduction

Both cognitive and personality traits predict economic and social outcomes. Traits have direct value in the labor market, but can also affect the way people make choices that affect outcomes (Borghans et al., 2008). Behavioral economics provides numerous examples of choices that are not explained by standard models (see Camerer, Loewenstein, and Rabin, 2004). Investigating how preferences are related to psychological traits improves our understanding of choice.

This paper examines the role of psychological traits in explaining ambiguity. Ellsberg (1961) found that people place higher values on bets with known probabilities (risk) than bets with unknown probabilities (uncertainty). He termed this preference *ambiguity aversion*. Versions of ambiguity aversion have been used to rationalize the equity-premium puzzle and why people act differently in complex situations (Seo, 2008). While evidence has accumulated that people generally prefer risk over uncertainty, less is known about how preferences for ambiguity differ between men and women and how differences are related to personality traits.

Using Halevy's (2007) version of Ellsberg's measure of ambiguity aversion, we investigate how the willingness to pay for lotteries changes when the degree of ambiguity is varied. We link valuations of bets to cognitive and noncognitive personality traits: IQ, the Big Five (openness, conscientiousness, extraversion, agreeableness, neuroticism), grit (ambition), self control and flexible thinking.

Ambiguity aversion is measured by presenting participants in an experiment with urns containing ten balls which can be either blue or yellow. In some urns, the amount of blue and yellow balls is known. In other urns, the amounts are not known. Participants have to bet on a color and give a minimum price for which they would sell the bet.

For men and women separately, we analyze evidence on ambiguity aversion and changes in measured ambiguity when the degree of ambiguity is reduced in lotteries. We further analyze the relationship between risk and ambiguity, and whether cognitive and noncognitive factors explain differences in ambiguity aversion between men and women.

We experiment on 15 and 16 year old students at a Dutch high-school. Only a fraction of them continue their education at the university level. The sample population studied offers a wider dispersion of traits than does the sample of university students analyzed by Halevy (2007). A unique feature of our experiment is that participation was compulsory. However we also know among our sample who would have voluntarily participated because we initially sought volunteers.

Participants generally value ambiguity less than risk. Women are more risk averse, while men are more ambiguity averse. Conditioning on risk

aversion, the gender gap in ambiguity vanishes. Psychological measures are strongly related to risk but not to ambiguity. Conditioning on personality traits explains about 20% of the difference between men and women.

Our evidence provides fresh insight into the relationship between psychological traits and economic preference parameters, reviewed in Borghans et al. (2008). There is a lot of evidence that women are more risk averse than men (Hartog et al. 2002; Agnew et al. 2008). Fehr-Duda et al. (2006) show that in general, women tend to be less sensitive to probability changes. With respect to ambiguity aversion, Schubert et al. (1999) find that women are more ambiguity averse than men in an investment context but not in an insurance context.[4] Powell and Ansic (1997) report that the higher level of risk aversion of women extends to the case of ambiguity. Huck and Wieland (2007) report that the less educated, people with lower incomes, and the unemployed are more susceptible to the Allais paradox. Dohmen et al. (2008) find that lower cognitive ability and less openness to new experiences predict greater risk aversion. Benjamin, Brown and Shapiro (2006) report that small-stakes risk aversion and short-run time preference are inversely related to achievement test scores. Few papers model the relationship found between psychological traits and economic preference parameters (see Borghans et al., 2008, for a survey).

This paper is organized in the following way. Section 2 describes the experimental procedure. Section 3 discusses the empirical results. Section 4 concludes.

2. Experimental design and procedure

2.1 Structure of the experiment

Students are presented with different urns containing 10 balls which can either be blue or yellow. The version with only risk (Urn 1) is described as: "There is an urn with 5 blue and 5 yellow balls. At random, one ball will be drawn from this urn. If you guess the right color, you'll earn 2 euro. If you are wrong you'll get nothing". The ambiguous urn (Urn 4) is described as: "There is an urn with 10 blue and yellow balls, but the number of yellow and blue balls is unknown. It can be anything between 0 and 10 blue balls and 0 and 10 yellow balls. At random, one ball will be drawn from this urn. If you guess the right color, you'll earn 2 euro, if you are wrong you'll get nothing". Before the ball is drawn from the urn, students are asked to give the minimum price for which they would be willing to sell the bet. The computer then generates a random offer between 0 and 200 eurocents. If the offer is higher than the reservation price set by the participant, the bet is automatically sold and the participant

[4] Schubert et al. (1999) report no gender difference in risk aversion.

gains the money the computer offered. If the offer is lower than the reservation price, the ball is drawn from the urn.

A ball is drawn by spinning a wheel similar to a pie-graph that indicates the distribution of yellow and blue balls. In the case of ambiguous urns, ambiguity resolved is at this point based on a random draw that determines the number of yellow and blue balls in the urn. When the wheel stops spinning, the participants can see whether the arrow points at a blue or a yellow ball.

Before the experiment begins, subjects are given an interactive tutorial to educate them on how to set reservation prices. In the tutorial, they are asked to set the reservation price for a one euro coin. If they set the reservation price higher than 101 eurocents or below 100 eurocents they are instructed that they make a loss using that strategy. For students who set the wrong reservation price, the questions and explanation are repeated.[5] The tutorial ends with two hypothetical Ellsberg questions. After this explanation, in round 1 the students set reservation prices for 2 series of 6 urns with monetary stakes. After each series, one of the six urns is randomly drawn by the computer and a random offer is made.

There are, in total, 12 urns with different distributions of blue and yellow balls. This paper analyzes four of these urns with the following distributions: Urn 1: 5 blue and 5 yellow balls; Urn 2: between 4 and 6 blue/yellow balls; Urn 3: between 2 and 8 blue/yellow balls; Urn 4: between 0 and 10 blue/yellow balls.

Urns 1 (risk) and 4 (uncertainty) represent the classic Ellsberg questions. Urns 2 and 3 are added to analyze how reservation prices change in response to changes in ambiguity.[6] The order of the urns presented is randomized. In a second round we repeat the same menu of choices. We use average scores over both rounds in our analysis.

2.2 IQ and Psychological Traits

We collected several measures of IQ and personality. In this paper we use: 8 Raven Progressive Matrices to measure IQ; 50 items to measure the BIG 5 (Openness, Conscientiousness, Extraversion, Agreeableness, Neuroticism) from Goldberg (1992); 5 questions to measure ambition from Duckworth's et al. (2007) Grit-scale; 10 items from the Self control Act Frequency Measure

[5] A working paper shows that students who score high on flexible thinking and the Raven test less often set wrong reservation prices in this tutorial. Agreeable and extraverted students set wrong reservation prices more often (Borghans et al., 2009).

[6] We measured the time the participants took to decide their reservation price. On average students spend 17.7 seconds (sd=5.8 seconds) per question. Students with more self control take more time to decide the reservation price.

(Duckworth et al., 2007); and 10 items from the Stanovich and West (1997) Flexible Thinking Scale,

We also obtained an achievement test (CITO), scores taken at age 12, and the scores on the Differential Aptitude Test, another achievement test. Except for the flexible thinking variable, all measured traits have high Cronbach's Alphas, a measure of inter-correlation among scores. People with high IQs are less extraverted, have more self-control, are able to think more flexibly, make fewer cognitive mistakes, and have lower rates of time preference.

Many people interpret achievement tests as measures of cognitive ability. However, scores on such tests are determined, in part, by noncognitive traits. We use Raven Progressive matrices as our measure of intelligence because this is generally interpreted as a pure measure of cognitive ability.[7] Regressing achievement test scores on the Ravens score and personality measures, a substantial fraction of the variation in the achievement scores is attributable to personality traits. In our data, Raven accounts for 81% of the explained variance of the Differential Aptitude Test. For the CITO achievement test taken at age 12, Raven accounts for 47.3% of the explained variance. Half of the variation in the score is due to cognitive ability and half is due to noncognitive traits (Borghans, Golsteyn, Heckman, 2008). Noncognitive traits affect motivation to do well on these tests. They also influence investment behavior which determines true cognitive abilities (see Cunha and Heckman, 2008).

2.3 Procedures

Our subjects attend a high school near Maastricht, in the Netherlands. This school educates diverse students who will attain different levels of education. There is more diversity in our sample than in the samples of university students widely used in the literature. There are three academic tracks. We exclude students from the lowest track. The middle track is vocational. The upper track is collegiate.

Participation was compulsory. The students in our samples are 15 and 16 years of age. Some of the students had valid reasons not to participate. Of an initial sample of 374 students, 347 students (93.1%) actually participated. A unique feature of the data is that we also know who would have participated in case of voluntary participation because we initially sought volunteers (52 students volunteered).

Most students finish the experiment within 1.5 hours. The maximum time spent is almost 2 hours. On average, they earn 21.30 euros with a minimum of 8.20 euros and a maximum of 36.60 euros. In the Netherlands, a

[7] Even for this measure, some correlation with the personality measures is found.

normal wage for a 16 year old person is around 3 euros per hour. Most students in this age group do not work and receive on average of 20 euros per month as pocket money (NIBUD, 2005). Thus the amounts earned by participants were relatively high compared to their alternative wage. The money is paid in cash after students finish the experiment. During the experiment, students are notified of their cumulative earnings after each spin of the Ellsberg wheel.

3. Results

Table 1 reports the reservation prices averaged over rounds 1 and 2 that respondents give for urns 1 and 4.[8] The difference in the valuation of Urns 1 and 4 is a measure of ambiguity aversion. On average students are ambiguity averse. The reservation price of Urn 1 is 12.4 cents higher than that of Urn 4 (p=0.000).

Separating the analysis for the people who volunteered and for those who did not, we find that risk aversion is *higher* for the volunteers while ambiguity aversion is somewhat lower. These differences are not statistically significant. The standard deviation is lower for the volunteers (the difference is statistically significant for Urns 3 and 4), especially for the answers of volunteers who are in the collegiate track.[9]

Men have much higher reservation prices for urn 1 than women so they are less risk averse than women. However, men display more ambiguity aversion than women in the sense that the difference in reservation prices between urn 1 and urn 4 is larger for men than for women.[10]

One possible explanation for gender differences in ambiguity aversion is that people who are more risk averse might lower their valuation of a lottery less when ambiguity in introduced, i.e. the effects of risk and ambiguity need not to be additive. Figure 1 plots ambiguity aversion against risk aversion. Despite the high variance there is a positive relation. The regression coefficient is 0.779 (s.e. 0.055). The slopes are statistically indistinguishable between men and women.

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[8] There is no statistically significant difference between the scores on round 1 and 2. See Borghans et al. (2009).

[9] For this group the difference is statistically significant for Urn 1, 3 and 4. See Borghans et al. (2009).

[10] Valuations of risky and ambiguous lotteries can be transformed into the risk-aversion parameters γ in a Constant Relative Risk Aversion framework, conditional on the wealth of the students. For this group it is not relevant to use the expected life-time income as measure of wealth. We use 0 euro wealth (following Holt and Laury (2002)), 20 euro (average monthly pocket money) and 40 euro (pocket money plus earnings in the experiment). The parameter for the risky urn equals, respectively, .25, 8.59 and 16.81 for women and -.07, -2.06 and -4.03 for men. The parameter for the ambiguous urn equals .32, 11.99 and 23.49 for women and .16, 5.02 and 9.84 for men.

Table 1
Risk and Ambiguity aversion for volunteers and non volunteers and by gender

	N	Urn 1				Urn 4				Ambiguity aversion				
Variable		Mean	Std. Dev.	Std. Error	p-value*	Mean	Std. Dev.	Std. Error	p-value*	Mean	Std. Dev.	Std. Error	p-value*	P value diff between urn 1 and 4
Total	347	93.2	46.6	2.5		80.9	48.2	2.6		12.4	31.0	1.7		0.000
Non volunteer	295	94.5	47.5	2.8	Ref	82.0	49.4	2.9	Ref	12.6	31.3	1.8	Ref	0.000
Volunteer	52	86.0	41.1	5.7	0.228	74.8	40.1	5.6	0.323	11.2	29.1	4.0	0.757	0.008
Volunteer in collegiate track	39	84.7	37.9	6.1	0.230	76.2	38.5	6.2	0.517	8.6	27.0	4.3	0.408	0.055
Women	163	80.0	49.2	3.9	Ref	72.7	51.5	4.0	Ref	7.5	29.6	2.3	Ref	0.002
Men	184	104.9	41.0	3.0	0.000	88.1	43.9	3.2	0.003	16.8	31.5	2.3	0.005	0.000

* P-values of difference between specific group and a reference group indicted by “ref”.

Figure 1
Ambiguity aversion (vertical axis) conditional on risk aversion (horizontal axis)

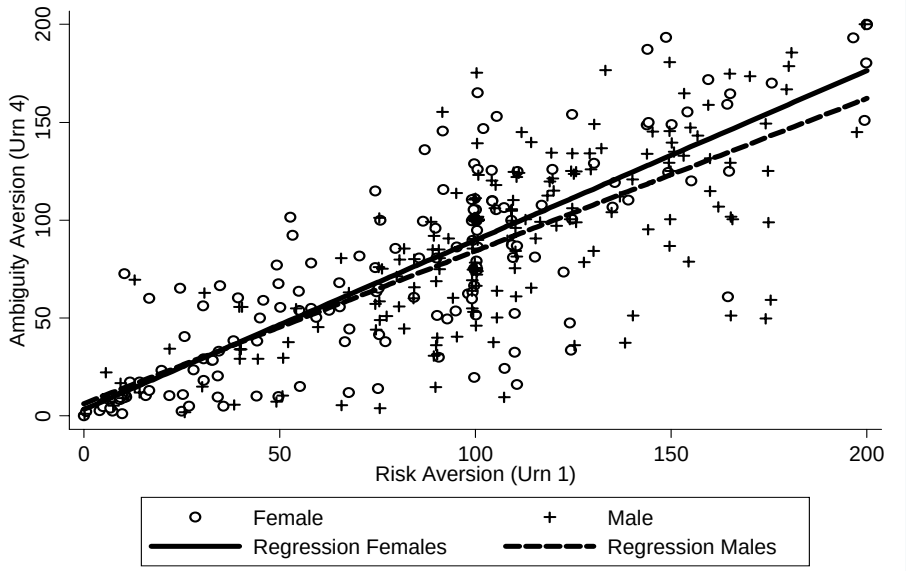


Table 2
Risk and ambiguity and (non)cognitive traits

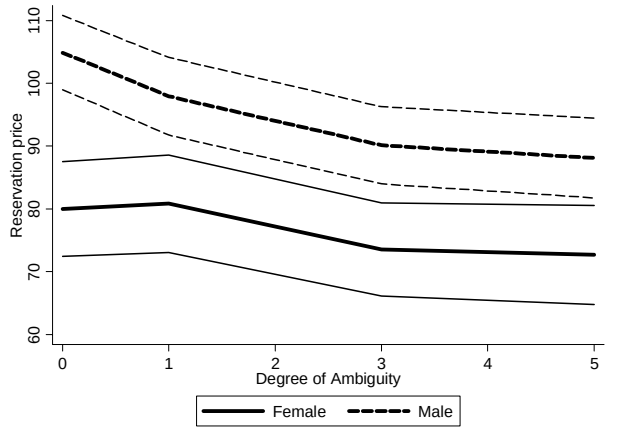
	Urn1		Urn 2		Urn 3		Urn 4	
	Coef.	p-value	Coef.	p-value	Coef.	p-value	Coef.	p-value
Raven IQ	0.101	0.353	0.169	0.127	-0.015	0.890	0.028	0.810
Conscien-tiousness	-2.045	0.586	-1.731	0.651	-0.637	0.869	-4.650	0.248
Extraversion	0.707	0.810	0.476	0.874	-1.407	0.640	-0.365	0.908
Agreeableness	-7.804	0.012	-4.932	0.117	-4.546	0.150	-4.303	0.194
Neuroticism	-6.187	0.039	-7.108	0.020	-4.273	0.164	-4.101	0.199
Openness	6.461	0.051	7.492	0.026	3.771	0.263	3.405	0.334
Ambition	8.978	0.016	8.893	0.019	6.121	0.107	5.257	0.186
Flexible thinking	1.476	0.702	1.837	0.640	6.349	0.108	4.591	0.267
Self control	-6.876	0.098	-9.791	0.021	-6.851	0.110	-3.968	0.372
Constant	88.470	0.000	81.057	0.000	83.481	0.000	80.196	0.000
R-squared	0.087		0.096		0.048		0.039	

A second explanation for gender differences is that risk and ambiguity are related to cognitive and noncognitive traits on which men and women differ. Table 2 reports the relationship between the reservation prices of the risky urn and the ambiguous urn as dependent variables and the Raven IQ and personality

traits as independent variables. The value of the risky urn is affected by several personality traits while the value of the ambiguous urn is not. People who are less agreeable, less neurotic, more open to experience and who have more ambition are less risk averse (i.e. set a higher reservation price for urn 1). The model for Urn 4 has approximately half the R-squared of Urn 1.

Figure 2 plots the changes in the reservation price when the degree of ambiguity is successively increased in the lotteries (95% confidence intervals are presented around the means). A value of 0 on the horizontal axis represents the risky urn with 5 blue and yellow balls. The ambiguous urn with 4-6 balls of each color is represented by 1, 2-8 by 3 and 0-10 by 5. For men, the reservation price decreases sharply when ambiguity increases from urn 1 (no ambiguity) to urn 2 (4-6 balls). When ambiguity increases further (2-8 balls and 0-10 balls) the decrease in value of the lottery is similar to the decrease for women.

Figure 2
Varying the degree of ambiguity, Women versus men



We examine whether the difference between men and women in ambiguity aversion can be explained by the difference in risk aversion. To answer this question, we calculated the valuation of the ambiguous urns 2-4 (with 4-6, 2-8 or 0-10 yellow and blue balls) controlling for the value of the risky Urn 1. Figure 3 shows that the adjusted valuation of the ambiguous urn of men is lower than the value set by women. The difference between men and women now becomes statistically insignificant for all levels of ambiguity aversion. The gender difference in ambiguity aversion disappears when we control for the difference in risk aversion between men and women.

A second issue is whether cognitive and noncognitive traits can explain part of the gender difference. Figure 4 shows that when we control the value of lotteries for cognitive and noncognitive traits (as reported in Table 3), the

difference between men and women decreases by approximately 20%. So gender differences in ambiguity aversion can only be partly explained by differences in cognitive and non-cognitive traits.

Figure 3
Difference between male and female ambiguity aversion, controlling for risk (Urn 1)

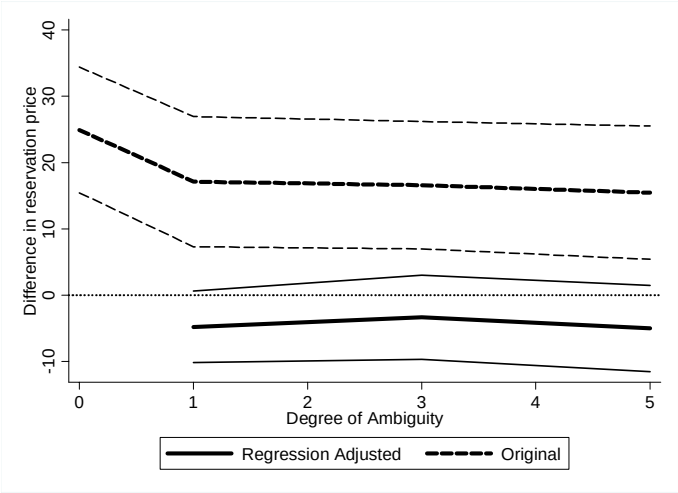
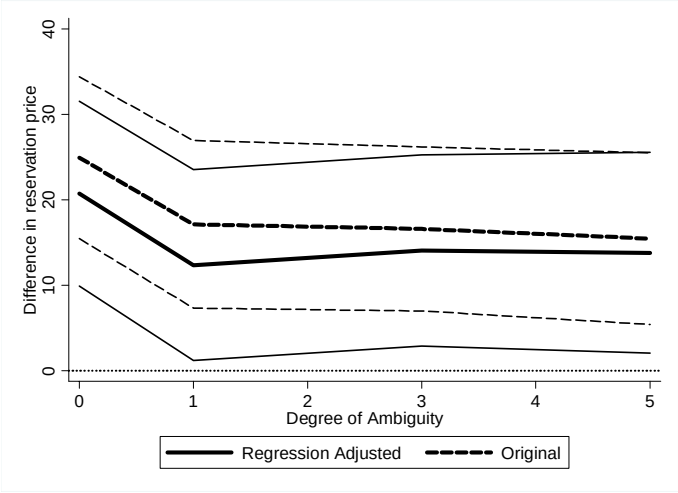


Figure 4
Difference between male and female ambiguity aversion, controlling for IQ and personality traits



4. Conclusions

This paper analyzes gender differences in ambiguity aversion and whether they can be explained by differences in personality traits. Using Halevy's (2007) measure of ambiguity aversion, we investigate how willingness to pay increases when the degree of ambiguity is reduced, and we analyze the extent to which differences between men and women are due to risk aversion and cognitive and personality traits.

Our analysis indicates that participants generally value ambiguity less than risk. Women are more risk averse, while men seem to be more ambiguity averse. Volunteers have a lower standard deviation in their answers. This suggests that volunteers are more similar in characteristics. Conditioning on risk aversion, the gender gap in ambiguity aversion vanishes. Psychological traits are strongly related to risk but not to ambiguity. Conditioning on personality explains about half of the difference in ambiguity between men and women.

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