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Math skills and risk attitudes

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Abstract

We study whether math ability affects decision making under risk. Participants where divided in three math skill groups according to their performance in a GRE-like math test. We find no difference in behavior between groups across several risk measuring tasks.
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Keywords: Decision making under risk; GRE test; Math skills

JEL classification: C91; D81

1. Introduction

Within the Experimental Economics family there is some concern on how unobservable individual features may drive experimental results. For instance, in a risk aversion test the calculation of expected payoffs might be affected by individual math abilities.

We want to check the relationship between computational abilities and decision making under risk. To do so, we first classified our participants according to their performance in a test similar to the math section of the Graduate Record Examinations (GRE). We constructed three ability groups according to the scores obtained in the test: 10% Top, Intermediate and 10% Bottom. Notice we assigned the 10% extremes of the sample to the Top and Bottom groups in order to stress test the hypothesis of equality between the three sub-samples. A percentage lower than 10% would make our sub-samples simply too small.

Each participant took a battery of six risk aversion measuring tasks. The first four tasks corresponded to four lottery panels like the ones described in Sabater-Grande and Georgantzis (2002). This is a revised version of Roth and Malouf (1979) ternary lotteries. The fifth task was a modified, no premium, lottery panel as the initial ones. Finally, they played a Holt and Laury (2002) type of risk attitude elicitation mechanism.

Risk attitudes seem to be quite uniform across groups. Indeed, our tests indicate that our three sub-samples are indistinguishable for all but the second task (see Table 2).

Following this introduction, Section 2 contains the objectives and hypothesis of this study. Section 3 explains our experimental design. Section 4 explains the results. Finally, Section 5 concludes. Our experimental instructions are available from the authors at http://www.ugr.es/~pbg/material/intro.htm.

2. Objective and hypothesis

2.1. Objective

To analyze whether subjects endowed with heterogeneous mathematical abilities differ, in terms of risk aversion.

Table 1
Demographic data

	Top	Intermediate	Bottom
Age (years)	20.79	19.4	20.37
Male (%)	84.2	47.2	31.8
N	19	154	19

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Panel 1										
P	1.0	0.9	0.8	0.7	0.6	0.5	0.4	0.3	0.2	0.1
Xpuntos	1.00	1.12	1.27	1.47	1.73	2.10	2.65	3.56	5.40	10.90
Preferencia										
Panel 2										
P	1.0	0.9	0.8	0.7	0.6	0.5	0.4	0.3	0.2	0.1
Xpuntos	1.00	1.20	1.50	1.90	2.30	3.00	4.00	5.70	9.00	19.00
Preferencia										
Panel 3										
P	1.0	0.9	0.8	0.7	0.6	0.5	0.4	0.3	0.2	0.1
Xpuntos	1.00	1.66	2.50	3.57	5.00	7.00	10.00	15.00	25.00	55.00
Preferencia										
Panel 4										
P	1.0	0.9	0.8	0.7	0.6	0.5	0.4	0.3	0.2	0.1
Xpuntos	1.00	2.20	3.80	5.70	8.30	12.00	17.50	26.70	45.00	100.00
Preferencia										

Fig. 1. Lottery panels.

Hypothesis. Subjects endowed with heterogeneous mathematical abilities do not differ, in terms of risk aversion.

3. Experimental design

Experimental sessions were conducted in the classroom during the Microeconomics 1 course at the University of Granada (Spain). This undergraduate course is taught on the spring semester of the first year. A total of four sections participated in the experiment.

Subjects were informed that the number of points obtained during each experimental session contributed to the final grade of the course in the following way: Each of the four sections of the course plays a different tournament. The winner in each section receives three extra bonus points in his or her final grade. Note that grades in Spain go from 0 to 10, 10 being equivalent to A+. The other participants' bonus depends on how close they were to the winner.

3.1. GRE general test

First, subjects took a test with 19 sample questions from the quantitative section of the GRE general test plus 6 specifically designed probability items formulated in the same way as the GRE questions. We added that 6 probability items in order to get more probability related results. The complete design of this test and other relevant information about it is well reported in Espinosa and Gardeazabal (2005).

A total of 192 subjects took the GRE test. We divided our sample in three sub-samples, Top, Intermediate and Bottom, according to their performance. Top consists of the 10% highest scores (19 subjects) and bottom the 10% lowest. Intermediate gets the 80% (154) remaining subjects. Following the GRE tests subjects faced tasks 1 to 5. Task 6 was played after as a separate session.[1]

Table 1 shows the demographic characteristics of our sample distinguishing between Top, Bottom and Intermediate. Notice there is a higher proportion of males in the Top sub-sample than in Bottom or Intermediate. Some studies indicate that males are less risk averse than females (see Jiménez, 2004 or Byrnes et al., 1999). Therefore, there might be a gender bias. That is, the Top sub-sample might report a lower risk aversion because of being composed mostly by males.

3.2. Risk aversion tasks

In a second step, we measure the risk aversion in terms of lottery playing. We use six tasks to check if individual behavior under uncertainty is affected by individual math capabilities.

3.3. Tasks 1 to 4: lottery panels

These are the lottery panels used by Sabater-Grande and Georgantzis (2002), S&G hereafter.[2] They designed a revised version of the ternary lotteries approach (see Roth and Malouf, 1979, or Murningham et al., 1988, among others). Let a lottery (p, X) imply a probability p of earning X (else nothing). Consider a continuum of such lotteries constructed to compensate a riskier options with increase in the expected payoff. Formally, each continuum of lotteries will be defined by the pair (c,r) corresponding, respectively, to the certain payoff c above which the expected payoff is increased by r times the probability of earning nothing. Therefore, $pX(p) = c + (1-p)r \Rightarrow X(p) = \frac{c+(1-p)r}{p}$.

In order to simplify the decision problem faced by our subjects, we have used lottery panels each one of which corresponds to a discretization of a continuum of lotteries. Fig. 1 presents the payoffs corresponding to the favorable outcome of each lottery whose probability p is given at the first row of each panel; the second row shows the payoffs and the third is the place where subject mark his preferred choice. These panels had

[1] We got only 13 original Top, 124 Intermediate and 14 Bottom participants for task 6. It was not our intention originally to extend the study to task 6. We decided to do so in order to get additional evidence for our results.

[2] Brañas-Garza et al. (2007) uses this tool to analyse pathological gambling.

Panel 5										
P	1.0	0.9	0.8	0.7	0.6	0.5	0.4	0.3	0.2	0.1
Xpuntos	1.00	1.11	1.25	1.42	1.66	2.00	2.50	3.33	5.00	10.00
Preferencia										

Fig. 2. S&G modified.

been constructed using $c=1$ and $r=0.1, 1, 5, 10$. Each subject is asked to choose the most preferred lottery for each panel.

By inspection, the farther right the subject chooses, the less risk averse he is. Risk neutral (risk loving) subjects would choose $p=0.1$ in all panels.

3.4. Task 5: a modification of S&G

The fifth test is a modification of S&G panels. We use a variation of S&G lottery panels on which subjects do not receive any premium. A risk neutral individual should be indifferent between all the lotteries in Panel 5, see Fig. 2.

3.5. Task 6: a variation of Holt and Laury

This test was introduced in Brañas-Garza et al. (2004) (BGJM hereafter). It is a variation of the Holt and Laury (2002) design in the sense that subjects have to choose between a sure amount of money and a lottery. In contrast to the general tendency in the literature, BGJM does not offer directly the lottery but the following two-player game.

Individuals were told that they were the player 1 and that player 2's choice would be selected by the toss of a fair coin; hence, player 2 would play each action with a 50% of probability. The sequence players followed was: First, they had to decide which strategy they will play (*A or B*) and, second, they had to fill a payments card with ten decisions where each of them consists of choosing between a sure amount of money (ranked from 1 to 10) or playing the game (Fig. 3). Brañas-Graza et al. (2004) assumes that when filling the payment card, the individual considers that the relevant row of the above game is the one corresponding to his chosen strategy. Hence, the game reduces to a lottery. Therefore, an individual would choose to play the lottery if the sure monetary payoff is lower than the certain equivalent of the lottery. Note that the amount of money at which the individual switches from playing the game to the sure amount of money is precisely the certain equivalent of the lottery.[3]

4. Results

Now we study how each population behaved in the referred panels. Fig. 4a to e show cumulative frequencies in the vertical axis and probability of winning the lottery in the horizontal axis. Fig. 4f shows cumulative frequencies (in the vertical axis) for decisions taken in the payments card related to task 6. The series of figures show that most of the time subjects belonging to the Top sub-sample (continuous line with crosses) are a bit more risky than Bottom (continuous line with dots) and Intermediate (dashed line). This pattern does not seem to be so strong. Moreover, the small difference can be justified because a possible gender bias. Remember there is a majority of males in the Top sub-sample and males are usually less risk averse.

We check in Table 2 whether results are statistically different between sub-samples in each task. These results arise from a series of Kruskal–Wallis and Median non-parametric tests for $k=3$ unrelated samples. The null hypothesis says that the sub-samples come form the same population (Kruskal–Wallis), or that the median is the same in all the three sub-samples (Median). We perform the same analysis in each panel.

Both series of Kruskal–Wallis and Median report similar results. All the three sub-samples come from the same population according to the Kruskal–Wallis tests for all the tasks besides task 2. All sub-samples have the same median according to the Median test.

Top group members are mostly males. Experimental evidence explains males are less risk averse than women. Hence, part of their more risky (although only significant in task 2) behavior may be explained by this gender bias.

We run three OLS regressions in order to distinguish the gender and ability effects, see Table 3. We define three dependent variables: (1) the average choice of each individual i across tasks 1 to 4 $\left(\hat{P}=\frac{1}{4}\sum_j p_{i,j};\ i=1,\ldots,192;\ j=1,\ldots 4\right)$; (2) the variance ($\sigma^2$) of choices of each individual i across tasks 1 to 4; (3) we define a subject's *sensitivity* to the difference between choices in panel 1 and panel 4, $(S_i)=|P_i^4-P_i^1|$. Our explanatory variables are the age of the subject (Age), a Top dummy (Top), a Bottom dummy (Bottom) and a Female dummy (Female). Notice we are only using data from tasks 1 to 4. The reason is that task 6 gives a different type of data that cannot be pooled with the other tasks. Including the no-premium task 5 does not make much sense either.

Columns (1) to (3) in Table 3 show the estimates obtained. The "*" symbol denotes significance of $\alpha<1\%$; "**" corresponds to $\alpha<5\%$; "***" corresponds to $\alpha<10\%$; no asterisk implies no significance.

[3] As an example, consider the dominant strategy for the player 1. It gives either 4 or 8 with the same probability. This implies that under Expected Utility Theory, we can only characterize the respondents' attitudes toward risk into this interval. So, a value of 6 would mean that he is a risk neutral person. If the value is lower than 6, the individual would be risk averse and risk loving if his value was bigger than 6.

	p	1-p
A	4,4	8,3
B	3,8	0,0

Fig. 3. Game.

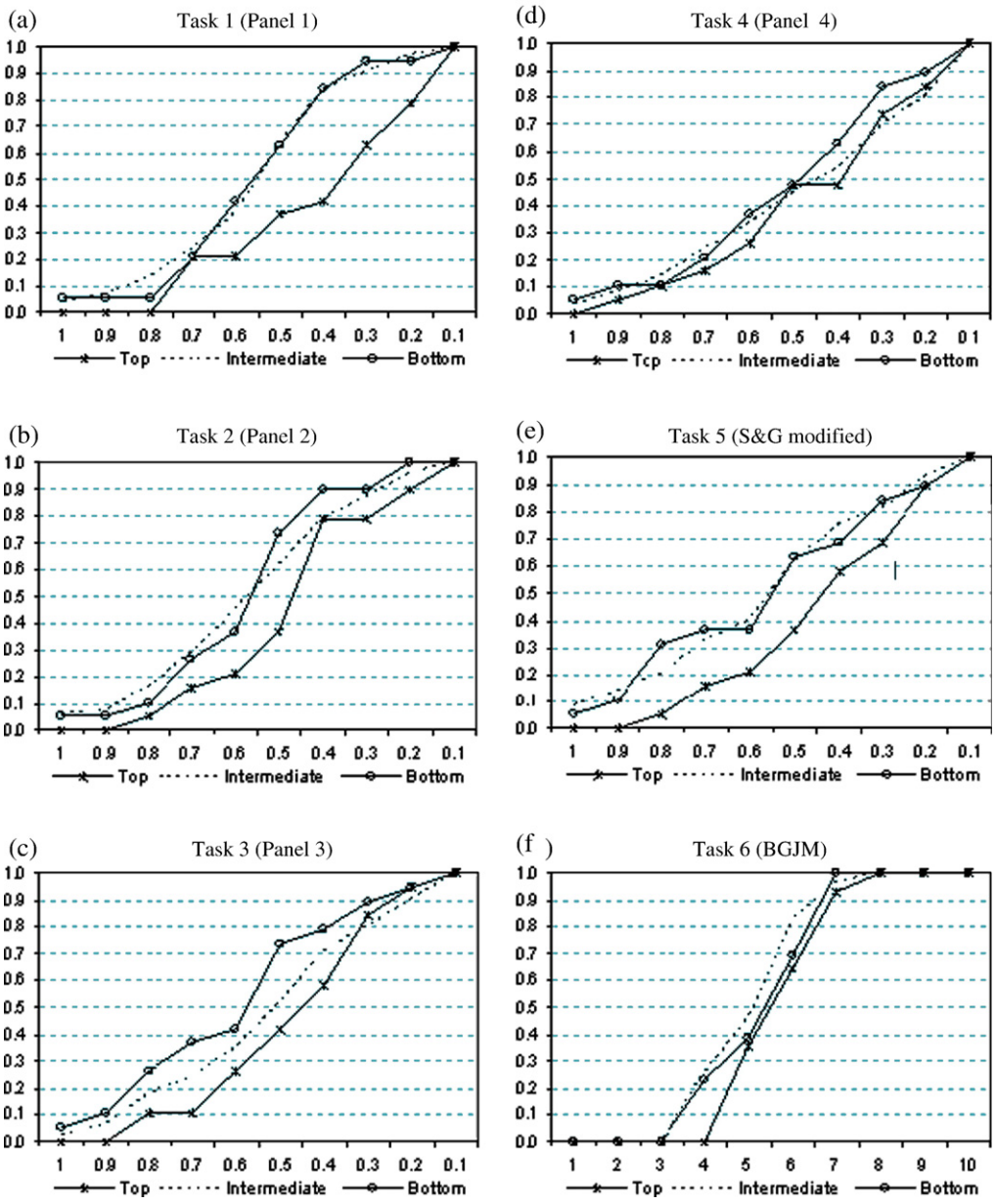


Fig. 4. Cum. freq. through lotteries.

The most salient result in our regressions is that the Top and Bottom dummies are never significant whereas Female is a highly significant explanatory variable for the average, model (1). Female is also significant for explaining sensitivity, but only at 10%. Age is significant in the three models but the value of the coefficient is very small.

Table 2
Between subjects analysis

	Test 1	Test 2	Test 3	Test 4	Test 5	Test 6
Kruskal-W χ^2	3.47	8.35	3.87	3.05	0.55	4.56
p-value	0.17	0.01	0.14	0.21	0.75	0.10
Median χ^2	1.51	2.30	4.12	1.05	0.08	2.66
p-value	0.14	0.31	0.12	0.59	0.96	0.26

Therefore we can conclude that the small and generally insignificant differences across sub-sample can be better explain by gender rather than by mathematical ability. Our main result follows that logic.

Table 3
Individual behavior

	$\widehat{P}$	σ^2	Sensitivity
	(1)	(2)	(3)
Top	−0.08	−0.01	−0.05
Bottom	−0.00	−0.01	−0.04
Female	0.09*	0.00	−0.04***
Age	0.01***	−0.00**	−0.01***
C	+0.22	+0.06*	+0.41*
$\overline{R}^2$	7.3	4.5	4.5

4.1. Result

Individual computational capabilities seem to be unrelated to risk attitudes.

5. Conclusions

We study whether math ability affects decision making under risk. Participants where divided in three different groups according to their performance in a series of GRE math items. Then, they faced six risk aversion tasks. Although individual abilities seem to be, a priori, crucial in calculating expected payoffs and then in lottery playing, we find virtually no difference across groups. The small and generally insignificant differences can be better explained by gender. This is a critical result on the direction of supporting the validity of the Experimental Economics methodology.

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