Economics Letters 110 (2011) 97–100

Contents lists available at ScienceDirect

Economics Letters

journal homepage: www.elsevier.com/locate/ecolet

Behavioral biases and cognitive reflection☆

Eva I. Hoppe *, David J. Kusterer

Department of Economics, University of Cologne, Albertus-Magnus-Platz, 50923 Köln, Germany

ARTICLE INFO

Article history:
Received 14 October 2009
Received in revised form 29 October 2010
Accepted 9 November 2010
Available online 18 November 2010

JEL classification:
C91
D80
J24

Keywords:
Cognitive reflection test
Base rate fallacy
Conservatism
Overconfidence
Endowment effect

ABSTRACT

In a large-scale laboratory experiment, we investigate whether subjects' scores on the cognitive reflection test (CRT) are related to their susceptibility to the base rate fallacy, the conservatism bias, overconfidence, and the endowment effect.

1. Introduction

Only recently, researchers have started to investigate the impact of cognitive ability on judgment and decision making. Frederick (2005) introduces the cognitive reflection test (CRT) which is a simple, three-item test to measure a person's mode of reasoning and cognitive ability.[1] Frederick (2005) shows that people with high CRT scores are generally more patient and more willing to gamble in the domain of gains.[2] In a related study, Oechssler et al. (2009) replicate the findings regarding time and risk preferences and in addition they study the relationship between cognitive abilities and the conjunction fallacy, conservatism, and anchoring.[3] One central result is that individuals with low cognitive abilities tend to be significantly more affected by behavioral biases.

In the present study, we investigate whether the incidence of further behavioral biases is related to cognitive abilities. Specifically, we study the base rate fallacy, overconfidence, and the endowment effect. Moreover, we replicate the finding of Oechssler et al. (2009) related to the conservatism bias in order to investigate an interesting question that was brought up in their paper. Are people that exhibit the conservatism bias (i.e., overweight the base rate) less susceptible to the base rate fallacy (i.e., to underweight the base rate)? We observe the contrary. In particular, we find that individuals with lower cognitive abilities are significantly more likely to exhibit both, the base rate fallacy and the conservatism fallacy. With regard to overconfidence, we find that subjects with higher CRT scores have a significantly more precise self-assessment. Finally, test scores do not affect the occurrence of the endowment effect which is striking in both, low and high CRT groups.

2. Experimental design

The experiment was conducted in July 2009.[4] Using ORSEE (Greiner, 2004), we recruited the participants from the subject pool of the Cologne Laboratory for Economic Research. In total, 414 students from the University of Cologne participated in the experiment. Following several socio-demographic questions (concerning gender, age, field of

☆ We thank an anonymous referee for helpful comments and Patrick Schmitz for valuable discussions and suggestions.

* Corresponding author. Tel.: +49 221 470 2999; fax: +49 221 470 5077.
E-mail addresses: eva.hoppe@uni-koeln.de (E.I. Hoppe), david.kusterer@uni-koeln.de (D.J. Kusterer).

[1] The CRT has recently also been used to assess the decision making processes of professional groups such as judges and financial planners, see Guthrie et al. (2007) and Nofsinger and Varma (2007).

[2] Using other measures of cognitive ability, Brañas-Garza et al. (2008) and Slonim et al. (2007) also study whether there are relations between cognitive abilities and risk or time preferences.

[3] See also Bergman et al. (2010), who analyze the anchoring effect and find that the amount of anchoring decreases but does not vanish with higher cognitive ability.

[4] It was run subsequent to an unrelated principal–agent experiment (see Hoppe and Kusterer, 2009). In this previous experiment, the participants earned 11.03 € on average including a show-up fee of 4 €. The sessions lasted between 30 and 40 min.

0165-1765/$ – see front matter © 2010 Elsevier B.V. All rights reserved.
doi:10.1016/j.econlet.2010.11.015

Table 1
Distribution of answers to the CRT questions.

Question	Correct	Intuitive	Other
Bat and ball	56.7%	39.9%	3.4%
Widgets	58.9%	28.2%	12.9%
Lily pads	68.9%	16.1%	15.1%

study, and length of study), the subjects had to fill in a questionnaire consisting of three questions building the CRT and several questions related to the behavioral biases mentioned in the introduction.[5] Participants were given 15 min to fill in the questionnaire and the experimenter stopped the experiment after the time was over.[6]

Subjects were paid 0.40€ for each CRT question they answered correctly. Moreover, for the decision problems related to the base rate fallacy and conservatism, they received 0.40€ if their answer did not deviate more than 15 percentage points from the correct answer. Regarding overconfidence, subjects had to answer five general knowledge questions and they had to assess how many of these they answered correctly. For each correct answer (including the assessment question) they received 0.20€. Finally, with regard to the endowment effect, subjects could receive additional 0.20€ or, alternatively, take a highlighter home. In total, subjects earned between 0 and 2.80€, and the average payoff was 1.24€. Moreover, 180 subjects left the lab with a brand new highlighter. The experiment was programmed and conducted with z-Tree (Fischbacher, 2007).

3. Cognitive reflection test

To measure cognitive ability, we use the three-item cognitive reflection test (CRT) that was introduced by Frederick (2005). The three questions are designed such that they have an intuitive but wrong answer that comes to mind quickly and a correct answer that is easy to understand when explained. Hence, the test is supposed to measure a person's ability to engage in cognitive reflection and thus to resist reporting the spontaneous but wrong answer. In particular, the three questions read as follows.

1. A bat and a ball together cost 110 cents. The bat costs 100 cents more than the ball. How much does the ball cost? (spontaneous answer: 10 cents; correct answer: 5 cents).
2. If it takes 5 machines 5 min to make 5 widgets, how long would it take 100 machines to make 100 widgets? (spontaneous answer: 100 min; correct answer: 5 min).
3. In a lake, there is a patch of lily pads. Every day, the patch doubles in size. If it takes 48 days for the patch to cover the entire lake, how long would it take for the patch to cover half of the lake? (spontaneous answer: 24 days; correct answer: 47 days).

In our sample, 13% of the subjects answered none of the questions correctly, 24% knew the correct answer to one question, 27% to two questions, and 36% answered all three questions correctly. On average, the subjects answered 1.84 of the CRT questions correctly.[7]

Table 1 shows the distribution of the answers to the CRT questions. For each question, the majority of the subjects gave the correct answer. Among the subjects who did not submit the correct answer, the intuitive answer was given most frequently.

[5] Subjects found a calculator, a pen, and a piece of paper in their cabin.

[6] Note that only three participants did not complete the questionnaire within the given time limit so that our analysis is based on 411 completed questionnaires.

[7] There is a strong gender difference: male subjects have an average score of 2.12, while female subjects have an average score of 1.61 only. The difference is highly significant ($p<0.0001$, two-sided Mann–Whitney U test). This gender difference has also been found in other studies using the CRT, e.g. Frederick (2005) and Oechssler et al. (2009).

Table 2
Behavioral biases by CRT group.

Category	Item	CRT group		
		low	high	p-value
Base rate fallacy	Avg. prob. stated (correct prob.: 9%)	77.4%	61.5%	$p\approx0.0002$
Conservatism	Avg. prob. stated for urn A (correct prob.: 97%)	56.8%	60.1%	$p\approx0.056$
Overconfidence	% overconfident	60.7%	57.4%	$p\approx0.056$
	% correct self-assessment	23.2%	32.4%	
	% underconfident	16.1%	10.2%	

The p-values regarding the base rate fallacy and the conservatism bias result from two-sided Mann–Whitney U tests, while the p-value regarding overconfidence is obtained using a two-sided χ^2 test.

4. Results

The central results of our study are summarized in Tables 2 and 5. Depending on their CRT score, we divide the participants in two groups. The "low" group consists of individuals who answered zero or one of the questions correctly, while the "high" group consists of participants that gave the correct answer to two or three questions.[8] We refer to subjects in the "high" group as the more *analytical* decision takers, while we describe subjects in the "low" group as relatively *intuitive* decision takers.

4.1. Base rate fallacy

When people are asked to judge the probability of an event, they often have to take into account information about the base rate probability and at the same time, they have to consider specific evidence about the case at hand (Tversky and Kahneman, 1982). In such a context, they exhibit the base rate fallacy if they follow the representativeness heuristic and neglect the base rate probability.

In analogy to the mammography problem in Eddy (1982), subjects in our study faced the following problem: "In a city with 100 criminals and 100,000 innocent citizens there is a surveillance camera with an automatic face recognition software. If the camera sees a known criminal, it will trigger the alarm with 99% probability; if the camera sees an innocent citizen, it will trigger the alarm with a probability of 1%. What is the probability that indeed a criminal was filmed when the alarm is triggered?" The correct answer is ≈9%, but in both CRT groups, a large fraction of the subjects stated a probability larger than 90%. These subjects exhibit the base rate fallacy since they do not or barely consider the low base rate of criminals in the population. However, compared to the low CRT group, subjects in the high CRT group are considerably less susceptible to this bias and state the correct probability more often (see Fig. 1).[9]

It is also striking that the average CRT score of subjects who correctly take into account the small base rate is considerably larger than the average CRT score of subjects who exhibit the base rate fallacy (see Table 3).

4.2. Conservatism bias

While people that exhibit the base rate fallacy underweight base rates, there are also situations where base rates are overweighted relative to sample evidence. In such situations, subjects are too conservative in adapting prior probabilities to new evidence, and hence this fallacy is

[8] This categorization was used by Oechssler et al. (2009). We also considered the categorization of Frederick (2005) who assigned subjects with zero correct answers to the "low" group and those with three correct answers to the "high" group. However, with regard to our data this would imply not to analyze more than 53 % of the observations. Note that the latter categorization would not change our results qualitatively.

[9] In the high CRT group, 19.1% of the subjects choose 9 or 10% as their answer, while in the low CRT group, this answer is stated in only 9.7% of the cases ($p=0.01$, two-sided χ^2 test). Moreover, the average probability assessed by the subjects in the high CRT group equals 61.5%, which is significantly smaller than 77.4%, the average probability assessed in the low CRT group.