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Higher cognitive ability is associated with lower entries in a *p*-beauty contest

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ABSTRACT

"Beauty contests" are well-studied, dominance-solvable games that generate two interesting results. First, most behavior does not conform to the unique Nash equilibrium. Second, there is considerable unexplained heterogeneity in behavior. In this work, we explore the relationship between beauty contest behavior and cognitive ability. We find that subjects with high cognitive ability exhibit behavior that is closer to the Nash equilibrium.

1. Introduction

A "beauty contest" (Nagel, 1995) is a simple strategic situation where people simultaneously choose a number from some finite range, commonly 0–100. The winner is the person whose selection is closest to some fraction, *p*, of the average of all the choices. Ties are either resolved randomly or by dividing the prize equally among the winners. In a commonly studied variant of a beauty contest, *p* is strictly greater than 0 and strictly less than 1, which implies a unique Nash equilibrium where all choices are identically zero.

The first beauty contest experiment documented large and persistent deviations from this prediction (Nagel, 1995). Further research has confirmed this finding while studying the effects of varying stakes, learning, and subject pools (Camerer, 2003; Chou et al., 2009; Duffy and Nagel, 1997; Ho et al., 1998). Repetition tends to produce convergence toward the Nash equilibrium, in some studies larger stakes are associated with behavior that is closer to equilibrium, and substantial deviations from Nash equilibrium have been documented in a variety of different subject pools.

In this paper we ask if there is a relationship between cognitive ability and entries in the beauty contest. There is a nascent literature on cognitive ability and economic behavior. Small-stakes loss aversion and impatience are associated with lower cognitive ability in a series of related studies (Benjamin et al., 2006; Burks et al., 2009; Dohmen et al., 2007;

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Frederick, 2005). Studies of simple bargaining games report inconsistent relationships between behavior and cognitive ability (Brandstätter and Güth, 2002; Millet and Dewitte, 2007). In repeated prisoner's dilemmas, a meta-study reports higher levels of cooperation conducted at universities that admit students with higher standardized test scores (Jones, 2008). Finally, one recent study examined the relationship between various measures of cognition and dominance violations (Rydval et al., 2008). The authors found that reasoning errors were associated with lower performance on a test of working memory.

Cognitive ability scores have high predictive validity for behaviors that are central to economics. These include modest correlations between cognitive ability and wages, education, employment, and occupation (Cawley et al., 2001), as well as smoking, illegal drug use, and teen pregnancies (Heckman et al., 2006). Furthermore, a study of large stakes retirement decisions find that lower cognitive ability is correlated with a preference for lump-sum payments over annuities at discount rates of up to 30% (Warner and Pleeter, 2001). These relationships are sensible given that the tests were designed to predict real world outcomes (Geary, 2004).

We contribute to the investigation of cognitive ability and economic behavior with an experimental study that has the following attributes. First, we directly test cognitive ability, which we prefer to the use of proxies, such as SAT scores or GPA. Second, we examine behavior in the beauty contest, a setting without any obvious preference-based explanation for non-equilibrium behavior. Third, we draw our subject pool from the Swedish population-based Twin Registry, which is an improvement over a subject pool of students in terms of representativeness.

2. Methods

Subjects played a beauty contest with a range of [0, 100] and the parameter p was set at 0.5 (See Appendix A for full beauty contest instructions). The test used was a short, standard psychometric test of cognitive ability developed by the Swedish psychometric company Assessio (Sjöberg et al., 2006). Subjects had 20 min to complete the test, and were notified with 5 and 1 min remaining. The test is divided into three sections on analogies, number series, and logical series.

A total of 658 subjects were drawn from a population-based registry in Sweden. Because the subjects were part of a related study on heritability (Cesarini et al., 2009), all were same sex twins. Subjects were born between 1960 and 1985, and were solicited by e-mail and recruited in all major Swedish cities through the summer and fall of 2006. A condition for participation was that both twin siblings be able to participate. Subjects who agreed to participate were invited to a local college where they participated in a series of experiments under controlled conditions. Upon arrival, they were informed about the general proscription against deception in economics. There was no scope for communicating with other participants prior to making decisions in the experiment.

Participants were further notified that if they felt that there were any ambiguities in the instructions, they should feel free to ask questions, and questions were answered privately. We also stressed, both in the written instructions and orally, that answers would be treated with complete confidentiality. Two subjects did not take the test of general mental ability and these observations were dropped. No subject declined to take part in the beauty contest. In addition, we obtained subjects' age, sex, and level of education.

3. Results

As in previous studies of the beauty contest, very few people in our sample conform to the Nash prediction, and choices range from the equilibrium of 0 all the way to the maximum allowed choice of 100. The mean choice in our study is 34.12, versus the unique Nash equilibrium of 0, and the winning choice of 17.06. In all analyses that follow, standard errors are adjusted to take into account non-independence within family (Liang and Zeger, 1986).

Dominance violations, i.e. entries above 50, are much more common among subjects with low cognitive ability. We define a dummy variable which takes the value 1 if the individual violates dominance. Running a probit regression with this dummy as the dependent variable, and IQ as the independent variable, produces a coefficient of -0.42 ($p < 0.0001$). Among subjects in the highest two deciles of cognitive ability, 7 out of 142 violate dominance. Among subjects in the lowest two deciles of cognitive ability, 58 out of 150 violate dominance.

Cognitive ability is clearly correlated with the distance from Nash equilibrium in this beauty contest. Visually, this is shown in Fig. 1 where we graph the average beauty contest choice, and 95% confidence bands for the mean, stratified for each decile in the cognitive ability distribution. Subjects in the highest two deciles of cognitive ability have an average choice that is very near the revenue maximizing number of 17.06, whereas subjects in the lowest three deciles have average choices just below 50. In Fig. 2, beauty entries are plotted against the scores of cognitive ability.

Regressing the distance from Nash equilibrium on cognitive ability and controls which include sex, education, and age, the coefficient on cognitive ability is statistically significant ($p < 0.0001$). The relationship between cognitive ability and beauty contest behavior is not changed appreciably by introducing additional covariates (see Table 1). Depending on which controls are included, moving up one standard deviation in the distribution of cognitive ability is associated with a 7–10 point decrease in beauty contest choice. Beauty contest choice shows a statistically significant increase along with subject age. There is no statistically significant relationship between sex and beauty contest choice. Education, defined as having some college education, is significantly correlated with choices that are closer to Nash. When we use the absolute deviation from the winning choice (17.06) as the dependent variable, the results are very similar. These results are reported in Table 2.

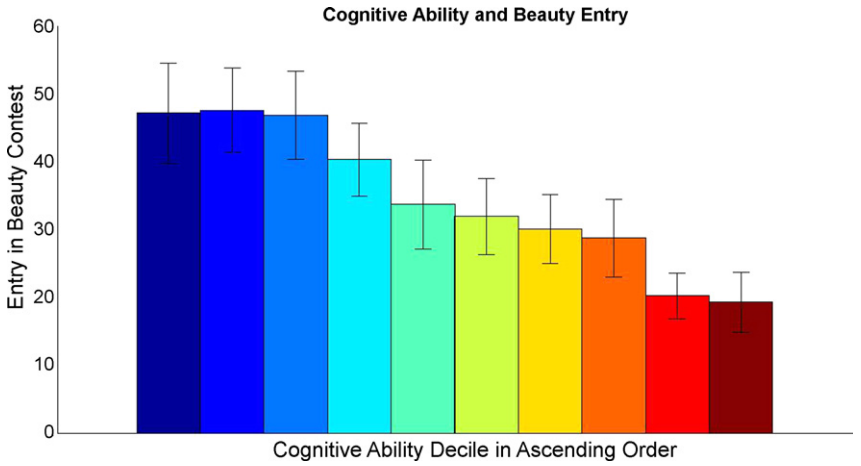

Fig. 1. Beauty contest entry and cognitive ability (by decile), 95% standard error bars are shown.

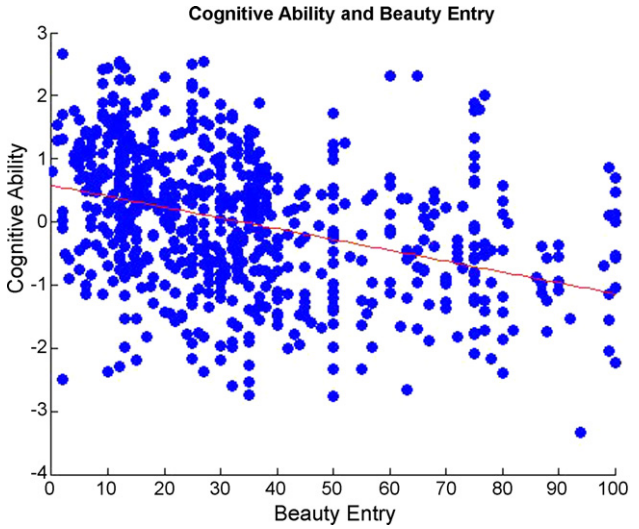

Fig. 2. Scatterplot of beauty contest entry against cognitive ability. Cognitive ability is standardized to be mean zero and have unit variance.

Table 1
Dependent variable: beauty contest choice.

	(1)	(2)	(3)	(4)	(5)
Cognitive ability	−9.67 **(0.92)	−8.66 **(0.95)	−9.47 **(0.96)	−8.81 **(1.01)	−7.61 **(1.04)
Age (years)	–	0.50 **(0.13)	–	–	0.48 **(0.13)
1 if female	–	–	2.53 (2.24)	–	2.46 (2.28)
1 if college educated	–	–	–	−4.68 *(2.17)	−4.88 *(2.17)
Constant	34.04 **(0.95)	17.66 **(4.15)	32.03 **(1.96)	37.22 **(1.82)	19.84 **(4.68)
Observations	656	656	656	656	642
R^2	0.165	0.187	0.166	0.166	0.195

Heteroskedasticity robust standard errors in parentheses, clustered at the family level.
* Significant at 5%.
** Significant at 1%.

4. Discussion

We find that the "distance to Nash equilibrium" in a beauty contest is negatively correlated with cognitive ability. There are two salient interpretations of this correlation. First, cognitive ability may be related to non-equilibrium beliefs about the entries of other participants. If so, people with higher cognitive ability are, on average, better at accurately forming such beliefs. Second, a bounded rationality interpretation is that subjects with lower cognitive ability have computational

Table 2
Dependent variable: absolute deviation of beauty contest choice from the Revenue-Maximizing Entry (17.06)

	(1)	(2)	(3)	(4)	(5)
Cognitive ability	−7.30 ** (0.84)	−6.41 ** (0.81)	−7.21 ** (0.83)	−6.62 ** (0.89)	−5.72 ** (0.91)
Age (years)	–	.44 ** (.11)	–	–	.44 ** (0.11)
1 if female	–	–	1.22 (1.89)	–	.96 (1.90)
1 if college educated	–	–	–	−4.05 * (1.97)	−3.84 (1.97)
Constant	20.82 ** (0.84)	18.34 ** (4.23)	32.62 ** (1.97)	37.05 ** (1.78)	20.36 ** (4.84)
Observations	656	656	656	642	642
R^2	0.126	0.191	0.171	0.175	0.196

Heteroskedasticity robust standard errors in parentheses, clustered at the family level.
* Significant at 5%.
** Significant at 1%.

difficulties finding the equilibrium. Since entries above 50 are more common in subjects with lower cognitive ability, and since such entries violate dominance, it is likely that at least part of the observed correlation is accounted for by this second interpretation. The current design does not distinguish between these two interpretations, and we believe this would be a useful area for subsequent studies.

A fundamental question is whether behavioral anomalies observed in the laboratory should concern economists. For example, Ken Binmore argues against taking experimental evidence uncritically, suggesting that people get to equilibrium by an interactive process of trial-and-error learning (Binmore, 1999). Beyond experience, a form of selection may also limit the economic costs of behavioral anomalies. A series of papers concludes that people who are in a market frequently tend to behave as predicted by standard economic theory (List, 2003). And, some argue that institutional factors mitigate the extent to which behavioral anomalies persist in the real world (Levitt and List, 2007).

Others argue, however, that behavioral anomalies can persist despite ample scope for learning (Mullainathan and Thaler, 2001), and in some settings irrationality at the individual level can be magnified, not mitigated, at the group level (Fehr and Tyran, 2005). Finally, Richard Thaler has critiqued the view that learning and selection minimize the relevance of behavioral anomalies, noting that some of the most important decisions such as career choice, marriage partner, and number of children do not easily allow for trial-and-error learning or selection (Thaler, 2000).

Our findings are broadly consistent with other studies investigating the relationship between cognitive ability and economic decisions (Benjamin et al., 2006; Burks et al., 2009; Dohmen et al., 2007; Frederick, 2005). The contribution of our study is to strengthen the previous findings, because this experiment has three features that are not found in combination in any of the prior studies. We directly test cognitive ability, we examine behavior in a setting without any obvious preference-based explanation for behavior, and we draw from a broad subject pool. Given the robust relationship between measured cognitive ability and important economic outcomes including income, we favor further study of these issues.

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Appendix A. Instructions (translated from Swedish)

"In this section you will take part in a guessing contest. Your task is to guess a number between 0 and 100. All participants of this study will be asked to provide a guess (several hundred people take part in the study). The person whose guess is closest to half the average guess will win 1000 SEK (for instance, if the average guess is 50, the person whose guess is closest to 25 will win the 1000 SEK). Please indicate your guess below."

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