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Cognitive Ability and Cooperation: Evidence from the Public Goods Experiments

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The most important unanswered question in evolutionary biology, and more generally in the social sciences, is how cooperative behavior evolved. What it takes to bring out our cooperative spirit is a scientific puzzle that is driving basic scientific research and shaping the future of science. By using the public goods game model, we designed four types of experiments, namely, non-punishment (NP), free punishment (FP), cost punishment (CP), and external punishment (EP) experiment, to test the hypothesis that people with higher cognitive abilities have internalized a higher tendency of cooperation. We found that people with higher cognitive abilities are more willing to sacrifice private gain for the public good in FP, CP, and EP experiment; They also imposed more "pro-social punishment" (spending time and energy to punish unfair actions, even though there's nothing to be gained by these actions for themselves), and less "antisocial punishment" (punishing the high contributors as much as they punished the low contributors).

Key Words: Cognitive ability; Pro-social punishment; Antisocial punishment; Cooperative gain.

JEL Classification Numbers: A10, C70, C91.

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1. INTRODUCTION

An individual's occupational status is closely determined by his or her educational attainment. People with a better diploma will be more competitive in the labor market. The usual explanation for this observation is that under the condition of asymmetric information, the diploma acts as a "signal". Thus, what kind of signal does a diploma convey? Does a better diploma only show a higher level of academic achievement? "Honor graduates" will be shown on the diploma if a student exhibits outstanding academic achievement in some universities in western countries. Such graduates will be more favored in the labor market. What kind of signal does an outstanding academic achievement convey? People with higher cognitive ability will achieve better education diplomas, while people with higher cognitive ability will make outstanding academic achievements and win the title of "Honor graduates." Thus, what kind of signal does higher cognitive ability convey?

We put forward the hypothesis that people with higher cognitive ability have stronger cooperative tendency, and people with stronger cooperative tendency will contribute more private gain to organizations. For this reason, those with better education diplomas and therefore higher cognitive abilities are favored by the labor market.

The subject of "how human cooperative behavior evolves" was established by the journal of "Science" in 2005 as one of the 25 major scientific problems that are driving basic scientific research and shaping the future of science (Kennedy 2005). The July 2005 edition of "Science" stated that, "Cheaters can gain a leg up on the rest of humankind, at least in the short term. But cooperation prevails among many species, suggesting that this behavior is a better survival strategy, over the long run, despite all the strife among ethnic, political, religious, even family groups now rampant within our species." This is an issue that needs evolutionary biologists, zoologists, neuroscientists and economists to join efforts together. We should eventually explore what factors contributed to our spirits of cooperation in the end. The majority of developed countries have established a good educational system which aims not only to teach culture, knowledge, and skills, but also to develop cooperative spirit. When outstanding graduates cultivated by the educational system enter into the labor market, they will bring more cooperative benefit to their organization. Is this right? This paper attempts to test this hypothesis.

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Herrmann et al (2008) employed a public goods game for anonymous college students from 15 different countries with widely varying levels of economic development, including China. Their perspective is how an individual who has contributed a certain amount to the public good punishes other group members who contributed either less, the same amount, or more than them. They found that people in countries with good social and moral atmosphere showed a higher level of cooperation and would punish non-cooperators, which is called "pro-social punishment," even though there's nothing to be gained by these actions for themselves. By contrast, in countries with poor social and moral atmosphere, college students punished those who contributed the same or more than them as harshly as those who rode free on them, which was contrary to "the principle of maximizing personal utility" and thus lowering the entire level of cooperation. Herrmann et al (2008) defined this behavior as "antisocial punishment." Herrmann et al (2008)' evidence comes from public goods experiments that they conducted in 16 comparable participant pools around the world. In China, participants come from Chengdu City. China is a developing country, with emphasis more on the personal interactions among individuals with minimal social ties. The success of China may depend critically on moral virtues but not on material interests. The moral value of sacrificing oneself for the good of the family may be beyond "the principle of maximizing their personal utility." So according to Herrmann et al (2008), people in China do not easily cooperate with strangers and may show a tendency toward antisocial punishment. However, in their study the variable of cognitive ability was not controlled. If the cognitive abilities of college students differ, does their cooperative tendency likewise differ? Can college students with higher cognitive ability be more likely to perform pro-social punishment rather than antisocial punishment?

Liebrand (1984) and Yamagishi (1986) proposed that differences in individual cognitive abilities may be very important in understanding and modeling cooperation. Stevens and Hauser (2004) and Korniotis and Kumar (2010) highlighted that cognitive ability significantly affects cooperative gains. However, these studies have failed to find the mechanism between cognitive ability and cooperative gains. Emonds et al (2012) checked the mechanism through which people with lower cognitive ability have a lower ability to take risks, leading to lower contributions to public goods and less cooperative gains. By contrast, people with higher cognitive ability will be more likely to be risk-loving, leading to a higher contribution to public goods and more cooperative gains. Emonds et al (2012) only focused on the effect of "contribution" on cooperative gains but did not consider effects of "pro-social punishment behavior" as well as "antisocial punishment behavior" proposed by Herrmann et al (2008). In an organization, where "antisocial punishment" prevails, and where there is no "pro-social punishment," cooperative gains would not be remarkably high even if everyone contributes to the public goods as much as possible in the first round. In addition, the cooperative tendency of people can differ under different social mechanisms. For example, cooperative behavior differs in internal and external punishment systems (Vollan and Pröpper, 2009).

This paper attempts to explore the relationship between cognitive ability and cooperative tendency through public goods experiments. We designed four types of punishment experiments: non-punishment (NP), free punishment (FP), cost punishment (CP), and external punishment (EP). The first three experiments belong to internal punishment experiments, and the final one belongs to external punishment experiment. We analyzed differences in the ability to maximize cooperative gains across participant pools with different cognitive abilities in four types of punishment experiments and attempt to find the causality between cooperative tendency and cooperative gains.

The structure of this paper is as follows: The second part presents the experimental set up. The third part describes the experimental data. The fourth part discusses the econometric analysis of the data and its robustness. The last part presents a summary.

2. EXPERIMENTAL DESIGN

The experiments were conducted on June 8, 2010, and the participants were 195 students of the Central University of Finance and Economics, China. Our pilot experiments were conducted in 2008. The data used here were collected from 2010 experiments.

The experimental set up was based on the ideas of Fehr and Gächter (2002) and Herrmann et al (2008), but we introduced four penalty systems (NP, FP, CP and EP) in our experiments.

The public goods game is a stylized model of situations that require cooperation to achieve socially beneficial outcomes in the presence of free-rider incentives. Fehr and Gächter (2000) put forward the basic set up of public goods investment experiments: Groups with four members played the following public goods game. Each member received an endowment of 20 money units (MUs) and each one could contribute between 0 and 20 MUs to a group project. Subjects could keep the money that they did not contribute to the project. For every MU invested in the project, each of the four group members, that is, also those who invested little or nothing, earned 0.4MUs. Thus, the investor's return from investing one additional MU in the project was 0.4MUs, whereas the group return was 1.6MUs. Because the cost of investing 1MU in the project was exactly 1MU, whereas the private return was only 0.4MUs, it was always in the material self-interest of any subject to keep all MUs privately irrespective of how much the other three subjects contributed. Yet, if all group members kept all MUs privately, each subject earned only 20MUs, whereas if all of them invested their 20MUs each subject would earn 32MUs ($0.4*80$). Cooperation makes "the cake" bigger. All the interactions in the experiment took place anonymously. Members were not informed of the identity of the others in the group. Subjects made their investment decisions simultaneously and, once the decisions were made, they were informed about the investments of the other group members. Using this experiment, Herrmann et al (2008) analyzed the effects of internal penalty system on cooperative behavior. In this paper, we introduce an external random penalty system under which low contributors will be punished by a possibility of 25%.

Our experimental procedure is as follows: All 195 students were divided into 39 groups, with each group five students, one leader and four members. The leader was responsible for imposing external punishment. One of the goals of our experiment was to see whether and at what level punishment stabilized cooperation in the FP, CP, and EP experiment compared to the NP experiment. To allow for the emergence of different cooperation levels, we therefore repeated the experiment 10 times under both conditions, keeping the group composition constant. All members were asked to contribute an amount between 0 and 20 units to public goods in each round. Each of the 195 subjects played four public goods games. At the beginning they were informed that the experiment would last for ten periods. As in Fehr and Gächter (2000, 2002), the experiments typically lasted 60 min per session. In every period, the group members knew nothing about the previous cooperation and punishment decisions of the others in the group, which ensured that subjects could not develop any kind of reputation. At the end of each period, subjects were informed about their own decisions, the decisions of the other group members, and their monetary pay-off in the current period. At the beginning of the experiment, subjects were explained the pay-off structure of the game (available from the authors on request. Please email to zhangsu@pku.edu.cn).

NP experiments

Participants make decisions on the amount of contributions to public goods and they are not permitted to punish other members. If everyone in the group keeps their own 20 units and chooses to contribute none, they will receive 20 units of money. To avoid the effect of the actual amount of money on behavior, we inform participants that 1 unit token is equivalent to actual currency ranging from 1 to 10 Yuan. If a participant invests 1 unit of token to public goods, everyone in the group will receive 0.4 units because of his or her contribution. If four participants in the group invest x_1, x_2, x_3, x_4 units of tokens respectively, the total gains of one participant depend on the units of money he or she hold in hands plus the return obtained from public goods. For example, the gains of the member who invested x_1 in this round are: $(20 - x_1) + 0.4 \times (x_1 + x_2 + x_3 + x_4)$.

FP experiments

The only and crucial difference between the FP experiment and the NP experiment was that participants in the FP experiment could punish each of the other group members after they were informed about the others' investments, whereas the NP experiment ended after participants were informed about the other group members' contributions. A punishment decision was implemented by assigning the punished member between zero and 10 deduction points. Each deduction point assigned reduced the punished member's earnings by 3 tokens and cost the punishing member nothing. All punishment decisions were made simultaneously. Participants were not informed about who punished them.

CP experiments

As in Fehr and Gächter (2000, 2002), the only difference between the two conditions of CP and FP was that in the punishment condition, subjects could punish each of the other group members after they were informed about the others' investments. A punishment decision was implemented by assigning between 0 and 10 points to the punished member. Each point assigned cost the punished member 3 tokens and the punishing member 1 tokens. All the punishment decisions were also made simultaneously.

EP experiments

All other rules are the same as in NP experiments. But in external random punishment experiments, an out supervisor (the leader) was ready to impose penalties on the participants whose contributions were less than average. In each round, the supervisor will choose one from four members to inspect: if his or her contributions are more than or equal to the average of the group, he or she will not be punished; on the contrary, he or she will be punished. The imposed amount of penalties is (average amount of investment $-$ the amount of his or her investment) $*\, 2$ tokens.

Important data collected in these experiments is as follows:

Contributions

Contributions refer to the amount of investments in public goods, which is an important measure of a participant's cooperative tendency. Without knowledge of other member's decisions, when contributing 1 unit of money, one member can only receive 0.4 units from the return of public goods, lower than the return of 1 unit of money when making the decision to keep this unit in hands. If four members in the group all choose to hold their own 20 units and invest none to public goods, they will each get 20 units of money. On the other hand, if they choose to invest all of their money to public goods, they will each get $20 * 4 * 0.4 = 32$ units of money. By this set up, mutual cooperation allows both to obtain a large reward, whereas defection increases the immediate payoff to a selfish individual. Also we can see that cooperation often depends on a delayed reciprocity in which each partner risks short-term costs to achieve a long-term mutual advantage. What amount a participant will contribute depends on his or her cooperative spirit as well as other factors.

Pro-social punishment

Most people seem to feel bad if they observe that norm violations are not punished, and they seem to feel relief and satisfaction if justice is established (Dominique J. F., U. Fischbacher, et al, 2004). So some people will spend time and energy to punish unfair actions, even though there is nothing to be gained by these actions for themselves. Pro-social punishment is to punish those who contribute less than average, namely, free riders. We label the punishment of free riding as pro-social because the punished group member rode free on the punisher's contribution. Put differently, from the perspective of the punisher the target member behaved less prosocially on average than the punisher. Evolutionary models and empirical evidence indicate that such altruistic punishment has been a decisive force in the evolution of human cooperation. Thus, pro-social punishment is also an important measure of a participant's cooperative tendency.

Antisocial punishment

Although it has been suggested that costly punishment can promote the evolution of cooperation, people might punish not only freeloaders, but cooperators too. When the target member contributed the same amount or more but was still punished, we call the punishment in these cases antisocial punishment. While various theoretical models find that punishment can promote the evolution of cooperation, with the threat of punishment deterring free-riders, these models a priori exclude the possibility of antisocial punishment. A series of cross-cultural experiments, however, finds substantial levels of anti-social punishment which cannot be explained by explicit retaliation. Antisocial punishment is puzzling, as it is inconsistent with both rational self-interest and the hypothesis that punishment facilitates cooperation (David G. Rand and M. A. Nowak, 2011). Antisocial punishment cracks down the enthusiasm of cooperation. Thus, antisocial punishment is also an important indicator for measuring a participant's cooperative tendency.

Cooperative gains

Personal gains are not only associated with participant's decisions on contribution, but also with pro-social behavior and antisocial punishment behavior. In the external experiment, personal gains are also related to the probability of punishment. Thus, personal gains are defined as cooperative gains.

Before the experiments, we collected the data on college students' cognitive abilities. A strong case has been made for substantial genetic influence on cognitive ability. Dozens of studies including more than 8 000 parent-offspring pairs, 25 000 pairs of siblings, 10 000 twin pairs, and hundreds of adoptive families all converge towards the conclusion that genetic factors contribute substantially to general cognitive abilities such as verbal, memory, and numeric ability(see Robert and Spinath, 2002). But according to Christelis et al (2010), school education has also an important effect on personal cognitive ability. We find that many tests in Chinese university are in essence similar to "Cognitive Reflection Test" designed by Frederick (2005). Thus, this paper uses participants' test scores in one semester to quantify their cognitive abilities. In other words, we think cognitive ability is to some extent a product of our educational system. When a participant's test score is less than 2.5, he or she is believed to have relative poor cognitive ability. If the score is between 2.5 (including 2.5) and 3.5, we believe that his or her cognitive ability is medium. Lastly, when the score is equal to or above 3.5, we think he or she has relatively high cognitive ability. Participants in this experiment are college students from the Central University of Finance and Economics in China, the scoring rule of which sets 4.5 as the full mark. Thus, we choose the aforementioned principles of classification.

The hypotheses that we need to test are as follows:

H1: Do people with higher cognitive abilities harvest more cooperative gains in the public goods experiments in the four types of penalty system?

If people with higher cognitive abilities harvest more, what is the mechanism? Our hypothesis is that people with higher cognitive abilities have higher cooperative tendency, and higher cooperative tendency can bring more cooperative gains.

H2: An individual's cooperative tendency is showed by his or her "contributions to public goods," "pro-social punishment," and "antisocial punishment." Therefore, we need to test the hypotheses that people with more contributions, more pro-social punishment, and less antisocial punishment (that is, with higher cooperative tendency) can win more cooperative gains in the four types of penalty systems.

H3: Suppose H1 and H2 are established, whether people with higher cognitive abilities can contribute more, impose more pro-social punishment, and conduct less antisocial punishment in the four types of penalty system?

The control variables in this experiment include personal background, family background, location (urban or rural), and institutional factors indicated by punishment rules. Personal background includes birth weight, sucking period, gender, and risk preferences (following Fischbacher et al (2012)). Family background includes mother's years of schooling, father's years of schooling, family structure, and family income. Punishment rules include NP, FP, CP, and EP with a probability of 25%. Of the control variables, the unit of birth weight is in "grams," and the unit of sucking period is in "months." Risk attitudes of college students are obtained using the following method which is similar to Van Praag, C. M., and Cramer J. S(2001). We asked participants one such question: We assume that a project has a 10% chance of generating 1000 Yuan. To participate in this project, you should pay a participation fee. How much would you like to pay at most? A participant with payment above 100 Yuan is defined as risk-loving. If the amount of his or her payment is less than 100, he or she is risk averse. It is obvious that if he or she is risk neutral when the amount is precisely 100.

3. DESCRIPTIVE STATISTICS OF THE DATA

It was expected to collect data from 156 participants, but actually 152 of them successfully reported information to us, with effective rate of collecting data being 97.44%. The descriptive statistics of the basic data can be seen in Table 1.

TABLE 1.

Descriptive statistics of the basic data

	Male	Female	Percentage	Total
Grade point achievement(GPA)				
$GPA < 2.5$	17	7	15.79%	24
$2.5 <= GPA < 3.5$	31	43	48.68%	74
$GPA >= 3.5$	10	44	35.53%	54
Total	58	94	100%	152
Location				
Rural	9	13	14.47%	22
Urban	49	81	85.53%	130
Total	58	94	100%	152
Family structure				
Two-parent families	55	87	93.42%	142
Single-parent families	3	7	6.58%	10
Total	58	94	100%	152

It can be seen in Table 1 that in our experiments, male students accounted for 38.16%, whereas female students accounted for 61.84%. Students from rural China accounted for 14.47%, whereas those from the cities accounted for 85.53%. Students with relatively low level of GPA (namely those with low cognitive abilities) accounted for 15.79%. And those with medium and relatively high cognitive abilities accounted for 48.68% and 35.53% respectively.

In Table 2, we showed the descriptive statistics of participants' cognitive abilities.

TABLE 2.

Descriptive statistics of participants' cognitive abilities

		Mean	Maximum	Minimum	Standard deviation	Observations
Personal factors	Risk preference	76	900	0	100.83	152
	Poor cognitive ability	78.33	200	0	61.27	24
	Medium cognitive ability	80.57	900	0	128.97	74
	Good cognitive ability	69.87	400	5	66.03	54
	Birth weight	3251	4500	1500	464.30	152
	Poor cognitive ability	3135	3800	2000	419.23	24
	Medium cognitive ability	3226	4100	1500	492.84	74
	Good cognitive ability	3338	4500	1900	434.47	54
	Sucking period	9	24	0	5.92	152
	Poor cognitive ability	8.18	24	0	6.89	24
	Medium cognitive ability	9.17	24	0	5.70	74
	Good cognitive ability	9	24	0	5.8	54
Family factors	Family income	8175	50000	500	8372	149
	Poor cognitive ability	5952	30000	700	5959	23
	Medium cognitive ability	9112	50000	500	8650	72
	Good cognitive ability	7874	50000	700	8794	54
	Father's years of schooling	14	23	2	3.25	150
	Poor cognitive ability	14	21	2	4.19	23
	Medium cognitive ability	14.7	23	2	3.19	74
	Good cognitive ability	13.7	18	6	2.82	53
	Mother's years of schooling	13	24	0	3.60	151
	Poor cognitive ability	13.5	21	4	3.48	23
	Medium cognitive ability	13.4	20	2	3.43	74
	Good cognitive ability	12.8	24	0	3.91	54
School factors	GPA	3.16	4.22	1.5	0.64	152
	Poor cognitive ability	2.04	2.48	1.5	0.29	24
	Medium cognitive ability	3.07	3.47	2.5	0.27	74
	Good cognitive ability	3.78	4.22	3.5	0.21	54

In Table 2, we first see that participants' risk preference showed a roughly inverted "U-shaped" pattern as a function of cognitive abilities. Secondly, birth weight is positively correlated with cognitive abilities. Thirdly, participants' mother's years of schooling is negatively correlated with their cognitive abilities. In our sample, participants' sucking period lasted for 5.7 to 24 months.

Each type of experiment was conducted for 10 rounds. There are 152 effective participants in each round, so we get a dataset with 1520 observations. The descriptive statistics of cooperative gains across different cognitive ability in four types of mechanism are as follows.

TABLE 3.

Descriptive statistics of cooperative gains across different cognitive ability in four types of mechanism

	Cooperative gains				
	Mean	Maximum	Minimum	Standard deviation	Observations
NP gain	2.63	4.4	1.04	0.49	1520
Poor cognitive ability	2.68	3.88	1.2	0.54	240
Medium cognitive ability	2.66	4.4	1.04	0.5	740
Good cognitive ability	2.57	4.04	1.18	0.45	540
FP gain	2.24	4.4	−5.5	1.35	1520
Poor cognitive ability	1.91	3.32	−3.46	1.56	240
Medium cognitive ability	2.2	4.4	−5.5	1.36	740
Good cognitive ability	2.44	3.3	−3.76	1.21	540
CP gain	2.65	3.6	−3.26	0.77	1520
Poor cognitive ability	2.38	3.6	−3.26	1.06	240
Medium cognitive ability	2.62	3.5	−1.04	0.73	740
Good cognitive ability	2.81	3.42	−1.1	0.61	540
EP gain	2.35	4	0.64	0.48	1520
Poor cognitive ability	2.4	3.96	0.64	0.49	240
Medium cognitive ability	2.29	4	0.8	0.49	740
Good cognitive ability	2.41	4	0.78	0.44	540

Participants' cooperative gains in CP experiments are on average 2.65, the highest among all four mechanisms, while gains in FP experiments are 2.24 on average, the lowest among all four mechanisms. Participants with higher cognitive abilities can harvest more cooperative gains in FP, CP, and EP. For all four mechanisms, the standard deviation of cooperative gains decrease gradually as a function of participants' cooperative abilities.

Now, let's see the descriptive statistics of contributions gains across different cognitive ability in four types of mechanism in Table 4.

TABLE 4.
Descriptive statistics of contributions gains across different cognitive ability in four types of mechanism

	Contribution				
	Mean	Maximum	Minimum	Standard deviation	Observations
NP contribution	10.54	20	0	6.11	1520
Poor cognitive ability	10.91	20	0	6.6	240
Medium cognitive ability	11.09	20	0	6.42	740
Good cognitive ability	9.61	20	0	5.29	540
FP contribution	15.99	20	0	4.61	1520
Poor cognitive ability	14.81	20	0	5.08	240
Medium cognitive ability	15.69	20	0	4.75	740
Good cognitive ability	16.92	20	0	4	540
CP contribution	16.28	20	0	4.64	1520
Poor cognitive ability	14.96	20	0	4.98	240
Medium cognitive ability	16.23	20	0	4.3	740
Good cognitive ability	16.93	20	0	4.8	540
EP contribution	13.62	20	0	6.15	1519
Poor cognitive ability	14.33	20	0	6.3	240
Medium cognitive ability	12.89	20	0	6.38	739
Good cognitive ability	14.32	20	0	5.63	540

Participants' contributions in CP experiments are 16.28 on average, the highest among all four mechanisms, followed by that in FP experiments (15.99), and then in EP experiments (13.62). The contributions in NP experiments are 10.54 on average, the lowest among all four mechanisms. This finding is consistent with Denant et al (2007) that punishment mechanism can effectively improve participants' contributions. CP can improve participants' contributions more than FP, and this finding is consistent with Nikiforakis' (2008). In CP and FP, the amount of contributions gradually increases as a function of participants' cognitive abilities.

Table 5 showed the descriptive statistics of pro-social punishment in FP and CP.

Both in FP and CP experiment, people with higher cognitive abilities impose less pro-social punishment, which seems contrary to our hypothesis. In fact, this finding by descriptive statistics may be misleading. Our econometric models will show that people with higher cognitive abilities will impose more pro-social punishment when controlled for participants' personal background, family background and other factors. Lastly, let's pay attention to the descriptive statistics of antisocial punishment in FP and CP in Table 6.

TABLE 5.

Descriptive statistics of pro-social punishment in FP and CP

	Pro-social punishment amount				
	Mean	Maximum	Minimum	Standard deviation	Observations
FP pro-social punishment	2.45	20	0	3.21	827
Poor cognitive ability	2.96	10	0	3.55	119
Medium cognitive ability	2.53	20	0	3.17	422
Good cognitive ability	2.11	10	0	3.08	286
CP pro-social punishment	0.81	10	0	1.67	946
Poor cognitive ability	1.13	10	0	2.05	161
Medium cognitive ability	0.76	10	0	1.66	487
Good cognitive ability	0.72	10	0	1.41	298

TABLE 6.

Descriptive statistics of antisocial punishment in FP and CP

	Antisocial punishment amount				
	Mean	Maximum	Minimum	Standard deviation	Observations
FP antisocial punishment	3.63	10	0	3.31	241
Poor cognitive ability	5.95	10	0	3.77	43
Medium cognitive ability	3.17	10	0	2.81	127
Good cognitive ability	3.02	10	0	3.27	71
CP antisocial punishment	1.58	10	0	2.6	201
Poor cognitive ability	2.44	10	0	3.77	43
Medium cognitive ability	2.07	10	0	2.46	81
Good cognitive ability	0.58	5	0	1.36	77

In table 6, we see a decrease in antisocial punishment as a function of participants' cognitive abilities both in FP and CP experiment.

Figure 1 plots the average contributions to each round by the four types of mechanisms.

Figure 1 shows that participants' contributions are the least and participants' average cooperative tendency is the lowest in NP. As in Herrmann et al (2008), the presence of a punishment opportunity had dramatic consequences on the achieved cooperation levels. The most-cooperative participant pool of CP and FP (in which people contributed 80% of their endowment, on average) contributed 1.6 times as much as the least-cooperative participant pool of NP (with an average contribution of 50% of the endowment). Moreover, NP, FP, and EP experiment verified the viewpoints of "endgame effects". In the final round of experiments, the average contribution decreased compared with the previous value.

FIG. 1. Average contributions to each round by the four types of mechanisms

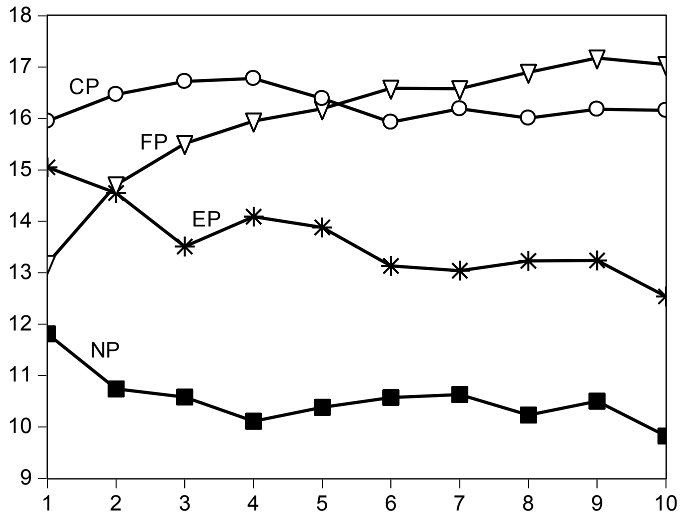


Figure 2 plots the average amount of pro-social punishment in each round of FP and CP.

Figure 2 shows that the amount of pro-social punishment in FP is significantly higher than that in CP. In FP experiment, the punisher punished 3 times as much as those in CP.

Figure 3 plots the average amount of antisocial punishment in each round of FP and CP.

Figure 3 shows that the amount of antisocial punishment in FP is significantly higher than that in CP. Comparing Figures 2 with 3, the amount of antisocial punishment is higher than pro-social punishment in each round for both FP and CP, which indicates that participants in our experiment have a higher tendency toward antisocial punishment than toward pro-social punishment. This finding is consistent with Herrmann et al (2008). In this work, we are concerned about the question of whether antisocial punishment is imposed by people with poor cognitive abilities. In other words, is it possible for antisocial punishment to be imposed by people with poor cognitive abilities? Although college students have not overall internalized a more cooperative "inherent tendency", people with higher cognitive abilities perhaps have internalized more cooperative "inherent tendency." Comparing Figures 2 with 3, we also find that the trend of antisocial punishment is evidently different from that of pro-social punishment in 10 rounds. In Figure 3, antisocial punishment showed an increas-

FIG. 2. Amount of pro-social punishment for 10 rounds in FP and CP

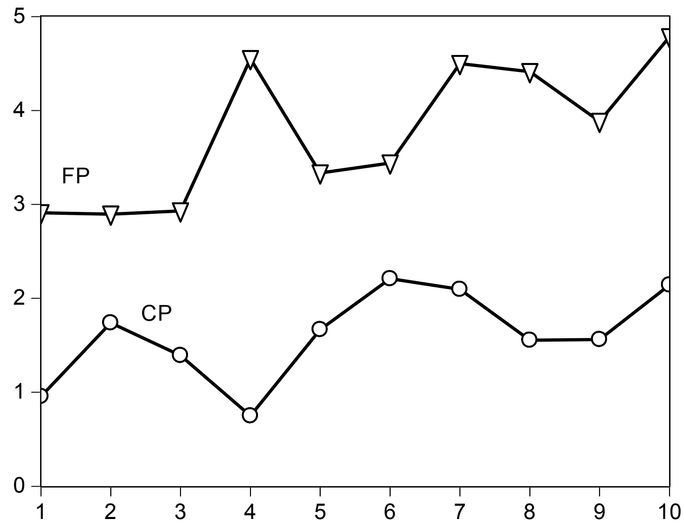
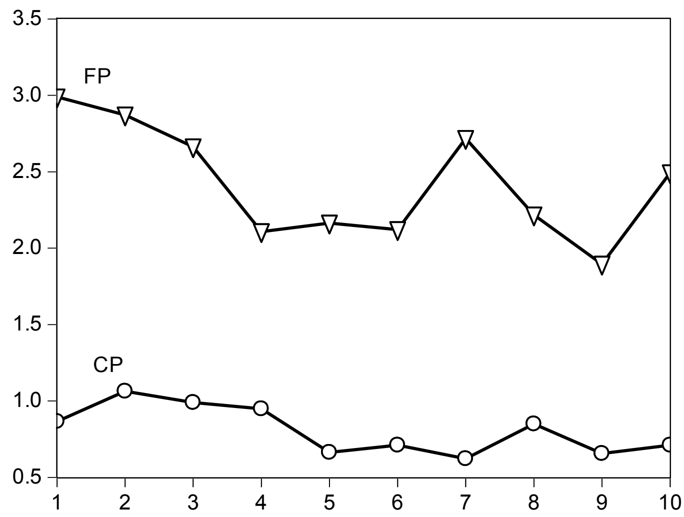


FIG. 3. Average amount of antisocial punishment for 10 rounds in FP and CP



ing trend. One possible explanation is that antisocial punishment behavior can be contagious. When someone with more contributions is punished by others whose contributions are less, he will become an antisocial punisher, causing antisocial punishment to increase. In view of Herrmann et al (2008), while the punishment of free riding is likely triggered by negative emotions that arise from a violation of fairness norms and from feeling exploited, the plausible reason for antisocial punishment is that people might not accept punishment and therefore seek revenge. Figure 3 also shows the "endgame effects" in FP and CP. In the last round of experiments, the average amount of antisocial punishment substantially increased compared with the previous round.

4. ECONOMETRIC ANALYSES

4.1. Test of H1: Relationship between Cognitive Abilities and Cooperative Gains

The regression analysis summarizing our findings on the impact of cognitive ability on cooperation is shown in Table 7.

TABLE 7.

Ordinary least square (OLS) regressions of cognitive abilities and cooperative gains

	Cooperative gains			
	NP gain	FP gain	CP gain	EP gain
Medium cognitive ability	-0.0220	0.2851^{***}	0.2382^{***}	0.0104
	(0.0364)	(0.0996)	(0.0560)	(0.0335)
Good cognitive ability	-0.1180^{***}	0.5283^{***}	0.4285^{***}	0.0976^{***}
	(0.0380)	(0.1040)	(0.0585)	(0.0348)
R-squared	0.0100	0.0176	0.0356	0.0098
Adjusted R-squared	0.0087	0.0163	0.0343	0.0083
F-statistic	7.6500	13.5856	27.9624	6.8219
Observations	1520	1520	1520	1388

Notes: The standard deviations are reported in brackets. *** Significant at the 1 percent level. ** Significant at the 5 percent level. * Significant at the 10 percent level.

In Table 7, except for NP experiments, people with higher cognitive abilities will make significantly higher cooperative gains in FP, CP, and EP experiments. The coefficient of cognitive abilities in FP and CP experiments is evidently higher than that in NP and EP experiments, which indicates that if participants can independently impose punishment, the effects of participants' cognitive abilities on cooperative gains are larger than that in the case wherein participants cannot impose or cannot independently carry out punishment.

4.2. Test of H2: Relationship between Cooperative Tendency and Cooperative Gains.

The regression analysis summarizing our findings on the impact of contribution, pro-social punishment, and antisocial punishment on final gains is shown in Table 8.

TABLE 8.

OLS regressions of cooperative behavior and cooperative gains

	Cooperative gains			
	NP gain	FP gain	CP gain	EP gain
Contributions	0.0046^{**}	0.1176^{***}	0.0765^{***}	0.0209^{***}
	(0.0021)	(0.0069)	(0.0038)	(0.0019)
Pro-social punishment		0.0355^{***}	0.1953^{***}	
		(0.0134)	(0.0328)	
Antisocial punishment		-0.1778^{***}	-0.2160^{***}	
		(0.0345)	(0.0249)	
R-squared	0.0035	0.1003	0.2751	0.0722
Adjusted R-squared	0.0028	0.0965	0.2715	0.0715
F-statistic	4.9905	26.6313	75.5376	117.9631
Observations	1425	241	201	1519

Notes: The standard deviations are reported in brackets. *** Significant at the 1 percent level. ** Significant at the 5 percent level. * Significant at the 10 percent level.

It can be seen that in the four types of mechanism, the effects of contributions on cooperative gains are significantly positive. Participants' contributions in FP and CP experiment are evidently higher than that in NP and EP, which means that if participants can independently carry out punishment, the positive effects of participants' contributions on cooperative gains are significantly heavier than that in the case wherein participants cannot impose or cannot independently carry out punishment. In FP and CP experiment, participants can impose pro-social and antisocial punishment, of which the effects of pro-social punishment on cooperative gains are positive. Participants who impose pro-social punishment can increase cooperative gains. Orbell et al (1988) and Wit and Wilke (1992) explained that pro-social punishment can promote group consents and therefore cooperation. In CP experiments, the effects of pro-social punishment on cooperative gains are greater than that in FP experiment. Compared with FP experiment, pro-social punishment in CP experiment can more easily form group consents to improve participants' cooperative gains. Our finding is also consistent with Fehr and Gächter (2002) that cooperation is necessary for the provision of public goods, and the punishment of non-cooperators, or free riders, is itself a public good- a service provided for the benefit of the whole community. Under the two punishment mechanisms, the effects of antisocial punishment on cooperative gains are negative. This finding is consistent with that of Herrmann et al (2008) and indicates that imposing antisocial punishment will reduce participants' cooperative gains.

4.3. Test of H3: Relationship between Cognitive Abilities and Cooperative Tendency

4.3.1. Cognitive Abilities and "Contributions to Public Goods"

The regression analysis summarizing our findings on the impact of cognitive ability on contribution is showed in Table 9.

TABLE 9.

OLS regressions of cognitive abilities and "contributions to public goods"

		Contribution			
		NP	FP	CP	EP
Cognitive ability	Medium cognitive ability	1.0371**	1.5878***	1.2278***	1.2246***
		(0.4801)	(0.3500)	(0.3740)	(0.3703)
	Good cognitive ability	1.3708**	3.1358***	1.5715***	2.6922***
		(0.5433)	(0.3870)	(0.4136)	(0.4176)
Personal factors	Birth weight	0.6130***	0.1876	0.3174**	0.2362*
		(0.1793)	(0.1274)	(0.1362)	(0.1393)
	Lactation period	−0.1022***	−0.0137	−0.0281	0.0127
		(0.0272)	(0.0195)	(0.0209)	(0.0209)
	Gender	2.0077***	1.9625***	−0.9298***	0.9161***
		(0.3565)	(0.2546)	(0.2721)	(0.2888)
	Risk neutral	−0.4933	0.8691***	0.7388**	−0.4123
		(0.3863)	(0.2750)	(0.2938)	(0.3050)
	Risk lovers	0.1788	0.3669	0.7641*	−2.2421***
		(0.5550)	(0.3994)	(0.4268)	(0.4260)
Family factors	Mother's years of schooling	0.3206	0.2254	0.7139**	−0.3593
		(0.4581)	(0.3256)	(0.3479)	(0.3468)
	Father's years of schooling	1.4803***	1.9087***	0.4723	0.7144*
		(0.5428)	(0.3841)	(0.4104)	(0.4121)
	Family structure	1.5589**	−0.3300	−0.4833	−0.3342
		(0.6565)	(0.4732)		(0.4892)
	Family income	$3.19E-05^{*}$	$-2.99E-05^{**}$	$-2.93E-05^{**}$	$2.46E-05^{*}$
		$(1.94E-05)$	$(1.39E-05)$	$(1.48E-05)$	$(1.49E-05)$

In the case of controlling other variables, participants' cognitive abilities are significantly positive in the four types of mechanism, indicating that cognitive abilities positively affect contributions. Higher cognitive abilities enable participants to make more contributions. In CP experiment, the

TABLE 9—*Continued*

		Contribution			
		NP	FP	CP	EP
Regional factors	Location	-1.3657^{**} (0.5494)	-1.3135^{***} (0.3889)	-0.6120 (0.4156)	-0.3465
Rounds	Second round	-0.8924 (0.6858)	1.6019^{***} (0.4936)	0.5772 (0.5274)	-0.5248 (0.5275)
	Third round	-1.0467 (0.6872)	2.4978^{***} (0.4956)	0.8872^{*} (0.5296)	-1.3071^{**} (0.5308)
	Fourth round	-0.9053	2.9332^{***} (0.4956)	0.9212^{*} (0.5296)	-0.6410 (0.5319)
	Fifth round	-0.8597	3.1781^{***} (0.4956)	0.5743 (0.5296)	-1.1332^{**} (0.5280)
	Sixth round	-0.9999 (0.6889)	3.5659^{***} (0.4956)	0.0437 (0.5296)	-1.3720^{**} (0.5334)
	Seventh round	-0.8364 (0.6900)	3.5387^{***} (0.4956)	0.4246 (0.5296)	-1.2776^{**} (0.5370)
	Eighth round	-0.7867	3.8720^{***} (0.4956)	0.2001 (0.5296)	-1.3077^{**} (0.5335)
	Ninth round	-0.7660 (0.6927)	4.1645^{***} (0.4956)	0.4178 (0.5296)	-0.5403
	Tenth round	-1.4988^{**} (0.6952)	4.0761^{***} (0.4956)	0.3566 (0.5296)	-0.4911
	R-squared	0.0548	0.1676	0.0531	0.0854
	Adjusted R-squared	0.0404	0.1556	0.0394	0.0701
	F-statistic	3.8066	13.8861	3.8654	5.5873
	Observations	1447	1470	1470	1279

Notes: The standard deviations are reported in brackets. *** Significant at the 1 percent level. ** Significant at the 5 percent level. * Significant at the 10 percent level.

marginal effect of the mother's level of education is significantly positive. In NP, FP, and EP experiments, the marginal effect of the father's level of education is significantly positive. That is, all the four types of experiment show the intergenerational transmission of the innate prosociality of sacrificing private gain to public. Children will have a higher tendency to contribute to public goods if their father or mother obtained a higher level of education.

4.3.2. Cognitive Abilities and "Pro-social Punishment"

Table 10 describes the probit regression results of the impact of cognitive ability on "pro-social punishment," which represents the cooperative tendency (pro-social punishment= 1; otherwise 0) in NP, FP, CP, and EP experiment.

TABLE 10.

Probit models of cognitive abilities and pro-social punishment

		Pro-social punishment			
		FP		CP	
		Coefficient	Marginal effect	Coefficient	Marginal effect
Cognitive ability	Medium cognitive ability	0.1510 (0.1078)	0.0542	0.0573 (0.1124)	0.0209
	Good cognitive ability	0.3051^{**} (0.1262)	0.1096	0.1163 (0.1341)	0.0424
Personal factors	Birth weight	−0.0031	−0.0260	-0.1500^{***} (0.0458)	−0.0547
	Breast period	−0.0034 (0.0059)	−0.0021	−0.0095 (0.0069)	−0.0035
	Gender	-0.4044^{***} (0.0844)	−0.1453	-0.4406^{***} (0.0891)	−0.1605
	Risk neutral	0.0813 (0.0893)	0.0292	−0.1303 (0.0967)	−0.0475
	Risk lovers	−0.0681 (0.1346)	−0.0245 (0.1403)	-0.3266^{**}	−0.1190
Family factors	Mother's years of schooling	−0.1739 (0.1097)	−0.0625	−0.0944 (0.1167)	−0.0344
	Father's years of schooling	−0.0299	−0.0832	-0.3746^{***} (0.1194)	−0.1365
	Family structure	0.0425 (0.1686)	0.0153	0.7375^{***} (0.2436)	0.2687
	Family revenue	$3.19E-05^{***}$ $(5.51E-06)$	$1.15E-05$	$2.32E-05^{***}$ $(5.74E-06)$	$8.46E-06$
Regional factors	Location	0.0479 (0.1296)	0.0171	0.3012^{**} (0.1353)	0.1097

In the case of controlling other variables, the effects of participants' cognitive abilities on pro-social punishment are positive in the FP and CP experiment and significantly positive in the FP experiment. This finding indicates that participants with higher cognitive abilities are perhaps more likely to impose pro-social punishment.

4.3.3. Cognitive Abilities and "Antisocial Punishment"

Table 11 describes the Probit regression results of the impact of cognitive ability on "antisocial punishment," which represents the cooperative

TABLE 10—*Continued*

		Pro-social punishment			
		FP		CP	
		Coefficient	Marginal effect	Coefficient	Marginal effect
Rounds	Second round	−0.0791 (0.1803)	−0.0284	−0.0625	−0.1200
	Third round	−0.0545	−0.1116	−0.2447 (0.1925)	−0.0892
	Fourth round	-0.4812^{***} (0.1734)	−0.1729	-0.4117^{**} (0.1875)	−0.1500
	Fifth round	-0.5770^{***} (0.1722)	−0.2073	-0.5606^{***} (0.1841)	−0.2043
	Sixth round	-0.4548^{***} (0.1730)	−0.1634	-0.4461^{**} (0.1887)	−0.1626
	Seventh round	-0.4211^{**} (0.1728)	−0.1513	-0.5034^{***} (0.1877)	−0.1834
	Eighth round	-0.4350^{**} (0.1747)	−0.1563	-0.5083^{***} (0.1866)	−0.1852
	Ninth round	-0.6644^{***} (0.1747)	−0.238663	-0.5111^{***} (0.1875)	−0.1862
	Tenth round	-0.6650^{***} (0.1736)	−0.2389	-0.7153^{***} (0.1816)	−0.2606
	McFadden R-squared	0.0718		0.0780	
	LR statistic	123.4527		118.9330	
	Prob(LR statistic)	0		0	
	Observations	1293		1259	

Notes: The standard deviations are reported in brackets. *** Significant at the 1 percent level. ** Significant at the 5 percent level. * Significant at the 10 percent level.

tendency (antisocial punishment= 1; otherwise 0) in NP, FP, CP, and EP experiments.

In the case of controlling other variables, the effects of participants' cognitive abilities on antisocial punishment are significantly negative in FP and CP experiment. This finding indicates that participants with higher cognitive abilities are less likely to impose antisocial punishment.

4.4. Significance Test of Models

4.4.1. Significance Tests of OLS Regression Equations

The null hypothesis is $H_0 : \beta_1 = \beta_2 = L = \beta_k = 0$, and the alternative hypothesis is that not all the coefficients of the explanatory variables are zero. The statistics F is defined by $F = (RSS/k)/[ESS/(n - k - 1)] \sim$

TABLE 11.

Probit models of cognitive abilities and antisocial punishment

		Antisocial punishment			
		FP		CP	
		Coefficient	Marginal effect	Coefficient	Marginal effect
Cognitive ability	Medium cognitive ability	-0.4260^{***} (0.1365)	-0.1633	-0.3650^{***} (0.1278)	-0.1394
	Good cognitive ability	-0.4972^{***} (0.1551)	-0.1906	-0.4776^{***} (0.1468)	-0.1824
Personal factors	Birth weight	-0.0056	-0.0391	0.0081 (0.0076)	-0.0119
	Lactation period	0.0016 (0.0080)	0.0006	0.0053 (0.0073)	0.0031
	Gender	0.0201 (0.1087)	0.0077	0.1266 (0.1000)	0.0484
	Risk neutral	-0.0726 (0.1169)	-0.0278	0.1764 (0.1144)	0.0674
	Risk lovers	0.1417 (0.1644)	0.0543	0.3138^{**} (0.1597)	0.1198
Family factors	Mother's years of schooling	-0.1911 (0.1392)	-0.0732	-0.2560^{**} (0.1273)	-0.0978
	Father's years of schooling	0.5237^{***} (0.1775)	0.2007	0.0862 (0.1448)	0.0329
	Family structure	0.8143^{***} (0.1672)	0.3121	0.3305^{*} (0.1746)	0.1262
	Family income	$-4.81E-06$ ($6.15E-06$)	$-1.85E-06$	$-1.74E-07$ ($5.70E-06$)	$-6.65E-08$
Regional factors	Location	-0.1286 (0.1672)	-0.0493	-0.3293^{**} (0.1471)	0.1258

$F(k, n-k-1)$, in which "n" represents the sample size, and "k" represents the numbers of parameters to be estimated in the model. RSS and ESS respectively represent the regression sum of squares and the residual sum of squares. If $F > F_\alpha(k, n-k-1)$, we reject the null hypothesis and believe that the regression equation is significant under the level of α and variables have a linear relationship. Conversely, we cannot reject the null hypothesis. In Table 7 (the regression of cognitive abilities and cooperative gains), the F statistics are $F_1 = 7.65$, $F_2 = 13.586$, $F_3 = 27.962$, and $F_4 = 6.822$. The number of model parameters to be estimated is 2 ($k = 2$), and the sample size is very large, such that we can determine $F_{0.01}(2, \infty) = 4.61$. At a significance level of 0.01, the four OLS results all reject the null

TABLE 11—*Continued*

		Antisocial punishment			
		FP		CP	
		Coefficient	Marginal effect	Coefficient	Marginal effect
Rounds	Second round	−0.4087 (0.3712)	−0.1566	0.1519 (0.2200)	0.0580
	Third round	0.4276 (0.2738)	0.1639	0.0618 (0.2250)	0.0236
	Fourth round	0.9012*** (0.2540)	0.3454	0.2994 (0.2121)	0.1143
	Fifth round	0.8808*** (0.2544)	0.3376	0.4357** (0.2069)	0.1664
	Sixth round	0.7636*** (0.2570)	0.2927	0.2686 (0.2129)	0.1026
	Seventh round	0.6349** (0.2603)	0.2433	0.3330 (0.2106)	0.1272
	Eighth round	0.4962* (0.2657)	0.1902	0.2228 (0.2150)	0.0851
	Ninth round	0.5472** (0.2636)	0.2097	0.1589 (0.2176)	0.0607
	Tenth round	0.4437* (0.2674)	0.1701	0.0788 (0.2212)	0.0300
	McFadden R-squared	0.0969		0.0511	
	LR statistic	94.4538		53.4194	
	Prob(LR statistic)	0		0.0001	
	Observations	1400		1441	

Notes: The standard deviations are reported in brackets. *** Significant at the 1 percent level. ** Significant at the 5 percent level. * Significant at the 10 percent level.

hypothesis. Therefore, the linear relationship between cognitive abilities and cooperative gains in the four OLS models is significant. Similarly, the linear relationship between cognitive abilities and cooperative gains in Tables 8 and 9 is significant.

4.4.2. Significance tests of Probit regressions

The null hypothesis is $H_0 : \beta_1 = \beta_2 = L = \beta_k = 0$, and the alternative hypothesis is that not all the coefficients of the explanatory variables are zero. In Table 10 (the regression of cognitive abilities and pro-social punishment), the values of probit models' LR are $LR_1 = 123.453$ and $LR_2 = 118.933$. In Table 11(the regression of cognitive abilities and anti-social punishment), the values of probit models' LR are $LR_3 = 94.454$ and

$LR_4 = 53.419$. We know that $\chi^2_{0.01}(21) = 38.93$ from the χ^2 distributiin Table. Therefore, at a significance level of 0.01, the above probit models all reject the null hypothesis.

5. CONCLUSIONS

Evolution is based on a fierce competition between individuals and should therefore reward only selfish behavior. Yet we observe cooperation among students with high cognitive abilities .Herrmann et al (2008) conducted a public goods game for anonymous college students of 15 different countries, including China. In their study, China is a developing country, such that family ethics are considered to be important; Moral values of sacrificing oneself for the good of the family may be beyond "the principle of maximizing their personal interests." Thus, people do not easily cooperate with strangers for their benefit and may show a tendency toward antisocial punishment. The FP and CP experiment we designed have partially verified the conclusion that the average amount of antisocial punishment is higher than that of pro-social punishment in each round. That is, antisocial punishment tendency is higher than pro-social punishment tendency for our participants. We put forward the hypothesis that although college students have not overall internalized more cooperative "inherent tendency", students with higher cognitive abilities do have internalized more cooperative "inherent tendency." In other words, outstanding graduates with better academic performance display signals to the labor market that their cognitive abilities are higher and may have a higher tendency to cooperate and bring more cooperative gains to their organizations.

By using the public goods game model, we design four types of experiments, namely, NP, FP, CP, and EP experiment to test this hypothesis. We find that people with higher cognitive abilities can harvest more cooperative gains in the public goods game in the FP, CP, and EP experiment. Regardless of whether in an internal or external punishment mechanism, if one wants to obtain more cooperative gains, he or she has to "make more contributions to public goods," "impose more pro-social punishment" (to maintain the justice) and "impose no antisocial punishment" (to prevent contagion of antisocial emotion). Internalized cooperative tendency within people are specifically reflected by "behavior of contributing to public goods," "behavior of pro-social punishment," and "behavior of antisocial punishment." After controlling for personal factors such as participants' risk attitudes and family factors such as family income, our model showed that people with higher cognitive abilities may conduct more "behaviors of contributing to public goods," more "behaviors of pro-social punishment," and less "behaviors of antisocial punishment" whether in an internal or external punishment system. The study of Herrmann et al (2008) showed weak norms of civic cooperation and the weakness of the rule of law in a country are significant predictors of antisocial punishment. Our research indicates that high cognitive ability is a significant predictor of high tendency to cooperate.

Without any mechanism for the evolution of cooperation, natural selection favors defectors. In light of our research, the educational system provides an important protection mechanism for the evolution of cooperative human behavior. By the educational system, not only culture, knowledge, and skills were educated and created, but also a spirit of cooperation was developed. When outstanding graduates cultivated by the educational system enter into the labor market, they will bring more cooperative benefit for their organization. So it is right to show the information of "honor graduates" on the diploma as a signal of strong cooperative tendency, which can enhance the competitive advantages of the outstanding graduates, who may have internalized a stronger tendency to cooperate.

To sum up, our results suggest that individuals with higher cognitive abilities have a deep reservoir of cooperative behaviors that can be exhibited in the most impersonal interactions with unrelated others. This reservoir of moral predispositions is based on an innate prosociality that is a product of our educational system, as well as the unique human capacity to internalize norms of social behavior.

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