Article

Explaining Public Goods Game Contributions with Rational Ability and Gender

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**Abstract:** As the link between psychology and economics has grown, so too has research on the link between personality traits and economic behavior. We build on this previous work, bringing to light the relationship between personality traits, gender and contributions in a one-shot public goods game. Our first main finding is that contribution to the public good is less for rational participants as measured by the REI-40. This effect is statistically more significant for men than for women. This is explained by our second main finding that men’s contribution choices tend to lie at the extremes, whereas women tend to populate the middle of the contribution distribution.

**Keywords:** public good; cooperation; gender; psychological traits, REI-40

1. Introduction

The public goods game has important implications as it is applicable to many real world situations that include a common good benefiting a group, but is not profitable enough to be financed by an individual. Even if a group comes together and is able to finance a project, there is an incentive to not contribute anything and free-ride. The incentive to free-ride in order to maximize one's own wealth leads to tax fraud, pollution, resource exploitation, and even plays an important role in the climate change issue. Nature, its resources, the air, and the planet are a public good and cooperation among humans would lead to a better world for society. The incentive to free-ride, however, can create huge cost to today's and future societies. Understanding the behavior in the public goods game is essential when trying to solve these big problems. Research on the public goods game therefore focuses on the factors that lead to, drive, and result in cooperation.

The public goods game can be played in a variety of forms, which allows researchers to investigate the driving forces for cooperative behavior in changing environments. For example, Andreoni [1] and Iturbe-Ormaetxe et al. [2] investigate the effect of positive and negative frameworks and find that cooperation is greater when the public goods game has a positive framework. The rates of contribution to the public good can also be influenced by including options like being excluded from the public good [3] or punishment and voting mechanisms [4–6]. These studies claim that external factors (i.e., the environment and the rules of the game) have an effect on the behavior of the entire group. Fosgaard et al. [7] find that the way a public good is framed actually affects misperceptions about the incentives of the game and once the misperceptions are removed, the framing difference vanishes. They suggest that internal factors such as beliefs might have a great part in this.

This leads to a string of literature that looks at the behavior of individuals in the public goods game. Specifically, the personality or psychological traits have been in the focus of these studies. The results, however, have not been consistent. For example, Perugini et al. [8] find that ‘agreeableness’ of the Big Six measurement is a good predictor for cooperative behavior of men in a multi-period public good game, while Kurzban and Houser [9] find neuroticism to be statistically significant. For cooperation in other economic games the Big Five personality traits, consisting of Extraversion, Agreeableness, Conscientiousness, Neuroticism, and Openness [10–12] have been used as predictors. Lu and Argyle [13] and Ashton et al. [14] find that extraversion is positively correlated with their cooperation-scale, whereas neuroticism has a negative correlation. Lu and Argyle [13] also find agreeableness to be positively correlated with their cooperation-scale. Hirsh and Peterson [15] report that more neurotic individuals were less likely to defect in a prisoner's dilemma game. Ben-Ner et al. [16] find negative significant effects for neuroticism for giving of females in the dictator game, but in a later paper find correlation between high levels of neuroticism and greater altruism [17].

Clearly, there is not a consensus on which personality traits predict cooperative behavior in economic games. Hence, it can be useful to make predictions about the behavior of personality profiles by adapting rational choice theory to the environment of a public good [18]. Assuming that all participants are utility maximizers, the individual utility function consists of two parts:



Where the first part – a(m)m(g,r) - is the utility received from a certain amount m depending on g (the amount invested by the individual) and r (the amount invested by everyone else) and a coefficient a(m), which converts the monetary amount in utility. For a simple public goods game with a return of 50% for each unit amount invested the amount m is then



With W being the initial endowment of the participant (e.g, in this study $1).

This first part of the utility function is similar to the one proposed by Andreoni [18] and straight forward as it fits nicely into rational choice theory. More money is preferred to less (i.e., coefficient a is positive) and hence utility increases with a bigger return. The individual also has an incentive to invest zero into the public good (i.e., g=0) to maximize m.

Since research has shown that – despite this incentive – individuals do invest in the public good, an additional part to the utility function is needed. And since the contribution to the public goods game has been shown to vary among individuals, this second part needs to be somehow dependent on the personality or psychological traits of the individuals. One way to represent this is given by the second part of the utility function:  is the sum of the T relevant personality traits ti times their respective coefficient bi and the given amount g. When g increases, the second part of the utility function can outweigh the negative marginal effect of the first part depending on the individual’s personality traits. E.g., an empathetic individual has a strict preference for group cooperative behavior knowing that the investment is best for the group.

This leads to the research question:

*Which personality or psychological traits determine cooperative behavior in the public goods game?*

In this research study, we collect data on a range of personality and psychological traits to test whether and which traits could predict cooperative behavior. There are some personality traits that can be expected to have little correlation with the behavior in a public goods game. For example, in the Big Five personality traits [10], openness to experience or conscientiousness are not likely to correlate with cooperative behavior as they refer to more risk-related issues. Not surprisingly, these measures were also not statistically significant in our analysis. In the Rational Experiential Inventory (REI-40) [19], however, rational ability and rational engagement could be expected to show some influence. ational ability refers to the individual’s tendency to be analytical and make logical connections, whereas experiential ability refers to being affective (i.e., doing what feels good) and reliant on past experiences. A more rational individual relies less on the past experiences for their decision and might think more thoroughly about the consequences of different strategies in this particular situation. They could conclude that her/his own actions have no influence on others’ contribution since it is a one-shot game and that there are no repercussions for un-cooperative behavior. Hence, a hypothesis is that individuals, who score higher on the rational ability measure will also invest less into the public good.

We find that none of the coefficients for the personality traits of the Big Five measurements show statistical significance. When testing the measurements of the REI-40 we find that ‘rational ability’ shows statistical significance for the behavior of males, and weak statistical significance for females. We explain the gender difference in statistical significance with the difference in the distribution of contributions between males and females.

In the following chapter we will present the experimental design of the survey and the public goods game. A chapter presenting the results follows it. Finally, we will conclude with the conclusion and an outlook on future research.

2. Experimental Section

2.1. Survey

Students from three different colleges in the North-East of the United States were invited to take part in our experiment using the universities’ respective experimental economics online recruitment systems. All participants were required to fill out an online personality traits survey using the website www.surveymonkey.com [20] at least one week prior to being invited to the laboratory. The online survey included the Big Five test [10,11], the REI-40 [19], the Wonderlic score [21], the Holt and Laury Lottery measuring risk aversion [22], and the Mind in the Eyes test [23,24]. The tests were selected either due to their significance in findings of previous research (as mentioned in the review above) or because it was assumed that there could be an intuitive connection between the scores and economic decision-making.

2.2. Public Goods Game

All participants, who successfully finished the survey, were then invited to participate in the laboratory experiment. At the beginning of each session participants were asked for demographic data: Age, gender, major, and college-years. Each participant then played the following games in a random order: the dictator game, the ultimatum game, the minimum effort game, and the prisoner’s dilemma game. After finishing these games all participants played a one-shot public goods game in which each participant could contribute to a public good and each contribution resulted in a payoff to all participants in the group, including one's self. The participants had to choose how much of a $1 endowment they would like to invest into the public good. In addition to the amount that each participant kept for themselves, she/he received a payout in the amount of half of the amount invested by the entire group. In a game with n participants the pay-off for the i-th person was:

(1)

Where ci is the individual’s investment into the public good and cj is the investment made by each jth group member. The participants were informed that investments are made anonymously and cannot be identified.

3. Results

Out of the 140 participants 55 were female and 85 were male. Group sizes varied from 8 to 16 and the average contribution was around 50 cents, which led to an average payout of $3.41 with a minimum of $1.63 and a maximum of $5.1.

Since the group sizes varied, while the marginal per capita return (MPCR) stayed constant, the gains from cooperation also change. This could influence the contribution decision of participants in different groups. Research by Isaac et al. [25] found a difference in efficiency due to group size at lower MPCR of 0.30 (i.e., for every unit amount invested, the public good produces 0.30 unit amounts), while at a MPCR of 0.70 no statistically significant difference was found. We find no significant differences between average contributions of participants in different groups. There are two explanations for this: (i) the MPCR in this experiment is 0.5 and hence too high to allow group size to be an important factor; (ii) the effect of group size might not be an important factor in a one-shot game. Contributions in the first round in the study by Isaac et al. [25] are between 40% and 50% of the initial endowment for almost all group sizes (except for the smallest group size of 4). Similarly, we checked for correlation and interaction effects of group size and other important variables (specifically gender and rational ability) and found no statistically significant result.

The important personality variable for the analysis of the behavior in the public goods game turns out to be rational ability as measured by the REI-40 [19], where rational ability refers to having a high level of ability to think logically and analytically. Our sample value of an average 3.30 out of 5 for rational ability is lower than the value of 4.0 out of 5 found by Sladek et al. [26], but close to the value of 3.39 for American College Students found by Calder et al. [27].

Table 1 gives a summary statistics of the important variables.

**Table 1.** Summary Statistics

|  |  |  |
| --- | --- | --- |
| **Variable** | **Median/Mean** | **S.D.** |
| **Age** | 22 / 21.5 | 2.07 |
| **Group size** | 10 / 11.4 | 2.66 |
| **Public Good Outcome** | 3.4 / 3.41 | 0.827 |
| **Public Good Contribution** |  |  |
| * for all participants (N=140) | 0.5 / 0.502 | 0.392 |
| * for all males (N=85) | 0.5 / 0.517 | 0.429 |
| * for all females (N=55) | 0.5 / 0.478 | 0.329 |
| * for group size = 8 (N=32) | 0.5 / 0.495 | 0.400 |
| * for group size = 10 (N=40) | 0.5 / 0.498 | 0.388 |
| * for group size = 12 (N=24) | 0.64 / 0.566 | 0.394 |
| * for group size = 14 (N=28) | 0.45 / 0.454 | 0.395 |
| * for group size = 16 (N=16) | 0.5 / 0.513 | 0.416 |
| **Rationality** |  |  |
| * for all participants (N=140) | 3.3 / 3.29 | 0.712 |
| * for all males (N=85) | 3.3 / 3.198 | 0.755 |
| * for all females (N=55) | 3.5 / 3.42 | 0.623 |

The average contribution of females and males was close with $.478 and $.517 respectively and its magnitude is in line with previous experiments [1,28,29]. The value of the standard deviation for all participants also does not give an unusual number (S.D.=0.392), however, when grouped by gender, it shows a difference of 0.1 with values of 0.329 for females and 0.429 for males. This difference will be important for the analysis in the sub-chapter 3.2. Gender Differences, but first we will discuss the analysis of the personality traits.

3.1. Personality Traits

Rational choice theory suggest that the rational actor would try to maximize personal payout by investing only the minimum amount possible, in this case zero, into the public good. In the ex-ante survey participant’s rational ability was tested as a factor in the REI-40 [19] and we find that participants whose score showed higher rational ability also contributed significantly less into the public good. Since the measure for rational ability can take on many values, we divided participants in five groups to facilitate the interpretation of the values. We adjusted the interval of the rational ability score to get a more even distribution of observations between the groups, since most participants achieved a score between 3 and 4 and very few participants achieve a score lower than 2. Table 2 shows the relevant statistics.

**Table 2.** Investment in Public Goods by participants with different rational ability scores

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Rational Ability Score**  **Investment in Public Good** | **0 < x ≤ 2** | **2 < x < 3** | **3 ≤ x < 3.5** | **3.5 ≤ x < 4** | **4 ≤ x** |
| **All participants (N=140)** |  |  |  |  |  |
| * **N** | 11 | 28 | 37 | 38 | 26 |
| * **Mean (S.D.)** | 0.85 (0.32) | 0.60 (0.42) | 0.51 (0.36) | 0.42 (0.36) | 0.34 (0.38) |
| **Only female (N=55)** |  |  |  |  |  |
| * **N** | 3 | 8 | 16 | 16 | 12 |
| * **Mean (S.D.)** | 0.93 (0.12) | 0.41 (0.40) | 0.57 (0.26) | 0.38 (0.25) | 0.41 (0.40) |
| **Only male (N=85)** |  |  |  |  |  |
| * **N** | 8 | 20 | 21 | 22 | 14 |
| * **Mean (S.D.)** | 0.81 (0.37) | 0.68 (0.42) | 0.48 (0.42) | 0.46 (0.42) | 0.27 (0.37) |

The table shows a decrease in investment in the public good from 0.85 for very low scores to less than half the initial endowment for scores higher than 3.5. While the trend is similar even when dividing by gender, the numbers are less straight forward for females than for males. The decreasing trend only holds for females scoring higher or equal to 3, while the few females scoring below this threshold do not show a clear trend. Further tests were run for the great variety of personality and economic traits we had collected in the online survey and no other variable showed a statistical significance similar to the rational ability measure.

In the next step, a regression analysis was used to see if the statistical significance holds when adding additional variables. Table 3 shows the results of the regression analysis with robust standard errors. Model 1 is the simplest model, only including rational ability, risk aversion, and age. In Model 2 we add gender and group size and in model 3 we control for college related variables, such as the amount of years the participant has been in college, the college the participant attends and their major. In Model 4 we add control variables for social cognition with a Mind in the Eyes test score and for general intelligence through the Wonderlic score. Besides age, none of the control variables showed statistical significance in any of the models.

**Table 3.** Regression results: PG contribution

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **PG contribution** | **Model 1** | **Model 2** | **Model 3** | **Model 4** |
| **Rational Ability** | -0.155\*\*  (0.047) | -0.153\*\*\*  (0.047) | -0.152\*\*\*  (0.048) | -0.158\*\*\*  (0.048) |
| **Risk Aversion** | -0.001  (0.075) | 0.005  (0.076) | 0.002  (0.079) | -0.012  (0.080) |
| **Age** | 0.037\*\*  (0.012) | 0.043\*\*  (0.013) | 0.030  (0.017) | 0.029  (0.018) |
| **Male** |  | 0.015  (0.061) | 0.030  (0.071) | 0.043  (0.074) |
| **Group Size** |  | -0.014  (0.012) |  |  |
| **Years in College** |  |  | 0.015  (0.044) | 0.022  (0.045) |
| **Constant** | 0.206  (0.348) | 0.188  (0.352) | 0.087  (0.402) | 0.521  (0.562) |
| **Control Variables** | No | No | College, Major | College, Major, Wonderlic Score, Mind in the Eyes score |
| **R2** | 0.138 | 0.145 | 0.156 | 0.166 |
| **Adjusted R2** | 0.119 | 0.114 | 0.090 | 0.088 |
| **F** | 11.46\*\*\* | 7.712\*\*\* | 4.306\*\*\* | 3.544\*\*\* |
| N=140, \*p<.05, \*\*p<.01, \*\*\*p<.001, Standard Errors in parentheses | | | | |

Rational ability shows statistically significant and negative coefficients with a similar value of about -0.15 for all three models. As predicted by standard economic theory we find that the higher the score of a participant on the rational ability scale, the less likely that participant is to invest in the public good.

Adding the variable male and group size has almost no effect on the other variables and actually decreases the value for the F-test and the adjusted R-squared. Since there is no significant difference in the mean for female and male contribution, it is no surprise that the coefficient for male is not significant. Similarly, table 1 shows that average contribution differs very little between different group sizes, and hence the lack of statistical significance is not surprising.

One could expect risk aversion to show some effect, however the coefficient does not show statistical significance. In this case, the reason might be that investing more rather than a little is not perceived as a risk, because the participant’s choice does not affect the probability of different outcomes. The participant rather dependents on her/his own believe about the group’s behavior and strategy. The coefficient for age shows up statistically significant in model 1 and 2 and is positive for all four models. While it is not surprising that older individuals might contribute more to the public good, we do not allow ourselves a reliable interpretation since the coefficient is not statistically significant in model 3 and 4.

We also tested for the correlation of the remaining personality traits from the REI-40 test - rational engagement, experiential ability, and experiential engagement – and the measures of the Big Five personality factors, however none of the coefficients showed up statistically significant. In accordance with earlier studies on personality traits and economic games, we continue to find that, as much as the tests we apply can measure very specific personality traits, these traits only correlate to behavior in very specific environments.

Since model 1 has the highest R-squared and F-test value, we repeat the model for both females and males individually. Table 4 shows the results.

**Table 4.** Regression results: PG contribution by gender

|  |  |  |  |
| --- | --- | --- | --- |
| **PG contribution** | **All participants** | **Only females** | **Only males** |
| **Rational Ability** | -0.155\*\*  (0.047) | -0.131+  (0.071) | -0.169\*\*  (0.062) |
| **Risk Aversion** | -0.001  (0.075) | 0.006  (0.105) | 0.003  (0.099) |
| **Age** | 0.037\*\*  (0.012) | 0.053\*\*  (0.017) | 0.027  (0.016) |
| **Constant** | 0.206  (0.348) | -0.226  (0.497) | 0.472  (0.471) |
| **Control Variables** | No | No | No |
| **R2** | 0.138 | 0.180 | 0.126 |
| **Adjusted R2** | 0.119 | 0.131 | 0.094 |
| **F** | 11.46\*\*\* | 6.617\*\*\* | 6.27\*\*\* |
| **N** | 140 | 55 | 85 |
| +p<0.1 \*p<.05, \*\*p<.01, \*\*\*p<.001, Standard Errors in parentheses | | | |

The model ‘all participants’ is the same model as model 1 in table 3 and was added to the table for easier comparison.

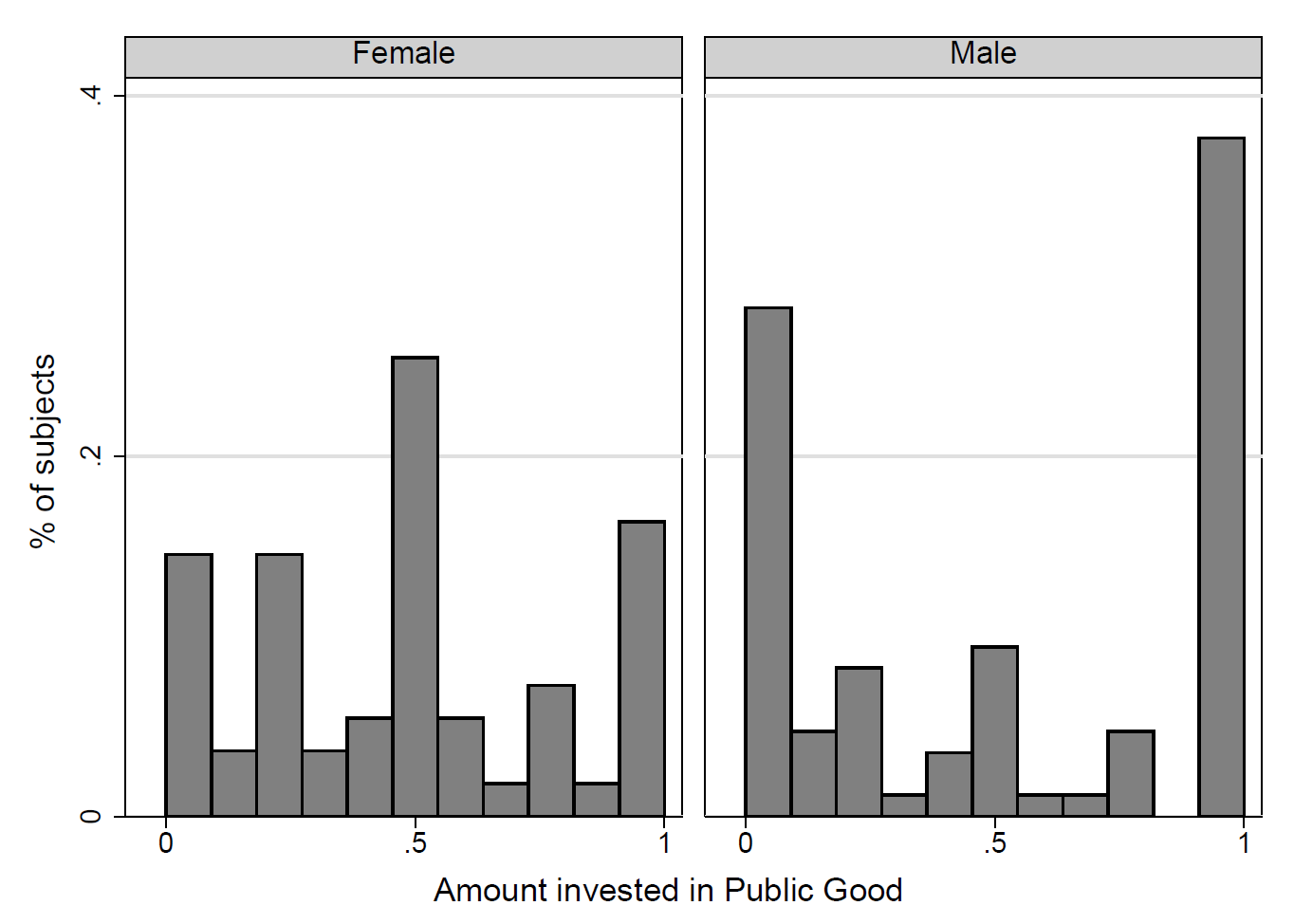
Age, which is statistically significant in the ‘all participants’ model, turns out to be only statistically significant for the ‘only females’ model. There are no gender-related distributional differences in age; hence, we can only conclude that age indeed has a stronger effect among females than males.

The coefficient for rational ability is statistically significant in the model for ‘all participants’ and the ‘only males’ model. In the ‘only females’ model the statistical significance reduces to only a weak statistical significance. To investigate the reason for this difference we take a closer look at the gender difference for the contribution to the public good.

3.2. Gender Differences

In the summary statistics in table 1 we saw that the value of the standard deviation for all participants does not give an unusual number (S.D.=0.392), however, when grouped by gender, it shows a difference of 0.1 with values of 0.329 for females and 0.429 for males.

The nature of the difference in distribution becomes more obvious in Figure 1. Females tend to give about 50% of their initial endowment to the public good with a few outliers at the edges of the contribution. Males are more strongly divided and give either very low contributions or very high contributions.



**Figure 1.** Public Goods Contribution by Gender

The gender difference in the standard deviation of the amount invested in the public good is confirmed by the statistical significance of a variance ratio test. This test has the null hypothesis that the ratio of the standard deviations from two groups is equal to 1. Table 5 below shows that the null hypothesis is rejected at the 5% level.

**Table 5.** Variance ratio test for the standard deviations of the amount invested in the public good by females and males

|  |  |  |
| --- | --- | --- |
| **Public Good Contribution** | **Median / Mean** | **Std. Dev.** |
| **Only Male** | 0.50 / 0.517 | 0.429 |
| **Only Female** | 0.50 / 0.478 | 0.329 |
| Null Hypothesis: | | |
| **Alternative Hypothesis:** ratio < 1, **p=0.0187** | | |
| **Alternative Hypothesis:** ratio ≠ 1, **p=0.0375** | | |
| N=140, n=85 (Males), n=55 (Females)  Notes: We also employed Levene’s T-test to test the null hypothesis that the two population variances are equal. The test rejected the null hypothesis (p=0.0000). | | |

This difference in behavior between females and males shows up in a variety of research and situations. Closest to the behavior in our public goods game is the finding by Cadsby and Maynes [30], who report that females tend to adapt their behavior to be very similar to each other, whereas males behave less dependent on others' behavior. In a meta-study Charness and Gneezy [31] find that “women make smaller investments in the risky asset than do men, and so appear to be financially more risk averse”. It confirms our finding of a less risky behavior, i.e., by choosing the middle path, by females in our public goods game. Furthermore, in a dictator game experiment Andreoni and Vesterlund [32] find that men are more likely to be either perfectly selfish or perfectly selfless, whereas women behave more “equalitarian” and share the wealth equally. Hauge and Rogeberg [33] also find that women – compared to men - make less self-interested choices when representing a group. Similarly, in research about the expression of political opinions Atkeson and Rapoport [34] show that women do not take as extreme positions as men.

The difference in the distribution of the gender contribution explains the less statistically significant coefficient for rational ability in the ‘only females’ model compared to the ‘only males’ model. Since the standard deviation of contribution amounts is significantly smaller for females than for males, the data points move close together. This makes it more difficult to see a clear trend.

4. Conclusion

The results in this paper show that rational ability as measured by the REI-40 is a good predictor for behavior in the public goods game. As predicted by rational choice theory, a more rational individual contributes less to the public goods game. Rational ability refers to the individual’s tendency to be analytical and make logical connections, whereas the other thinking style – experiential – refers to being affective (i.e., doing what feels good) and reliant on past experiences [35]. Most interactions in the real world are not ‘one-shot’ and hence have consequences for the individual. This also means that un-cooperative behavior can have negative repercussions in the individual’s future. From these experiences, many people learn to intuitively act cooperative, especially if they have an experiential thinking style. An individual with a tendency for a rational thinking style, in contrast, relies less on past experiences for their decision making. They take more time to analyze the situation and to elicit whether cooperative behavior maximizes their utility now and in the future.

The effect of rational ability on contributions is not only stronger for males than for females, its coefficient is also more statistically significant in an ‘only males’ model. The gender difference in the distribution of the public good contributions explains the higher statistical significance. Our study finds that neither females nor males are shown to be more cooperative, however the distribution of the contribution are significantly different. While the distribution of investment decision made by females is more narrow and centered around the average, for males the distribution looks entirely different. More than 70% of males give at the extremes, while less than 15% contribute around the average value.

With this study we contribute to the ongoing interdisciplinary research on the relationship between economic behavior and personality traits. We confirm the intuitive finding that rational individuals contribute less to the public good and are able to explain the gender difference with the distribution of contributions. Future researchers are encouraged to test their populations for distributional differences in their choice of contribution. In addition, one may compare these results to decision making outside of the laboratory. From an evolutionary perspective it seems intuitive that males are more prone to choose an extreme stand in order to distinguish oneself from the rest of the group, whereas women are more likely to behave more in accordance to the norm or average behavior.

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**Author Contributions:** All authors conceived, designed and performed the experiments; H.L. analyzed the data; G.D. and M.B. contributed to the interpretation and discussion of the data analysis and results; H.L. wrote the paper.

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