Personality and Cooperation in Finitely Repeated Prisoner's Dilemma Games*

John Kagel[a] and Peter McGee[b]

3/13/2014

Abstract

We investigate the role personality plays in Finitely Repeated Prisoner's Dilemma (FRPD) games. Even after controlling for demographic factors such as race, course of study, and cognitive ability, we find that cooperative behavior is significantly related to the Big Five personality trait Agreeableness. A one standard deviation increase in agreeableness increases the predicted probability of cooperation by a subject with modal demographic characteristics from 67.9% to 80.6%.

Key Words: finitely repeated prisoner dilemma, personality, cooperation

JEL Classification: D03, C92, C73

* We thank Emel Feliz-Ozbay, John Ham and Erkut Ozbay for helping to inspire this research. The research has been partially supported by National Science Foundation grant SES-1226460. Opinions, findings, conclusions or recommendations offered here are those of the authors and do not necessarily reflect the views of the National Science Foundation.

[a] Department of Economics, Ohio State University, Columbus, OH 43210, USA, Ph: (614) 292-4812, Email: kagel.4@osu.edu

[b] **Corresponding author**. Department of Economics, National University of Singapore, 1 Arts Link, Singapore 117570, Ph: (65) 6516-6108, Email: ecspjm@nus.edu.sg

I. Introduction

Economists are increasingly concerned with the role personality traits play in economic outcomes (Heckman et al. 2006, Borghans et al. 2008, Becker et al. 2012). Much of this work is done using survey data, but experimental economists are beginning to explore personality traits,which are easily measured in the laboratory (e.g., Deck et al. 2012, Feliz-Ozbay et al. 2013, Fréchette et al. 2013, Proto and Rustichini 2013).

We examine the role personality plays in one of the most replicated results in experimental economics: early round cooperation in a finitely repeated Prisoner's Dilemma (FRPD). Several theories have been proposed and explored to account for these decisions (e.g., Kreps et al. 1982, Neyman, 1985, Selten and Stoecker 1986, Jeheil, 2005). We hypothesize that early round cooperation in FRPD games is related to personality traits, in particular to the Big 5 personality trait "Agreeableness." Agreeableness is a broad trait associated with more specific traits—altruism, trust, cooperativeness—that have been previously incorporated into models of agents' preferences to explain cooperation in the FRPD (Andreoni and Miller 1993, Cooper et al. 1996, James 2002, Brosig 2002).[2]

II. Experimental Design and Data

Subjects played 10 super-games each consisting of 10 simultaneous-move, FRPD games; stage payoffs are given in Figure 1. Payoffs were denominated in experimental currency units (ECUs) which were converted into dollars at the rate of \$1 = 250 ECUs. Payoffs were computed over all plays of all the super-games and paid in cash at the end of an experimental session along with a \$6.00 participation fee. Upon completion of the last super-game, subjects completed a short demographic questionnaire, as well as a 44-item Big Five Inventory (BFI, John et al. 2008).[3] Subjects consented to allowing the registrar to furnish us with their GPAs and SAT/ACT scores. The experiment was programmed in z-Tree (Fischbacher 2007). A total of 52 subjects participated in 5 sessions lasting about 1.5 hours each.

[2] There have been some attempts to link measurable traits to behavior in experimental games similar to the standard Prisoner's Dilemma. Among economists, Boone et al. (1999) look at a different set of personality measures on cooperative behavior in a Prisoner's Dilemma: locus of control, self monitoring, sensation seeking, and type A behavior; they find that cooperative behavior is systematically related to a number of these traits. Among psychologists, Hirsh and Peterson (2009), Pothos et al. (2011), and Lönnqvist et al. (2011) look at the impact of Big 5 traits on behavior in variants of the Prisoner's Dilemma. However, these studies are all one-shot games with some combination of non-neutral language, a lack of financial incentives, a lack of additional controls, and substantial variations from the standard Prisoner's Dilemma (e.g., sequential moves, larger strategy space).

[3] The Big Five personality characteristics represent a consensus among personality psychologists on a general taxonomy of personality traits. The focus of the Big Five is on internal consistency rather than predictive ability, designed to measure personality at a very broad level of abstraction; with each dimension summarizing a large number of distinct, more specific, personality characteristics.

III Experimental results

Table 1 reports marginal effects from probit models—incorporating various controls—of the likelihood that a subject cooperates in the first round of a super-game.[4] In all cases the dependent variable is 1 if a subject cooperated, 0 otherwise, with standard errors clustered at the subject level. Column 1 includes basic regressors suggested by Dál Bo and Fréchette (2011) for infinitely repeated super–games: *Previous opponent cooperated in Rd. 1* is a dummy variable equal to 1 if a subject faced an opponent who cooperated in the first round of the previous super-game (0 otherwise), *Subject cooperated in Rd. 1 of first super-game* is a dummy variable equal to 1 if a subject cooperated in the first round of the first super-game (0 otherwise; included to capture innate tendencies to cooperate), and *Super-game* is a linear time trend variable included to capture any learning or experience effects in the data. All three variables are significant at the 5% level or better in column 1 and every subsequent specification.

Column 2 adds basic demographic variables— gender, race and academic major— obtained from the university Registrar's office. There are several racial categories but approximately 88% of subjects identify as white, black, or Chinese, so we include these three categories and collapse the other racial categories into one group, Other Race. Among these racial categories, white and black subjects are primarily U.S. citizens, while those identifying as Chinese are primarily students from the People's Republic of China.[5] Adding these controls to the variables shows that non-white subjects are less likely to cooperate: Chinese subjects are 32.3% less likely to choose to cooperate relative to whites ($p = 0.03$), and blacks are 29.2% less likely to cooperate ($p = 0.09$). We do not have any a priori hypotheses with regards to race. Moreover, our experiment is not designed to investigate hypotheses about race and subjects were not aware of the other player's race. The significant marginal effects for blacks are not robust to the inclusion of other control variables in columns 3 and 4, but the marginal effects for Chinese are. That Chinese subjects in our sample are less cooperative stands in contrast to the findings in Hemesath and Pomponio (1998), suggesting that more work is necessary to understand any cultural differences. The existing literature finds that business and economics majors are less likely to cooperate in prisoner's dilemma games than subjects majoring in other areas (e.g., Frank, Gilovich, and Regan 1993). Our results are broadly consistent with this, and add that science and engineering students are less likely to cooperate than liberal arts majors and undecided students, though the differences are not significant in this specification.

---

[4] Statistical tests for cooperation rates focus on outcomes in the first round because subsequent behavior is highly dependent on earlier outcomes, creating complicated interdependencies that are difficult to account for econometrically. Further, once two or more rounds have passed in which one agent has defected, in the overwhelming number of cases both agents defect for the remainder of the super-game.

[5] One subject who identified as black was from Nigeria, while one subject who identified as Chinese was from Malaysia.

The specification in column 3 adds the Big Five personality traits (agreeableness, extroversion, conscientiousness, neuroticism, and openness), which are of primary interest. Each of these variables is standardized within our sample to have a mean of zero and a standard deviation of 1. There are some changes in the marginal effects of the controls in column 2 after the inclusion of the Big Five: the marginal effect for black is 29% smaller and is no longer significant, and the marginal effects of studying science and engineering or business and economics both nearly double in magnitude, with p-values of 0.11 and 0.04, respectively. Among the personality traits, only agreeableness is associated with a significant marginal effect: A one standard deviation increase in agreeableness is associated with a 13.9% increase in the likelihood of cooperation in the first stage game of a super-game. Evaluating the predicted probability at modal or average demographic characteristics, the predicted probability of cooperation is 70.9%, with a one standard deviation increase in agreeableness increasing the predicted probability to 82.1%.[7] For the second largest racial group—Chinese—with otherwise modal characteristics, the same change in agreeableness increases the predicted probability from 37.1% to 51.6%.

Filiz-Ozbay et al. (2013) show that including a measure of cognitive ability may be important when estimating the marginal effects of the Big Five personality traits. For cognitive ability we use composite SAT and ACT scores to construct a dummy variable equal to one if the subject's composite score was at or above the 95th percentile for 2011.[8] In column 4 we add this variable to the probit model. The marginal effect for having a score in the top 5% is associated with an 18.5 percentage point increase in the likelihood of cooperating, though the effect falls just short of conventional significance levels ($p = 0.109$). After including the measure of cognitive ability, the marginal effect for Chinese increases in absolute value and is significant at the 1% level, while the marginal effect for blacks is not significant, with its magnitude is more than halved. The marginal effects for both academic majors increase in absolute magnitude and are both significant at the 5% level. While there are some small changes in the estimated marginal effects of the personality traits, the impact of agreeableness is robust to the inclusion of an ability measure: a one standard deviation increase in agreeableness is associated with a 15 percentage point increase in the likelihood that a subject cooperates in the first stage game of a super-game.[9] The same comparison of predicted probabilities of cooperation for the modal group shows that a

---

[7] For binary characteristics, the modal categories are white, male, liberal arts major or undecided; for the Big 5, the average score after normalization is 0. In addition, the predicted probabilities are evaluated assuming the subject did not cooperate in the first round of the first super-game, the subject's opponent in the previous super-game cooperated in the first round of that super-game, and at the 5th super-game.

[8] This is similar to the method used in Casari, Ham, and Kagel (2007) who create two dummies: above median and below the 95th percentile and above the 95th percentile. Only one of our subjects had a score below the national median, so we have opted for just one dummy. We use SAT/ACT scores as a proxy for cognitive ability as they are readily available and are highly correlated with various other measures of cognitive ability (Frey and Dutterman 2004).

[9] In unreported results, we used GPA in place od SAT/ACT scores . The results are qualitatively and quantitatively similar. We use SAT/ACT scores in our preferred specification because GPA is a noisier measure of cognitive ability (Noftle and Robins 2007).

one standard deviation increase in agreeableness increases the probability of cooperation from 67.9% to 80.6%.[10]

Our results show the importance of both personality and the history of play for cooperative behavior. One question these results raise is whether the demographic variables, especially agreeableness, impact the decision to cooperate in the first round of the first super-game. If so, it is possible that the models in columns 3 and 4 are misspecified. Probits reported in the online Appendix show that (1) none of the demographic, personality and cognitive ability characteristic included in Table 1 are significant predictors of the a subjects decision to cooperate in the first round of the first super-game and (2) running our preferred specification from Table 1 but omitting the dummy variable for whether a subject cooperated in the first round of the first super-game, the estimated marginal effects for the other regressors change very little. Taken together, these results indicate that factors influencing initial cooperation decisions remain unexplained.

IV Summary and Conclusions

Our results provide insight into the motivations behind cooperation in finitely repeated Prisoner's Dilemma games. Many attempts have been made to formalize the preferences that might explain such cooperation, often relying on behavioral "types" or beliefs about these types in the population (e.g., Kreps et al. 1982, Andreoni and Miller 1993, Brosig 2002). Our findings suggest that these preferences and types can be related to individual traits, particularly Agreeableness as measured by the Big Five Inventory. Understanding how individual differences influence play in games such as the FRPD may be an important step in enabling economists to explain the heterogeneity in behavior reported for games such as this.

[10] The modal category for test scores is having a score below the 95th percentile.

References

Andreoni, J. and Miller, J. H. 1993. "Rational Cooperation in the Finitely Repeated Prisoner's Dilemma: Experimental Evidence" *The Economic Journal,* 103 (418), 570-585

Becker, A., Thomas Deckers, T., Dohmen, T., Falk, A. and Kosse, F. 2012. "The Relationship Between Economic Preferences and Psychological Personality Measures*." Annual Review of Economics*, 4, 453-478.

Boone, C., De Brabander, B., and van Witteloostuijn, A. 1999 "The Impact of Personality on Behavior in Five Prisoner's Dilemma Games," *Journal of Economic Psychology* 20, 343-377

Borghans, L., Duckworth, A., Heckman J., and ter Weel, B. 2008 "The Economics and Psychology of Personality Traits," *Journal of Human Resources* 43(4), 972-1059

Brosig, J. 2002 "Identifying Cooperative Behavior: Some Experimental Results in a Prisoner's Dilemma Game," *Journal of Economic Behavior & Organization* 47 (3), 275-290

Casari, M., Ham, J., and Kagel, J. 2007 "Selection Bias, Demographic Effects and Ability Effects in Common Value Auction Experiments," *American Economic Review* 97, 1278-1304

Cooper, R., DeJong, D., Forsythe, R., and Ross, T. 1996 "Cooperation without Reputation: Experimental Evidence from Prisoner's Dilemma Games," *Games and Economic Behavior* 12 (2), 187-218

Dál Bo, P. and Fréchette, G., 2011. "The evolution of cooperation in repeated games: Experimental evidence." *American Economic Review* 101 (1), 411-429

Deck, C., Lee, J., Reyes, J., and Rosen, C. 2012. "Risk-taking Behavior: An Experimental Analysis of Individuals and Dyads" *Southern Economic Journal* 79 (2), 277-299

Feliz-Ozbay, E., Ham, J., Kagel, J., and Ozbay, E. 2013 "The Role of Cognitive Ability, Personality Traits and Gender in Gift Exchange Outcomes" *Working Paper*

Fischbacher, U. 2007 "z-Tree: Zurich Toolbox for Ready-made Economic Experiments," Experimental Economics 10 (2), 171-178

Frank, R., Gilovich, T., and Regan, T. 1993. 'Does Studying Economics Inhibit Cooperation? "*Journal of Economic Perspectives* 7 (2), pp 159- 171.

Fréchette, G., Schotter, A. and Trevino, I. 2013 "Personality, Information Acquisition and Choice under Uncertainty: An Experimental Study," *Working Paper*

Frey, M. and Detterman, D. 2004. 'Scholastic Assessment or *g*?: TheRelationship Between the Scholastic Assessment Test and General Cognition Ability," *Psychological Science* 15 (6), pp 373- 378.

Heckman, J., Stixrud, J., and Urzua, S. 2006. "The Effects of Cognitive and Noncognitive Abilities on Labor Market Outcomes and Social Behavior." *Journal of Labor Economics*, 24, pp. 411-482

Hemesath, M. and Pomponio, X. 1998. "Cooperation and Culture: Students from China and the United States in a Prisoner's Dilemma" *Cross-Cultural Research* 32 (2), 171-184

Hirsh, J. and Peterson, J. 2009 "Extroversion, Neuroticism, and Prisoner's Dilemma" *Personality and Individual Differences* 46, 254-256

James, H. 2002. "The Trust Paradox: A Survey of Economic Inquiries into the Nature of Trust and Trustworthiness." *Journal of Economic Behavior and Organization* 47 (3), 291-307

Jeheil, P. 2005 "Anlogy-based Expectation Equilibrium, " *Journal of Economic Theory.* 123, pp 81-104.

John, O., Naumann, L., and Soto, C., 2008 "Paradigm Shift: to the Integrative Big Five" In Oliver P. John, R. W. Robbins, and L. A. Pervin (Eds.), Handbook of Personality, Theory, and Research, N. Y. Guilford Press, pp. 114-158

Kreps, D. M., Milgrom, P., Roberts, J., and Wilson, R., 1982 "Rational cooperation in the finitely repeated prisoners'dilemma." *Journal of Economic Theory* 27 (2), 245-252.

Lönnqvist, J., Verkasalo, M., and Walkowitz, G. 2011. "It Pays to Pay – Big Five Personality Influences on Co-operative Behaviour in an Incentivized and Hypothetical Prisoner's Dilemma Game" *Personality and Individual Differences* 50, 300-304.

Neyman, A. 1985. "Bounded Complexity Justifies Cooperation in the Finitely Repeated Prisoner's Dilemma Game," *Economics Letters,* 19, pp 227-229.

Noftle, E. and Robins, R., 2007 "Personality predictors of academic outcomes: Big five correlates of GPA and SAT scores," *Journal of Personality and Social Psychology* 93(1), 116-130

Pothos, E., Perry, G., Corr, P., Matthew, M., and Busemeyer, J. 2011. "Understanding Cooperation in the Prisoner's Dilemma Game" *Personality and Individual Differences* 51, 210-215.

Proto, E. and Rustichini, A. 2013 "Cooperation and Personality," *University of Warwick CAGE Working Paper 143*

Selten, R. and Stoecker, R. 1986. "End behavior in sequences of finite repeated prisoner's dilemma supergames: a learning theory approach." *Journal of Economics Behavior and Organization* 7 (1), 47-70.

Figure 1: Payoff Matrix in ECUs

	A	B
A	105 105	5 175
B	175 5	75 75

Table 1: Estimated marginal effects in Probit models of the probability of cooperating in the first stage of a super-game

	Marginal effects			
Dependent Variable: Cooperate				
Previous Opponent	0.192***	0.177***	0.156***	0.181***
Cooperated in Rd. 1	(0.050)	(0.052)	(0.049)	(0.056)
Subject Cooperated in Rd. 1	0.246**	0.307***	0.282***	0.369***
of first super-game	(0.103)	(0.105)	(0.110)	(0.107)
Super-game	0.024**	0.027**	0.029**	0.039**
	(0.012)	(0.012)	(0.013)	(0.016)
Male		0.007	-0.037	0.056
		(0.106)	(0.110)	(0.116)
Black		-0.293*	-0.207	-0.090
		(0.174)	(0.141)	(0.147)
Chinese		-0.326**	-0.338**	-0.556***
		(0.149)	(0.120)	(0.121)
Other Race		-0.051	-0.058	-0.211
		(0.165)	(0.139)	(0.138)
Business and Economics		-0.126	-0.250**	-0.271**
		(0.114)	(0.120)	(0.126)
Science and Engineering		-0.122	-0.237	-0.311**
		(0.146)	(0.150)	(0.146)
Extroversion			0.020	-0.003
			(0.053)	(0.057)
Agreeableness			0.139***	0.150***
			(0.044)	(0.056)
Conscientiousness			-0.069	-0.044
			(0.049)	(0.055)
Emotional Stability			-0.009	0.012
			(0.059)	(0.063)
Openness/Intellect			-0.054	-0.061
			(0.059)	(0.064)
Top 5%				0.185
				(0.115)
Pseudo-R^2	0.090	0.158	0.219	0.277
Observations	470	470	470	380

Note: Standard errors in parentheses are clustered at the subject-level. The probit models are estimated by maximum likelihood. Marginal effects evaluated at sample means.

*** — significant at 1% ** — significant at 5% * — significant at 10%

Appendix

Table A1: Estimated marginal effects in Probit models of the probability of cooperating in the first stage of the first super-game and its subsequent importance

	Marginal effects	
Dependent Variable: Cooperate		
Previous Opponent Cooperated in Rd. 1		0.223***
		(0.052)
Super-game		0.036**
		(0.014)
Male	0.203	0.104
	(0.237)	(0.125)
Black	0.065	-0.087
	(0.320)	(0.154)
Chinese		-0.431***
		(0.166)
Other Race	-0.361	-0.299*
	(0.244)	(0.155)
Business and Economics	-0.003	-0.239*
	(0.194)	(0.125)
Science and Engineering	-0.146	-0.318**
	(0.221)	(0.146)
Extroversion	0.126	0.048
	(0.102)	(0.071)
Agreeableness	0.061	0.157**
	(0.109)	(0.062)
Conscientiousness	-0.096	-0.069
	(0.090)	(0.058)
Emotional Stability	0.057	0.020
	(0.104)	(0.064)
Openness/Intellect	0.007	-0.067
	(0.099)	(0.062)
Top 5%	0.174	0.212
	(0.198)	(0.134)
Pseudo-R^2	0.114	0.209
Observations	38	380

Note: Standard errors in parentheses are clustered at the subject-level. The probit models are estimated by maximum likelihood. Marginal effects evaluated at sample means. The racial category for Chinese is dropped in the first column because there is no variation in the first round of the first super-game amongst the subset of these subjects for whom we have test scores.

*** — significant at 1% ** — significant at 5% * — significant at 10%

Instructions

This is an experiment in the economics of market decision making. The instructions are simple, and if you follow them carefully, you may earn a CONSIDERABLE AMOUNT OF MONEY which will be PAID TO YOU IN CASH at the end of the experiment.

The One-Round Decision

You will be paired with another subject choosing between options A and B in the payoff table shown below, where the number listed in the top left hand corner of each box is your payoff and the payoff for the subject you are paired with in the lower right hand corner.

	A	B
A	105 105	5 175
B	175 5	75 75

One round decisions work as follows: Think of yourself as the row player in terms of the payoff table. If you choose A and the other subject chooses A your payoff will be 105 and the other subject's payoff will be 105. If you choose A and the other subject chooses B your payoff will be 5 and the other subject's payoff will be 175. If you choose B and the other subject chooses A your payoff will 175 and the other subject's payoff will be 5. Finally, if you both choose B, both of you will get a payoff of 75.

When making your choice, you will not know the choice of the other subject since choices are made simultaneously. You will have 30 seconds to make a choice. After all teams have made their choices, the computer will report back your choice and the choice of the subject you have been paired with for that round, along with your payoffs and the other subject's payoffs.

All payoffs are denominated in an Experimental Currency Unit (ECU). ECUs will be converted into dollars at a rate to be described below.

Blocks of Rounds

You will be paired with the **same** other subject for a set of 10 repeated choices using the **same** payoff table. After the 10^{th} round, you will be paired with another subject in the room and you will proceed to make 10 repeated choices with that team. We will conduct 10 blocks of choices of this sort.

Payoffs

You earnings for today will be based on the sum total of your earnings in *each and every* round you participate in. ECUs will be converted into dollars at the exchange rate of $1 = 250 ECU. In addition, each of you will receive a $6 participation fee. Are there any questions?

Before we begin, please answer the following questions to make sure you understand the structure of the experiment. When you are done, raise your hand and one of us will be around to check your answers.

1. The subject you are matched with will change every block of 10 periods… True / False

2. If you choose A…

   …and the other subject chooses A, what will your payoff be? _____
   …and the other subject chooses B, what will your payoff be? _____

3. If you choose B…

   …and the other subject chooses A, what will your payoff be? _____
   …and the other subject chooses B, what will your payoff be? _____