Teaching the Prisoner's Dilemma More Effectively: Engaging the Students

by

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December 2012

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Abstract

We introduce a simple but particularly compelling prisoner's dilemma classroom experiment that can be used in a variety of settings to demonstrate issues surrounding cooperative behavior (e.g., oligopoly, advertising, and public corruption). The prisoner's dilemma occurs in all 21 class sections in our experiment. This experiment is more likely to engage students in two ways. The "payoff" in the game involves the possibility of students earning a small number of extra points. Also, we find that presenting experimental results to students enhances their interest in the material. For example, we find evidence that female students are less likely to "defect" than are male students, and that international students are more likely and seniors less likely to "defect." Classroom discussions are greatly enhanced as a result.

Key Words: Classroom experiment; prisoner's dilemma; behavioral economics

JEL Codes: A22, C92, D01

MOTIVATION

Economic educators have used game theory as a pedagogical device for many years. Game theory can allow instructors to clarify concepts that can sometimes seem esoteric to students, helping them to better grasp and retain what is being taught. The prisoner's dilemma is a particularly common example of this. Simple explanations of the prisoner's dilemma have been used to motivate discussions of a wide variety of topics, including the behavior of oligopolists, the motivations behind advertising, national responses to global climate change, the causes of public corruption, and many others. Instructors often have students participate in simple games in the classroom. A number of researchers, including Friesner and Axelsen (2006), argue that games of this nature can help students "significantly increase their understanding of economics." In a similar vein, Gremmen and Potters (1997) provide evidence that the use of experimental games in the classroom significantly enhances learning achievement.

We present a method of introducing the prisoner's dilemma through a classroom game that we believe to be especially compelling. In this game the potential "payoff" involves extra

credit points for students. This tends to engage students in ways that other games may not. In our case, our use of this game in a number of classes has generated a considerable amount of data. Simple analyses of these data yield results that instructors can present in their classes, thereby further engaging students. For example, students generally find it interesting to discuss whether or not men are more likely to not cooperate (that is, to defect) in the game than are women, and whether or not the probability of defecting varies according to students' socio-economic status. The game we describe has the advantages of simplicity, and it takes very little class time to complete.

This paper proceeds in the following manner. In the next section we briefly discuss past use of game theory in classroom settings, as well as pertinent findings from the experimental economics literature. We then describe how the game is set up and conducted, before describing our results. A final section offers concluding thoughts.

LITERATURE REVIEW

The literature abounds with suggestions of classroom games. Examples of early discussions include Joseph (1965), Lumsden (1970), and Miller (1971). Holt and Capra (2000) describe a card game that they use as a springboard to discuss topics including bankruptcy, trade barriers, and public goods. Alba-Fernandez et al. (2006) describe a more complicated classroom game that they use to further their students' understanding of the Nash equilibrium. Ando and Ramirez-Harrington (2006) and Carson and Tsigaris (2011) present classroom games that can be used to illustrate environmental topics. Friesner and Axelsen (2006) describe an even wider application – they show how game theory can be used to teach an entire Principles of

Microeconomics course.[1] Indeed, most Principles of Economics textbooks contain at least some discussion of oligopolies in the context of game theory.

In addition to classroom games, other research has yielded insights that may further students' understanding of human behavior. For example, might women be less likely to defect in games than men? There is substantial evidence from the experimental economics literature that men may be more selfish and individualistic, and women more socially-oriented. Sherman's work (1971) is an early example of this. He reports evidence that women are more likely to be cooperative than men. With evidence from a dictator game, Eckel and Grossman (1998) argue that women are more generous than men. Using a trust game, Croson and Buchan (1999) also report evidence of greater generosity among women. Andreoni and Vesterlund (2001) find that women are kinder than men, at least when altruism is relatively expensive. Innocenti and Pazienza (2006) argue that women are more trusting than men. Similarly, Solnick (2001) suggests that although women don't actually seem to be content with less in bargaining situations, both women and men expect that women will settle for less. Others, however, present evidence that gender doesn't affect the propensity to lie (Childs, 2012) or that men may be more trusting than women (Chaudhuri and Gangadharan, 2007). There is in addition substantial evidence of gender differences in the social psychology literature.[2]

In addition, there is some evidence that individuals of higher socio-economic status may be more likely to defect. Piff et al. (2012) reason that those of higher socio-economic status may be more likely to engage in unethical behavior generally. They argue that "increased resources and independence from others cause people to prioritize self-interest over others' welfare," and they report experimental evidence confirming this. A well-known anecdote of this nature comes from Levitt and Dubner's (2005) *Freakonomics*. They describe a salesman who would leave

boxes of bagels in break rooms in office buildings in the Washington, D.C. area. He left the bagels and a basket in which customers were expected to leave payments on an honor system. He discovered that theft and non-payment were more common on the floors on which executives worked compared to lower-paid employees. However, Holland, Silva, and Mace, (2012) present evidence suggesting that poorer individuals may exhibit less altruism, and Hoffman (2011) and Chowdhury and Jeon (2012) show that altruism seems to increase with wealth.

Finally, there is experimental evidence that other characteristics of students participating in classroom experiments may affect their behavior. Hemesath (1994) finds that Russian students are more likely to cooperate in a prisoner's dilemma game, although Croson and Buchan (1999) find that differences in countries of origin are unimportant determinants of trust. Hu and Liu (2003) describe prisoner's dilemma games in which students majoring in economics and more senior students are more likely to cooperate.

A CLASSROOM GAME

We introduce a prisoner's dilemma game that is especially compelling to students in that the potential payoff involves extra points on an upcoming exam. Holt (1999) and Stodder (1998) point out that providing students with incentives raises student interest, but caution that providing extra credit points can be problematic if the game involves skill (for instance in a trading game). We argue that a prisoner's dilemma game does not suffer from this constraint. The point is to demonstrate to students that an individual's incentive to pursue self-interest can lead to results that make each individual in a group worse off. Specifically, Principles of Economics students were asked to complete a simple survey (see appendix) in which they were asked to choose between two alternatives: two points or eight points. The survey, as well as

verbal instructions, described what amounts to the payoff matrix: if all students select two points, then all students will receive an additional two points on their next midterm exam. If only a small number of students (two or fewer for classes with fewer than 100 students; three or fewer for larger classes) selects eight points those students are awarded eight points on the next midterm exam and all other students receive no points.[3] That is, selecting two is cooperative behavior while a selection of eight might be called "defecting." Finally, if more than the cutoff number of students selects eight points no one in the class receives extra credit points. Students were instructed to not talk during the exercise, and to not allow any other student to see their answer. Finally, students were assured that their choice would never be made known to anyone else.[4] We conducted this experiment at a point in the semester before the Principles of Microeconomics students covered game theory because we wanted all students to have the same knowledge (more specifically, a lack of knowledge) about game theory since it is not covered in Principles of Macroeconomics. (Some Principles of Macroeconomics students may have had Principles of Microeconomics but generally most students take Principles of Macroeconomics first).

The survey also gathered basic information about each student, including gender, major, year in college, and ZIP code of the town in which the student attended high school. This information was used in an analysis of the determinants of the likelihood of defecting. While the statistical details may not be especially interesting to the typical undergraduate student, the results can be presented and can be used to make the discussion even more interesting and effective. Instructors who covered game theory discussed the results as a way of introducing the basic principles of pay-off matrices, the incentive to defect, how strategic behavior can lead to suboptimal outcomes, etc.

RESULTS AND DISCUSSION

We ran this experiment in 21 different classes; data was obtained for 1,099 students (see Table 1). The incentive to defect is quite strong and it is rare for this experiment to result in extra points being awarded. However, instructors considering using this experiment in their classes should be aware that it can happen, particularly in smaller classes. In one of our Principles of Macroeconomics section this occurred.[5] The percentage of a class that defected varies somewhat, ranging from 5.4% to 30.8% with an average of 16.1%. The percentage of women who defect is 12.8%, while that of males is 18.4%. The results of the experiment were delivered to the instructors of each Micro Principles class in time for them to be used when the topic of game theory was introduced. Instructors reported livelier discussions, as students recognized that their grades could have been higher had there been some means to agree to cooperate (and to enforce such an agreement). This can also be used as a jumping off point for discussions about repeated games.

[INSERT TABLE 1 ABOUT HERE]

We also found that a relatively simple analysis yields results that have interesting implications, and also very useful for stimulating additional classroom discussion. We use a simple probit model, controlling for various student, instructor, and course characteristics. Table 2 provides descriptive information about our sample. About 42% of participants are female. We asked each student to list the ZIP code in the town in which the student graduated from high school. We determined median household income (MedianInc) in 2010 for each ZIP code from the American Community Survey. Median household incomes range from $14,355 to $178,285,

with an average of $72,223. Nearly 80% are either freshmen (Frosh) or sophomores (Soph); another 15.9% and 4.9% (respectively) are juniors (Junior) and seniors (Senior). A relatively small percentage (4.6%) list economics as their major (EconMajor). 4.5% of the students participating in the experiment are foreign students (Foreign). These come from 25 different countries, with China and Saudi Arabia the most common origins. Most (62.8%) of our students were enrolled in Micro Principles (Microprinc) rather than Macro Principles. About 10% of the observations were collected during the summer 2012 term; 90% comes from the fall 2012 semester. Finally, just greater than one-third of the participants had female instructors (Teacherfemale).

[INSERT TABLE 2 ABOUT HERE]

We tried a number of specifications before settling on the two presented in Table 3. Model 1 includes a proxy for students' household incomes, which were inferred from the median household income for their ZIP codes. This precludes our use of data from international students. Since income was not significant in any of the specifications we tried, we dropped it in Model 2. This adds 57 observations from international students; in that specification we include an indicator for such students (Foreign).[6] We also included instructor-specific fixed effects in both models. For purposes of parsimony these results are not presented, but are available from the authors on request.[7]

Our results indicate that female students are between 5.6% and 7% less likely to defect, a result that is significant at the 95% level or above. This result is consistent with earlier evidence from the experimental economics literature that suggests women may be more generous, altruistic, kind, or trusting than men. While this marginal effect may appear to be somewhat small in magnitude, it should be noted that the probability of defecting is about 50% larger for

males. Seniors are more likely to cooperate. This finding is somewhat unexpected since one might expect seniors to be better able to discern that defecting is the dominant strategy. That seniors are more likely to cooperate is consistent with the findings of Hu and Liu (2003, p. 700). They suggest that the likelihood of cooperation increases with maturity: "…the more events one experiences, the more considerate and thoughtful one becomes." As noted, median household income seems to have no discernible effect on the probability of defecting, and the dummy for majoring in economics is similarly unimportant. Interestingly, foreign students are more likely to defect in our sample. In an earlier prisoner's dilemma classroom experiment Hemesath (1994) found that Russian students were more likely to cooperate than American students. Although our experiment indicates that Americans are more likely to cooperate, the point here is that behavior in experimental games may vary according to nationality, perhaps due to differing cultural norms. However, we must be cautious in drawing any inferences because our sample contains relatively few foreign students.

We are not suggesting that a discussion of limited dependent variable models or econometric analysis would be useful outside of an econometrics class. Rather, we believe that a simple statement about the empirical findings (especially the gender result) might be intriguing to students and lead to even better classroom discussions. The instructors participating in our experiment found it so, with students particularly interested in the finding that women are less likely to defect than men. The instructor could discuss the concept of a dominant strategy and ask if the students understood that writing "8" was the dominant strategy for an individual student.

[INSERT TABLE 3 ABOUT HERE]

CONCLUSION

This classroom experiment should pique students' curiosity about game theory. Even though the possible extra points are a very small fraction of each student's course grade, this arrangement immediately interests students. In addition, there are several interesting findings in this experiment. First, the prisoner's dilemma tends to occur in all class sections. Second, while defecting does occur, it occurs for only 16.1% of the students which is smaller that might be expected. In other words, roughly 84% of the students cooperated. How does one explain such a high percentage of cooperation when the dominant strategy is to not cooperate (i.e., write a "8")? Third, it is interesting to note that the females are more likely to cooperate. While this tends to align with findings in other studies, there is a significant difference in our experiment. In most other studies, since the behavior of females was observed, females may have been signaling their willingness to cooperate because they may be involved with classmates in future academic endeavors on campus. But in our experiment the female and male behaviors are not observed so there is no signaling effect. Our finding may indicate that females may be predisposed to cooperate based on evolutionary selection characteristics, an idea that has been discussed elsewhere (Van Vugt, Cremer, and Janssen, 2007). This should make for an interesting behavioral economics discussion. The instructor could also discuss the concept of repeated (finite and infinite) games by asking the class if the experiment's results would likely change if it were repeated. Most examples of repeated games assume situations in which each player knows the move of the other player in the previous round. (For example, if Prisoner A gets a long prison sentence, he will know that prisoner B "ratted" on him since the state did not have enough

evidence to sentence them to long prison terms.) Knowing the moves of the previous round, they must decide if they want to cooperate (i.e. play “tit for tat”) or defect in the next round. But in our experiment involving many students in a class, no one knows which option (2 points or 8 points) any individual student played; that is, no one knows who "ratted". Thus it seems unlikely that students would change their option if this game were repeated.

NOTES

1. Charles Holt provides an extensive bibliography of classroom games on his website.
2. Charness and Rustichini (2011) present evidence that women are more likely to cooperate when they are observed by other women, while men are less cooperative when observed by other males. In our experiment, participant behavior is not revealed to anyone else.
3. Although these points do not represent a large portion of the semester grade (one point on a midterm exam is worth 0.1% of the course grade), nonetheless the students are very interested in trying to obtain the bonus points.
4. One of the authors administered the survey in the same manner in each class in an effort to eliminate any differences in the way various instructors would explain the game.
5. In this section, there were two defectors. The instructor awarded each of them eight points, but also gave the rest of the students two points for being "good cooperators."
6. Whether or not a student was an economics major and the instructor's gender were not statistically significant in any specification. In Model 1 we also included a quadratic term on income. This was never statistically significant.
7. All of the explanatory variables are dummies, except for median household income. For the dummy variables, we compute the marginal effects as the discrete difference in the computed probabilities at values of zero and one.

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TABLE 1
Participant Information

Class	Number of "Defectors"	Total Participants	% "Defecting"	% of Females "Defecting"	% of Males "Defecting"
Principles of Microeconomics					
Section 1	9	50	18.0	5.3	25.8
Section 2	7	36	19.4	14.3	22.7
Section 3	6	58	10.3	21.1	5.1
Section 4	8	65	12.3	5.4	21.4
Section 5	4	38	10.5	5.3	15.8
Section 6	8	28	28.6	30.0	27.8
Section 7	12	76	15.8	15.4	16.2
Section 8	6	48	12.5	14.3	11.1
Section 9	17	80	21.3	8.6	31.1
Section 10	8	73	11.0	11.1	10.9
Section 11	15	61	24.6	12.5	32.4
Section 12	15	77	19.5	22.5	16.2
Principles of Macroeconomics					
Section 1	7	57	12.3	6.3	14.6
Section 2	5	30	16.7	11.1	19.1
Section 3	9	39	23.1	23.1	23.1
Section 4	8	53	15.1	7.4	23.1
Section 5	2	37	5.4	6.7	4.5
Section 6	4	41	9.8	12.5	8.0
Section 7	12	76	15.8	12.9	17.8
Section 8	8	26	30.8	33.3	28.6
Section 9	7	50	14.0	5.9	18.2
Total	**177**	**1,099**	**16.1**	**12.8**	**18.4**

TABLE 2
Descriptive Statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
Female	1099	0.419	0.494	0	1
MedianInc ($)	1042	72,223	28,214	14,355	178,285
Frosh	1099	0.411	0.492	0	1
Soph	1099	0.380	0.486	0	1
Junior	1099	0.159	0.366	0	1
Senior	1099	0.049	0.216	0	1
EconMajor	1099	0.046	0.210	0	1
Foreign	1099	0.045	0.206	0	1
Microprinc	1099	0.628	0.484	0	1
Summer	1099	0.097	0.297	0	1
Teacherfemale	1099	0.346	0.476	0	1

TABLE 3
Probit Results

	Model 1		Model 2	
Variable	Coefficient (std. error)	Marginal effect	Coefficient (std. error)	Marginal effect
MedianInc ($)	-0.0014	-0.0003		
	(0.0017)			
Female	-0.3012***	-0.0698	-0.2364**	-0.0560
	(0.1003)		(0.0962)	
Soph	0.0576	0.0134	0.0121	0.0029
	(0.1071)		(0.1037)	
Junior	-0.1790	-0.0415	-0.1807	-0.0428
	(0.1491)		(0.1451)	
Senior	-0.6393**	-0.1482	-0.5293*	-0.1253
	(0.3053)		(0.2737)	
Foreign			0.3519*	0.0833
			(0.2049)	
Micro	0.0721	0.0167	0.0646	0.0153
	(0.1322)		(0.1255)	
Summer	0.0424	0.0098	0.0286	0.0068
	(0.2050)		(0.1939)	
Constant	-0.9033***		-0.9996***	
	(0.2028)		(0.1527)	
observations	1,042		1,099	
Log likelihood	-439.81		-471.20	
LR χ^2 (16)	32.93***		27.84**	
Pseudo-R^2	0.0362		0.0287	

*p < 0.1; **p < 0.05; ***p < 0.01

APPENDIX

Students,

This survey is part of a simple economic experiment. There is no obligation to participate, and no cost to you if you decide not to. The potential benefit is real: **extra points added to your second midterm grade.** There is no risk to you, and all information gathered will be kept strictly confidential.

Instructions:

- Do not talk with each other during the experiment.
- Do not look at anyone else's paper nor allow them to look at yours.
- Your answers will never be revealed to anyone else, including other students in this class.

The following is a simple situation. Please read carefully then select either the number 2 or the number 8:

- If everyone writes 2, all students get 2 points added to their second midterm grade.
- If only one or two students write an 8, both of them get 8 points and everyone else gets 0 points.
- If more than two students write an 8, everyone in the class gets 0 points.

Your choice (circle one): 2 points 8 points

Please complete the following information (as noted above, all information will be kept strictly confidential):

Last Name	First Name
Gender (write "M" or "F")	
Major or expected major (please be specific – for example write "accounting" not "business")	
Zip code of town in which you attended your senior year of high school (if you are an international student please list your country of origin and the postal code of your hometown):	

Thanks for your participation!