Theory of Mind Predicts Cooperative Behavior

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Abstract

Explanations for cooperation in Prisoner's Dilemma games (PD) have generated significant interest. While institutional explanations, such as the role of repeated interactions and communication, have offered considerable explanatory ability, a psychological measure of Theory of the Mind (ToM) – Reading the Mind in the Eyes – of an individual's ability to process social and emotional cognition offers new insights. Using this measure, we examine how ToM explains (un)cooperative behavior in a standard PD game. We find that subjects who have higher ToM are less cooperative in PD games and extract higher payoffs.

Keywords: Cooperation, Experiment, Prisoner's Dilemma, Reading Mind in the Eyes, Theory of the Mind

I. Introduction

The sources of cooperative behavior have been the subject of numerous research interest in biology, psychology, sociology, and economics. In standard cooperative environments, such as the famous Prisoner's Dilemma, mutually-beneficial, social welfare-maximizing outcomes contrast with selfish, individually-rational behavior that leads to socially destructive outcomes. Therefore, the facilitation of cooperation is an important issue to understand.

Initial research into the drivers of cooperation focused on institutional features that may facilitate it, such as reputation through repeated play (Axelrod, 1981; Axelrod and Hamilton, 1981), incomplete information (Kreps, Milgrom, Roberts, and Wilson, 1982), communication (Miettinen and Suetens, 2008), and sanctioning (Xiao and Kunreuther, 2013). New efforts have been put forth to explain individual differences in willingness to cooperate. For example, Boone, De Brabander and van Witteloostuijn (1999), Hirsch and Peterson (2009) and Kagel and McGee (2014) use a common assessment of personality traits, as measured in social psychology and used in management education and training, as a covariate of cooperation.

We investigate the psychological concept of Theory of the Mind (ToM) as an explanation of cooperation. Simple ToM assessments have been used in economic experiments with children to appreciate child development (Takagishi *et al*., 2010) and the effects of autism (Sally and Hill, 2006). We explore the "Reading the Mind in the Eyes" (henceforth, *Eyes* score) assessment (Baron-Cohen, 1991; Baron-Cohen *et al*., 2001) where subjects view photos of professional actors emoting by examining a photo that is cropped to display only their eyes, eye brows and a portion of their nose (see Appendix Figure A2). Subjects are then asked to evaluate the emotion being experienced by the actor. Their responses are added together to determine their *Eyes* score, which is on a scale of 0 – 36. Subjects who record a greater number of correctly-assessed scenarios are thought to be those who are more capable of attributing mental states (beliefs, desires, intents, etc.) to oneself and others, while understanding that other people might have mental states that differ from their own (Baron-Cohen, 1991). Such a skill in a person can be expected to enable one to understand that mental states can be the cause of the behavior of others (Premack and Woodruff, 1978).

Given that cooperative behavior requires the subject to engage in strategic behavior, forming expectations about the potential choices and beliefs of the opponent, one would expect that differences in the *Eyes* scores (as a measure of ToM) correlates with a subject's ability to strategically cooperate or defect. In cooperative games, an appreciation for the incentives faced by one's opponent can be expected to lead an individual to respond appropriately.[1]

A standard laboratory experiment common in economics is conducted. Subjects played the game known as the Prisoner's Dilemma. In it, two subjects are randomly and anonymously paired in a one-shot game. Each simultaneously selects one of two actions. One is a cooperative strategy where if both select this strategy, then both receive a high payoff. If both select the other, non-cooperative strategy, both receive a low payment. The dilemma is that if the opponent selects the cooperative strategy an even greater payoff can be earned by deviating to the non-cooperative action. Thus, cooperation is dominated by non-cooperation in wealth-maximizing individuals.

Subjects also engage in the *Eyes* assessment. The relationship between their score on the assessment and their behavior in the laboratory is analyzed. In the laboratory game approximately 60% of the subjects select the cooperative strategy. Thus, a subject randomly paired with another in the lab,

[1] Using an alternative Theory of Mind assessment, Sally and Hill (2006) consider children with and without autism. The sub-group who performed well on the ToM assessment were more likely to exploit cooperation claiming that, "theory-of-mind is necessary to respond in a strategic fashion in the Prisoner's Dilemma" (p.84).

accurately anticipating behavior by recognizing the beliefs and incentives of others, would find the non-cooperative strategy preferable. We present evidence that this is the case. Subjects who score higher on the ToM assessment cooperate less. Consequently, they earn a greater payoff in the game. This result is robust to the inclusion of other risk and ambiguity preferences and measures of competence levels.

Section II describes the methods employed. Section III summarizes the results from the laboratory, while Section IV presents our empirical results. Section V concludes.

II. Methods

We conducted the experiments at Rensselaer Polytechnic Institute (RPI), Union College (Union), and the University of Massachusetts (UMass) during a six-month time frame. In total there were 141 subjects across the three institutions.[2] Subjects were recruited using the Online Recruitment System for Economic Experiments (ORSEE) (Greiner, 2004) and were informed that they would be financially compensated for their participation in a two-part survey.

Upon signing up to participate in the experiment, subjects were given immediate access to complete the first part of the experiment. This entailed completing a survey. The survey collected background information, questions involving decision making under uncertainty assessments, and the *Eyes* assessment. Specifically, the decision making under uncertainty assessments included an assessment of the Allais and Ellsberg paradoxes and a measure of risk aversion (see Tables A1 and A2 in the appendix). The Allais Paradox assesses whether subjects exhibit a bias for certain outcomes (Allais, 1953), whereas the Ellsberg Paradox assesses whether subjects exhibit an aversion for ambiguous decision problems (Ellsberg, 1961).[3] These tests were taken using an online survey format, and subjects were given a 45 minute time limit.

The "Reading the Mind in the Eyes" test was developed by Baron-Cohen (1991) and Baron-Cohen *et al*. (2001) to be an advanced test of the Theory of the Mind. The assessment provides thirty-six photographs of actors and actresses showing the facial region around the eyes. The subject is asked to choose which of four words best describes what the person in the photograph is thinking or feeling. These words refer to both basic mental states (e.g. happy) and complex mental states (e.g. arrogant). The assessment aims to evaluate social and emotional cognition. It has been used to evaluate the effects of schizophrenia (De Achaval *et al*., 2010), autism (Baron-Cohen, 2009), eating disorders (Adenzato *et*

[2] The distribution of subjects across the three locations is 72, 38, and 32 at RPI, Union, and UMass, respectively.
[3] Ambiguity aversion differs from risk aversion in that subjects are not informed of the objective probabilities but rather must first form beliefs about the possibility distribution functions over the state of potential outcomes.

al., 2012), Asperger Syndrome (Senju *et al.*, 2009), bipolar disorder (Derntl *et al*., 2009), and social anxiety (Machado-de-Sousa *et al*., 2010) to name a few. Its stability over time has been established (Fernandez-Abascal *et al*., 2013) and it has been shown to relate to biological factors. For example, ToM is promoted by the administration of Oxytocin (Domes *et al*., 2007) and is inversely correlated with fetal testosterone exposure (Chapman *et al*., 2006), is independent of episodic memory (Rosenbaum *et al.*, 2007) and short-term improvement can be facilitated through literary fiction (Comer Kidd and Castano, 2013).

Approximately 1-2 weeks after completing the survey, the subjects were asked to report to a computer lab to participate in the economics games. The subjects were randomly assigned to a computer cubicle and informed they would be randomly and anonymously paired with another subject in a one-shot game.

A one-shot Prisoner's Dilemma Game was implemented in the laboratory. The Prisoner's Dilemma presents subjects with the opportunity to benefit from mutual cooperation, but also with the potential to obtain an even larger benefit by exploiting cooperative efforts.[4] This is often captured in a choice problem played amongst two subjects that have a choice between action "Up" or action "Down", while their opponent selected either "Left" or "Right".[5]

Along with the instructions, a payoff matrix was shown on the computer screen (Figure A1 in the appendix provides the matrix seen by the subjects). If the outcome <Up, Left> is selected, then both players would receive $4. Thus, Up and Left are the cooperative choices. If <Down, Right> arises, then they both receive $1. Furthermore, as is standard in the Prisoner's Dilemma, if <Up, Right> or <Down, Left> occurs, then the player selecting the cooperative strategy receives $0, while the other earns $5. Thus, the dominant strategy for a subject who is interested in maximizing monetary wealth in the one-shot environment is to select Down. A subject attempting to cooperate on the social welfare maximizing outcome selects Up. The game was played once. We create a variable *Prison* that takes on a value of one if the individual selected the cooperative action (Up), and zero otherwise. Additionally, a variable *Prison Outcome* is created that is equal to the amount earned by the subject in the game, which can take on values of 0, 1, 4, or 5.

After the subjects completed the game, they were then asked how much of $5 they would like to keep. This was done to identify those with nonstandard preferences. The payoff from the game was

[4] See Axelrod and Hamilton (1981) for one of the earliest discussions of behavior in the Prisoner's Dilemma.
[5] Figure A1 in the Appendix A1 provides a visualization of the game that all subjects played. For simplicity, all decision makers made the Up or Down decision so that to determine the outcome Left and Up are treated as equivalent choices, as were Down and Right.

added to the $15 that the subject was paid for completing the survey, then a $5 show-up payment was added to determine each subject's final pay. The average payment earned in the Prisoner's Dilemma game was $2.74.

III. Summary of Results from the Laboratory

Table 1 presents the descriptive statistics of the variables used in the analysis.

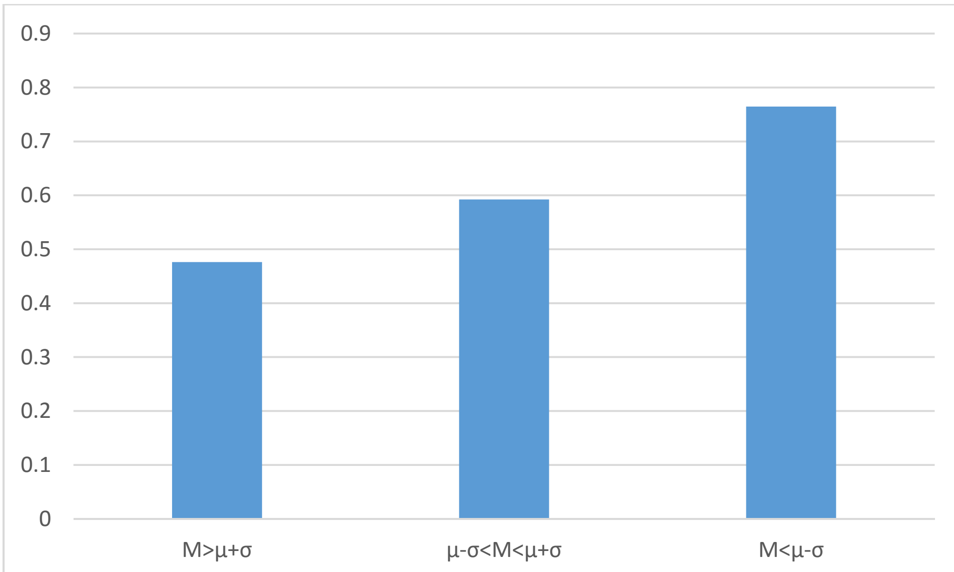
Table 1: Descriptive Statistics – Full Sample

Label	Description	Mean	St. Dev.
Prison	= 1 if the subject selected the cooperative strategy ("Up")	0.596	0.493
Eyes	# of correct choices in the Reading Mind in the Eyes assessment (min = 0; max = 34)	27.12	3.67
Controls (see Tables A2 & A3 for details)			
Vocab	score on vocabulary assessment (max = 10)	7.65	1.43
IQ	score on IQ assessment (max = 5)	2.56	1.59
Ells Consistent	= 1 if *Ellsberg 1 = Ellsberg 2*	0.582	0.497
Allais Consistent	= 1 if *Allais 1 = Allais 2*	0.567	0.495
Safe	# of safe choices made (see Table A1)	5.40	1.61

The cooperative strategy is selected by approximately 60% of the subjects. For each assessment, while a majority exhibit consistent decision making under uncertainty preferences, only 27% exhibited consistency in both. The mean (and median) subject is risk averse, since a risk neutral, expected utility maximizer would select the safer option four times. In the population, though, 77% of the subjects are registered as being risk averse.

Does a subject's ToM correlate with their behavior? Table 1 presents the proportion of subjects who selected the cooperative strategy across various values of *Eyes*. The sample is broken down into those observations where the ToM measurement is greater than one standard deviation above the mean (first column), those within a standard deviation of the mean (second column), and those where the measurement is more than one standard deviation below the mean (third column).

Figure 1: Eyes in the Mind and Cooperation



Subjects with the highest values cooperate the least. Those who score more than one standard deviation above the mean (> 30) cooperate less than 48% of the time. Those who score more than one standard deviation below the mean (< 24) cooperate over 76% of the time (a 60% increase in the rate of cooperation).[6] A further analysis is needed to isolate and identify the statistical significance of this effect.

IV. Results

A binary probit model is estimated with *Prison* as the dependent variable, which is equal to one if and only if the subject chose to cooperate. Background controls for gender, year in school, undergraduate major, and session fixed effects are included. Risk and uncertainty preferences, along with competence,

[6] Consistent with previous research, there is a relationship between gender and ToM (Kirkland *et al*., 2013). The correlation between *Male* and *Eyes* is -0.11 (p-value < 0.2)

are included as control variables to take into account important differences between individuals. Table 2 presents the results.

Table 2: Eyes in the Mind and Prisoner's Dilemma
(Probit, dependent variable = *Prison*)

	Coefficient	Marginal Effect	Standard Error
Eyes	-0.074	[-0.028]	(0.029) ***
Male	-0.497	[-0.186]	(0.208) **
Allais Consistent	0.230	[0.089]	(0.161)
Ellsberg Consistent	-0.194	[-0.074]	(0.239)
ln *Safe*	0.616	[0.236]	(0.162) ***
IQ	0.149	[0.057]	(0.100)
Vocab	0.273	[0.105]	(0.085) ***
McFadden R^2	0.133		
AIC	201.2		
% correct	65.5%		

The specification includes a constant and controls for major, year in school, session fixed effects, and the five dollar request.
*** 1%; ** 5%; * 10% level of significance
Standard errors clustered by session.

The results indicate a strong, negative relationship between a subject's *Eyes* score and cooperation. Using the marginal effect at the mean, a one standard deviation increase in a subject's *Eyes* score decreases the probability of cooperation by 10.6 percentage points (a 17.2% decrease from the mean).

Along with ToM, gender, risk preferences, and competence also independently and statistically significantly correlate with the decision to cooperate. Women, more risk averse, and less competent subjects have higher levels of cooperation. The *Eyes* score is pairwise uncorrelated (at the 5% level) with each of the other explanatory variables, except *Vocab*. The coefficient on *Eyes* retains its sign and statistical significance if *Vocab* is omitted.

The statistical significance of *Eyes* persists if (i) a logit specification is estimated, (ii) unadjusted or QML standard errors are calculated, (iii) the *Eyes* score is log-transformed, or (iv) the control variables are dropped from the specification. Thus, the results are robust to alternative specifications.

In our laboratory sessions, cooperation is selected by 59.7% of the subjects. Therefore, if a subject is randomly paired in the laboratory and anticipated this frequency of play, then the expected monetary payment from cooperating is 4 x 0.597 = $2.39, while the expected payment from not cooperating is (5 x 0.597) + (1 x 0.403) = $3.39. Our results suggest that subjects with higher ToM recognize this distribution of behavior and select the non-cooperative choice to increase their payoff. In our study, the subsample of those whose *Eyes* score was more than one standard deviation above the mean earned, on average, $3.38, while the rest of the sample earned $2.62.

This behavior cannot be explained by the argument that the ToM measurement is simply a measurement of intelligence. While *Eyes* is correlated with *Vocab* ($r = 0.20$; p-value < 0.02) and related with *IQ* ($r = .12$; p-value > 0.16), there is not a strong interaction effect between either of these variables and the *Prison* variable. If interaction terms between *Eyes* and the two competence measurements are included, their coefficients are statistically insignificant.[7]

IV. Conclusion

Theory of Mind postulates that individuals differ in their ability to assess their environment as they interact with others. We hypothesize that this should correlate with strategic decision making. We consider the important issue of cooperation in Prisoner's Dilemma games and find that individuals who are recorded as having higher ToM cooperate less. Presumably, they recognize the incentives faced by their potential opponents and that they will respond accordingly; rather, more accurately assessing the distribution of cooperative subjects and utilizing this information to generate higher payoffs during the experiment.

Our results indicate that this logic is correct. Those with a higher Reading the Mind in the Eyes score are less likely to cooperate and, consequently, given the behavior of the other subjects in the laboratory, earn a greater payoff.

It is important to emphasize that the experimental design did not allow for direct interaction between the subjects. Decisions were made anonymously and confidentially. Furthermore, the experiment was conducted as a one-shot game, so there could be no adaptation, learning, or reputational effects. Thus, the ToM assessment is capturing an independent mental ability of subjects that correlates with cooperative behavior.

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[7] In fact, each pairwise interaction term between *Eyes* and every other control variable is statistically insignificant.

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Appendix

Table A1 provides the risk assessment used in the experimental sessions.

Table A1: Risk Assessment

	Option A		Option B	
1.	$6	if 1	$11.55	if 1
	$4.80	if 2, 3, 4, 5, 6, 7, 8, 9, 10	$0.30	if 2, 3, 4, 5, 6, 7, 8, 9, 10
2.	$6	if 1, 2	$11.55	if 1, 2
	$4.80	if 3, 4, 5, 6, 7, 8, 9, 10	$0.30	if 3, 4, 5, 6, 7, 8, 9, 10
3.	$6	if 1, 2, 3	$11.55	if 1, 2, 3
	$4.80	if 4, 5, 6, 7, 8, 9, 10	$0.30	if 4, 5, 6, 7, 8, 9, 10
4.	$6	if 1, 2, 3, 4	$11.55	if 1, 2, 3, 4
	$4.80	if 5, 6, 7, 8, 9, 10	$0.30	if 5, 6, 7, 8, 9, 10
5.	$6	if 1, 2, 3, 4, 5	$11.55	if 1, 2, 3, 4, 5
	$4.80	if 6, 7, 8, 9, 10	$0.30	if 6, 7, 8, 9, 10
6.	$6	if 1, 2, 3, 4, 5, 6	$11.55	if 1, 2, 3, 4, 5, 6
	$4.80	if 7, 8, 9, 10	$0.30	if 7, 8, 9, 10
7.	$6	if 1, 2, 3, 4, 5, 6, 7	$11.55	if 1, 2, 3, 4, 5, 6, 7
	$4.80	if 8, 9, 10	$0.30	if 8, 9, 10
8.	$6	if 1, 2, 3, 4, 5, 6, 7, 8	$11.55	if 1, 2, 3, 4, 5, 6, 7, 8
	$4.80	if 9, 10	$0.30	if 9, 10
9.	$6	if 1, 2, 3, 4, 5, 6, 7, 8, 9	$11.55	if 1, 2, 3, 4, 5, 6, 7, 8, 9
	$4.80	if 10	$0.30	if 10

The variable *Safe* equals the number of selections, out of the nine, in which option A was selected

Table A2: Ellsberg and Allais Paradox

Suppose that an urn contains 300 balls and three possible colors: red, green, and blue. You know the urn contains exactly 100 red balls, but are given no information on how many green or blue balls are among the remaining 200 balls.

E1: You win if you guess which color will be drawn. Do you prefer to bet on
Red
Green

E2: Now suppose that you win if you guess that either of the two colors will be drawn. Do you prefer to bet that green or blue will be drawn or that red or blue will be drawn?
Green or Blue
Red or Blue

Choose either:
A1: A Chance of winning $4000 with probability 0.2
A2: A chance of winning $3000 with probability 0.25

Choose either:
B1: A chance of winning $4000 with probability 0.8
B2: A chance of winning $3000 with certainty.

In this assessment, the variable *Ellsberg 1* = 1 if Red is selected for E1 and *Ellsberg 2* = 1 if Green or Blue is selected for E2. A subject has *Ellsberg Consistent* = 1 if and only if *Ellsberg 1* = *Ellsberg* 2. In the second assessment, *Allais 1* = 1 if A1 is selected, *Allais 2* = 1 if B1 is selected. A subject has *Allais Consistent* = 1 if and only if *Allais 1* = *Allais* 2.

Figure A1 provides a screenshot of the Prisoner's Dilemma

Figure A1: Prisoner's Dilemma

Your choice \ Their choice	Left	Right
Up	$4 , $4	$0 , $5
Down	$5 , $0	$1 , $1

Figure A2 presents an example from the Mind of the Eye assessment.

Figure A2: Example

***Which emotion are the eyes showing?**

- Playful
- Comforting
- Irritated
- Bored