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Average player traits as predictors of cooperation in a repeated prisoner's dilemma☆

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ABSTRACT

Many studies have looked at how individual player traits influence individual choice in the repeated prisoner's dilemma, but few studies have looked at how the average traits of pairs of players influence the average choices of pairs. We consider cognitive ability, patience, risk tolerance, and the Big Five personality measures as predictors of individual and average group choices in a 10-round repeated prisoner's dilemma. We find that a pair's average cognitive ability measured by Raven's cognitive ability test predicts average cooperation rates robustly and average earnings more modestly. Openness predicts both greater joint cooperation and the use of reciprocity to sustain cooperation.

1. Introduction

A longstanding question in social science is "What causes cooperation?" Experimental game theory has been central in attempts to answer this question. Many studies have investigated how elements of game design can influence cooperation, as Sally's (1995) literature review demonstrates. Other studies have looked at whether *individual* traits predict greater individual cooperative choices in both the repeated prisoner's dilemma and repeated public goods games (inter alia, Boone, De Brabander, and van Witteloostuijn, 1999; Kurzban and Houser, 2005). But aside from gender differences, very few experiments have investigated whether average traits of *pairs* or *groups* of players predict greater joint cooperation (see Balliet et al. (2011) for a meta-analysis of the gender and cooperation literature). Since groups with different sets of average traits endogenously and exogenously form—across firms, legislatures, families, and nations—the question of whether average group traits have effects on cooperation is of interest. In particular, do group traits predict game outcomes that one would not predict from simply adding up the predicted effect of individual player traits? Until now, this question has been little-explored.

This paper focuses on individual and pair-level traits that predict cooperation in a 10-round prisoner's dilemma. To our knowledge, ours is one of a small number of laboratory experiments to investigate whether the average traits of the pair are important predictors of cooperation (with the exception of the aforementioned gender studies). In the case of the pair's average Raven's IQ score, it appears that average traits help predict joint cooperation. We explore the dynamics of this relationship in some detail below.

Why might average player traits matter more than individual player traits? In the case of cognitive ability, since conventional IQ scores are positively correlated with measures of emotional intelligence (inter alia Mackintosh, 1998, p. 242ff), one possible explanation is that a player with higher cognitive ability may be more adept at interpreting signals that her partner is potentially cooperative or potentially dangerous. We find evidence that high cognitive ability pairs achieve higher rates of joint cooperation not by playing cooperate more, but by more successfully synchronizing their plays of cooperate, reinforcing the idea that high cognitive ability pairs are better able to tacitly communicate to their mutual advantage. Notably, Proto et al. (2014) in a game similar to our own likewise found that higher cognitive ability pairs of players were more likely to reciprocate cooperative behavior throughout the repeated prisoner's dilemma game.

Other theoretical explanations deserve serious consideration as well: Perhaps higher-ability players are more likely to go beyond the

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simple backward induction argument that favors full defection and instead intuit something akin to the Kreps et al. (1982) insight that if both players pretend to be conditional cooperators then they can sustain cooperation until almost the end of the game. Again, this is a strategy that is more likely to work when both players come to the same conclusion. And at the most elementary level, some elements of Axelrod's (1984) advice for generating cooperation in a repeated prisoner's dilemma—that players be perceptive, that they understand the rules of the game, and that they recall the history of play—are more likely to be implicitly followed among players with higher cognitive ability.

The previous literature focuses overwhelmingly on how individual traits predict individual behavior; this focus is especially surprising in the case of the prisoner's dilemma, since the failure to achieve the Pareto-efficient outcome in this game is so often treated as a *social* dilemma. One might have thought that social scientists would expend greater effort to look at how group traits predicted group inefficiency, but such inquiries are rare. Aside from the aforementioned papers on the effects of group gender differences, some papers investigate how group traits such as religious affiliation influence *individual* cooperation (e.g., Koopmans and Rebers, 2009), but these do not explicitly investigate aggregate cooperation. The discussion immediately below focuses on cognitive ability, patience, and risk aversion, since they are the primary traits of interest in our experiment. In the results section we include a discussion of personality traits as predictors of individual cooperation.

Three repeated prisoner's dilemma experiments and one meta-analysis have investigated the relationship between average cognitive skills and average cooperation. The earliest of which we are aware is Terhune (1974) who, in a 150 round prisoner's dilemma, reported a statistically insignificant correlation of 0.1 between the average Wonderlic score of a pair of players and their average joint play of *coop–coop*. Segal and Hershberger (1999), in a study of twins knowingly playing a 100 round repeated prisoner's dilemma against their own twin, found a significant positive relationship (0.31, $p < 0.01$) between average twin IQ and average joint play of *coop–coop*. Segal and Hershberger also found a negative relationship (−0.27, $p < 0.01$) between average twin IQ and plays of *defect–defect*. Jones (2008, 2013), in a meta-analysis of repeated prisoner's dilemma experiments run at schools with differing average SAT and ACT scores, reported that average cooperation rates are higher at universities with higher average test scores. And recently, Proto, Rustichini, and Sofianos (2014) found that, as the title of their paper states, "Higher Intelligence Groups Have Higher Cooperation Rates in the Repeated Prisoner's Dilemma." That paper's experiment uses fixed continuation probabilities (leading to games of unpredictable length) rather than the fixed number of rounds we use in the 10-round experiment discussed below.

Turning to individual traits as predictors of individual cooperative choices, Putterman, Tyran, Kamei (2011) find that in the first period and in the first four periods of a repeated public goods game, higher IQ test subjects at Brown University contributed more to a 24 period game. This suggests that players with high cognitive abilities may implicitly follow the advice Axelrod (1984) offers to advocates of cooperation: cooperate early in the game.

Burks et al. (2009) likewise found that truck driving trainees who performed better on the Raven's IQ test were more likely to trust in the first stage of a sequential, one-round social dilemma, which they denote a prisoner's dilemma. In addition, they found that in the second stage, higher-IQ students were more likely to engage in both positive and negative reciprocity: they tended to return more when given more and return less when given less. The authors also controlled for risk tolerance, and found that more risk tolerant players sent more in the first round.

In a similar study of individuals ranging in ages from 9 to 25, van den Bos et al. (2010) found no statistically significant relationship between individual Ravens score and first-stage trust, and a marginally significant positive relationship between individual Ravens scores and second-stage reciprocity ($r = 0.17$, $p = 0.08$). Ben-Ner and Halldorsson (2010), in a similar experiment with students at the University of Minnesota that simultaneously included many personality and demographic controls, found insignificant relationships both between IQ and self-reported trust and separately between IQ and reciprocity.

Jones (2014) finds limited evidence that in a sophisticated 3×3 repeated prisoner's dilemma, an individual with a standardized test score in approximately the top sixth of the subject pool is more likely to cooperate and an individual with a score in approximately the bottom sixth of the subject pool is less likely to cooperate. However, the median specification suggests no relationship between individual ACT scores and individual rates of cooperation. Likewise, Hirsch and Peterson (2009) found no statistically significant relationship between individual cognitive ability as measured by the Wonderlic and individual cooperativeness in a 10-round prisoner's dilemma.

Turning to games involving cognitive load manipulations—artificially reducing the cognitive capacity of subjects by asking them to memorize unrelated facts—Milinski and Wedekind (1998) ran two-player iterated prisoner's dilemmas with one confederate, and imposed higher cognitive loads in some treatments by requiring players to stop and play a memory game. When the memory game was included between rounds, players were less likely to play the relatively sophisticated "win-stay, lose shift" strategy rather than the less sophisticated "generous tit-for-tat" strategy. The latter is less sophisticated because it conditions only on the opponent's recent play, while "win-stay, lose shift" relies on memory of both the opponent's play and one's own action. The authors find that players who used the more sophisticated strategy cooperated more and earned more.

Duffy and Smith (2014), in a four-player repeated prisoner's dilemma, impose higher cognitive loads on some groups of players by giving those players a seven digit number to memorize (the high load condition) while giving others a two digit number to memorize (low load). The authors find limited evidence that in the low load condition, players tend to cooperate more in early rounds ($p < 0.1$), and then collapse faster toward joint defection in the last five rounds. In line with Milinski and Wedekind, Duffy and Smith report that "low load subjects are better able to condition their strategy on previous outcomes" (p. 4).

Harris and Madden (2002) found that greater impatience predicts more defection in a 40-round prisoner's dilemma "played against a computer opponent using a tit-for-tat strategy" (p. 429); these subjects had a monetary incentive for better performance. In these experiments players knew they faced a computer. And turning to risk aversion, Glöckner and Hilbig (2012) report that in repeated prisoner's dilemma experiments higher individual risk aversion predicted *higher* levels of individual cooperative play, while Sabater-Grande and Georgantzis (2002) report the opposite.

Thus, a variety of recent experiments have investigated the individual-level relationship between cognitive ability, patience, risk aversion, and behavior in social dilemma experiments. The most consistent finding has been that repeated prisoner's dilemma studies tend to find that average player cognitive ability predicts average cooperation. Other findings are more inconsistent. Some limitations of past experiments are that almost none have explicitly investigated which average group traits predict greater joint cooperation or higher payoffs, and none have tested for cognitive ability, patience, and risk tolerance simultaneously. Since cognitive skill, patience, and risk tolerance are positively correlated in most samples, it would be valuable to investigate which has the most robust relationship with pro-social behavior in the prisoner's dilemma. This should help future researchers searching for the microfoundations of pro-social behavior.

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