Facing the Grim Truth: Repeated Prisoner's Dilemma Against Robot Opponents[*]

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Abstract

We report on an experiment where subjects play an indefinitely repeated prisoner's dilemma game (1) against robot opponents known to play the Grim trigger strategy, and (2) the game's continuation probability is varied affecting whether cooperation can be rationalized. These two innovations allow us to classify the play in each supergame in one of 6 mutually exclusive categories, allowing us to identify whether subjects play theoretically optimally, whether they are biased towards/against cooperation, whether they make strategic mistakes, or whether they do something else. Some subjects defect after cooperating, perhaps anticipating the end of a supergame (in an attempt to "snipe"), and others cooperate after defecting (thus making strategic errors), which is harder to rationalize. Consistent with a simple model of inattention, we find two gradients in strategic play, with cognitive differences predicting optimality vs errors gradient, and non-cognitive differences predicting persistent bias towards cooperation. These results suggest that cognition is important for the successful implementation of strategies.

Keywords: Cognition, Cooperation, Rational Inattention, Prisoner's Dilemma, Repeated Games, Experimental Economics.

JEL Codes: C72, C73, C92.

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1 Introduction

Cooperation in repeated interactions is an important aspect of social behavior. It has also been the subject of much recent experimental research, surveyed in Dal Bó and Fréchette (2018). Yet it is still unclear what exactly determines behavior in prisoner's dilemma settings. One common observation is that subjects sometimes cooperate even in a one-shot prisoner's dilemma. Equally, subjects sometimes cooperate too little when a dilemma is indefinitely repeated. For example, when the continuation probability is sufficiently high that strategies supporting cooperation such as the Grim trigger strategy could be both an equilibrium, a significant proportion of subjects choose always to defect, thereby leaving money on the table. However, it is difficult to interpret either behavior as mistaken, given many possible confounds, including diverse beliefs about the strategies employed by others, heterogeneous risk attitudes, social preferences and cognitive limitations.

This study attempts to simplify the analysis by conducting a novel experiment that excludes several confounding factors by design. Subjects play a series of indefinitely repeated prisoner's dilemma (IRPD) games with different continuation probabilities against a robot opponent known to play the Grim trigger strategy. This design reduces or eliminates multiple equilibria, strategic uncertainty and social preferences as factors influencing cooperation, and focuses attention on the cognitive task of trading off present gain against future reward. The optimal policy is simple in theory: a subject should cooperate in each round if and only if the continuation probability, δ, is above a critical level, here 0.5. Further, much existing experimental analysis of repeated games focuses on first round behavior because behavior in higher rounds is not independent of previous rounds. Here we do not have this issue and thus can readily analyse whether subjects implement the optimal policy over the whole supergame.

We find that first round cooperation is strongly increasing in the continuation probability, ranging from 9.5% when $\delta = 0.1$ to 76% when $\delta = 0.7$. This responsiveness to δ is much greater than that estimated based on Dal Bó and Fréchette (2018) in standard subject versus subject experiments, which suggests that our design is successful in reducing strategic uncertainty. However, on average, subjects cooperate too much in the first round (48% of decisions rather than 33%), and too little overall (50% rather than 56%).

As noted our methodology allows us to look in detail beyond the first round. We find that there are substantial deviations from the optimal strategy. First, 52% of subjects cooperate at least once after already having defected in a supergame, behavior that is difficult to rationalize. Further, 24% of subjects make this type of mistake repeatedly, in at least 3 out of 17 relevant supergames. Second, subjects commonly defect after having started out the play of a supergame by cooperating. Specifically, we find cooperation significantly decreasing with the round number when theory suggests it should be constant. Although the supergames have an unknown, random end, subjects may be "sniping": defecting in the round they guess will be the last round of the supergame.[1] We are able to identify these

[1] As is standard in indefinitely repeated games, we employ a constant termination probability of $1 - \delta$,

behaviors only because of our novel, single-person design but our findings offer an alternative interpretation of results from other repeated game experiments.[2]

We further find that test scores from a cognitive reflection test predict earnings and are negatively associated with the error of cooperating after having defected, supporting the idea that cognitive failures are a cause of deviations from optimal behavior. However, we also find that individuals with higher cognitive test scores are more likely to snipe. More generally, our results suggest that cognitive factors are important in explaining the excess cooperation observed when δ is low and the insufficient cooperation observed when δ is high.

Further, behind the aggregate results, there is considerable heterogeneity - some subjects never cooperate while others always do. To try to explain this diversity, this experiment also proposes and tests a novel use of the theory of inattention. Inattention theory suggests that individuals with high information costs should obtain less precise information about a decision problem, and therefore be more influenced by their initial prior. We elicit a prior by asking subjects the frequency they will play cooperate in the first round of the supergames, before they play. However, we find that a self-reported measure of patience, which we also collect, fits the theory better in that it predicts cooperation rates of subjects with lower cognitive reflection test scores. That is, it is as though subjects with lower cognitive test scores are influenced by their intrinsic level of patience, even though only the actual δ should matter. In contrast, subjects with higher test scores respond more strongly to the continuation probability δ and are not influenced by their own patience level.

Two prior studies, Roth and Murnighan (1978) and Murnighan and Roth (1983), used a similar idea of having groups of subjects play against a fixed strategy, as well as being the first to run experiments on supergames with an uncertain end. A fundamental difference between those two studies and the present study is that subjects in those earlier studies were *not informed* of the strategy they faced or that their opponent was in fact the experimenter. Thus, subjects in those prior studies, who participated in sessions along with other subjects, faced some strategic uncertainty.[3] By contrast, in this experiment we instruct subjects that they are playing against programmed opponents who *play the Grim trigger strategy.* Second, these two prior studies did not allow subjects to play multiple supergames with the same continuation probability. Dal Bó and Fréchette (2018) argue that such repetition is an

where δ is known to subjects. Subjects may nonetheless believe that the termination probability rises over time. Alternatively, Mengel et al. (2021) find that subjects respond to past *realized* supergame lengths.

[2]Romero and Rosokha (2018) and Cooper and Kagel (2021) also report decreasing cooperation rates in indefinitely repeated prisoner's dilemma experiments. However, there such decreased cooperation may be caused by beliefs that cooperation by opponents may be about to end.

[3]In Roth and Murnighan (1978), p. 194 subjects "were told that they played a programmed opponent, but were not told what strategy he would be using." The programmed opponent was in fact an experimenter playing the Tit for Tat (or "matching") strategy. In Murnighan and Roth (1983) p. 289, subjects "were told that they would be playing a different individual in each of the three sessions but that the person's identity would not be revealed. Actually all of the subjects played against the experimenter who implemented either matching [Tit for Tat] or [the] unforgiving strategy [Grim trigger]." Roth and Murnighan (1978) p. 194 explain that such design choices were made to "control for differences in subjects' behavior due to differences in their opponents."

important feature, in that more recent experiments have found significant learning effects with experience. Learning may be less important in our setting where there is no strategic uncertainty, but nonetheless we think it is important to give subjects an opportunity to learn by doing. In the most similar paper, Duffy and Xie (2016) consider play against robot players known to play the Grim trigger strategy but in an n-player Prisoner's Dilemma game under random matching, where they vary n and the stage game payoffs but *not* δ.

Of course, there are many experiments on the repeated prisoner's dilemma, where subjects play other subjects. For example, Proto et al. (2019) (see also Proto et al. (2021)) also find that individual differences between subjects affect play, with higher cognitive ability players being more cooperative, making fewer mistakes and earning higher payoffs. The main difference is that, in a two human subject pairing there is not a unique optimum policy as there is here, and so errors have to be inferred. For example, Proto et al. (2019) assume that playing defect directly after both players chose to cooperate is an error in implementation. However, here it seems that such behavior may represent an attempt to guess the final round. Further, as noted, with our design we can also identify excessive cooperation.

Our methodology is similar to that of Charness and Levin (2009) who show experimentally that the winner's curse phenomenon is still a factor in a single person bidding problem. That is, in both cases there are individual cognitive failures that are responsible for misbehavior in larger groups. Here, the individual failure is the inability to play a constant strategy in a stationary environment, which leads to suboptimal behavior even in the absence of strategic uncertainty. The difference here (besides the different game investigated) is our use of a within-subject design where subjects face situations both where cooperation is optimal and where it is not. In that sense, we are adapting the methodology of Duffy et al. (2021) and Charness et al. (2021), which also have an experimental design where subjects face opposed environments, to study repeated interactions.

2 Theory and Hypotheses

In our experiment, subjects play the indefinitely repeated prisoner's dilemma with continuation probability δ against a computer playing a fixed strategy. The specific payoffs subjects faced in the stage game are given in (1),

$$\begin{array}{ccc} & \text{X} & \text{Y} \\ \text{X} & \mathbf{75},\ \mathit{75} & \mathbf{15},\mathit{120} \\ \text{Y} & \mathbf{120},\ \mathit{15} & \mathbf{30},\ \mathit{30} \end{array} \tag{1}$$

where X (Y) denote the cooperate (defect) actions. The main theoretical prediction tested in our experiment comes from the Folk Theorem for repeated games which (Mailath and Samuelson, 2006, p. 69) states that if players are sufficiently patient, then any pure-action profile whose payoff strictly dominates the pure-action minimax is a subgame perfect equilibrium of the repeated game in which this action profile is played in every period. This result carries over to the situation of indefinitely repeated games by replacing "players are sufficiently patient" with "the continuation probability is sufficiently high". However, here for one player, the computer, the strategy is fixed to be the Grim strategy. This converts the problem from a game with multiple equilibria to a single person decision problem with a unique optimum policy. This is to cooperate (defect) in every round of a supergame if the continuation probability exceeds (is below) a critical level δ^*, which for our parameterization (1) is 0.5.

To see this, note first that since the computer is programmed to play the Grim trigger strategy, it first cooperates and continues to cooperate so long as all previous play by its opponent has been cooperate, but after any defection, it switches to defect for all subsequent periods. Thus, any player should understand, given that the continuation probability is fixed at δ, that the return to playing cooperate (X) forever is

$$75 + 75\delta + 75\delta^2 + ... = \frac{75}{1-\delta}. \tag{2}$$

In contrast, the expected return to defecting in period one is,

$$120 + 30\delta + 30\delta^2 + ... = 120 + \frac{30\delta}{1-\delta}. \tag{3}$$

Simple calculations reveal that (2) is greater than (3) if $\delta > 0.5$. Thus, the critical continuation probability is $\delta^* = 0.5$.

Note that, because the continuation probability is constant over time, the problem is stationary and so, if it is optimal to cooperate in period one, it is also optimal to cooperate at all future periods. Thus, it cannot be optimal to switch within a supergame from cooperate to defect Further, given the fixed Grim strategy of the computer, if a player ever defects, it is always optimal to continue defecting and not to switch back to cooperating. This brings us to a simple hypothesis.

Hypothesis 1. *Rational Play: subjects should play Cooperate, X (Defect, Y) in every round of every supergame when $\delta >$ ($<$) $\delta^* = 0.5$.*

Three important factors present in the standard two player repeated prisoner's dilemma are removed in our experimental design. First, our design reduces the problem of *multiple equilibria*. When the continuation probability is sufficiently high for cooperation to be supported, there are typically an infinite number of equilibria which presents subjects with difficult coordination problems. Given that the opponent in our design is playing the Grim strategy, the set of equilibria is reduced to just two, always cooperate or always defect. Second, our design minimizes *strategic uncertainty*. This type of uncertainty is always present in the standard design because subjects do not know which strategy their opponent is following. Indeed, a simplification used by Dal Bó and Fréchette (2018) is to suppose that strategy choices are limited to Grim trigger and the strategy of always defecting. They show that there exists $\delta^{RD} > \delta^*$ such that only if $\delta > \delta^{RD}$ is it risk dominant to choose the Grim strategy and hence start out cooperating. Or, in other words, although it is an equilibrium to cooperate as long as $\delta > \delta^*$, strategic uncertainty can make it difficult to cooperate unless $\delta > \delta^{RD}$, a higher hurdle.

Third, researchers have found evidence for *social preferences* being important in many experimental settings, see, e.g., Camerer (2003), Chaudhuri (2008). In the repeated prisoner's dilemma, Bernheim and Stark (1988) and Duffy and Muñoz-García (2012) show how social preferences, in the form of positive concerns for the other player, reduce δ^*. Thus, in conventional experiments, subjects with social preferences could cooperate even when $\delta < \delta^*$. Further, there is a second order effect. Subjects who are entirely self-interested, but who believe that other subjects have social preferences and are thus more likely to cooperate, will themselves be more cooperative than in the absence of such beliefs (see, for example, Andreoni and Samuelson (2006)). That is, strategic uncertainty and social preferences can potentially interact with one another. However, in our design, since the opponent that subjects face always is known to play the Grim strategy there is a unique optimum response and no strategic uncertainty. Further, subjects are unlikely to feel altruism toward their computer opponent, or believe that it has altruistic feelings for them. Thus, multiple equilibria, strategic uncertainty and social preferences as well as any interactions between them are minimized, if not eliminated by our design.

2.1 A Simple Cognitive Model

In this section, we outline a very simple cognitive model that may be used to explain deviations from optimality in single-person decision problems. The optimal strategy is to cooperate if and only if the current δ is above $\delta^* = \frac{1}{2}$. This cognitive model tries to place some structure on deviations from this ideal and how this might vary across subjects according to their cognitive ability. It is based on ideas about attention in Gabaix (2019) and cognitive uncertainty in Enke and Graeber (2019).[4]

The model works in the following way. A decision maker is faced with a single person decision problem. She has a default which is derived from previous experience. But she also attempts to determine by introspection which is the optimum action. This is modelled by assuming that she received a signal, the informativeness of which depends on her cognitive ability which varies across individuals. A further assumption is that she is in effect aware of her cognitive limitations and will place greater weight on her default the higher is her cognitive uncertainty.

We can represent this mathematically, adapting Gabaix (2019)'s simple Gaussian frame-

[4]We show here that this leads to the choice of cooperation being given by a probit choice rule. This then is similar to the rational inattention model of Matějka and McKay (2015) which results in a logit choice rule. The principal difference there is that precision of the signal is endogenous rather than exogenous, being chosen by the agent. However, if individuals vary in the cost of information, they will end up with signals of different precisions even in the endogenous model.

work, by saying that a subject i has an initial default d_i, which we can think of as a default payoff to cooperation in situations outside the laboratory. Now in the lab, faced with a supergame with a particular δ, she must try to update the payoff to match the particular circumstances faced. Let the true relative return to cooperation in a repeated game with continuation probability δ be $\pi(\delta)$ so that $\pi(\cdot)$ is a strictly increasing function with, given our chosen parameters, $\pi(\frac{1}{2}) = 0$. Then assume a subject i, faced with a decision problem where the continuation probability is δ_0, subjectively estimates $\pi(\delta_0)$ as being normally distributed with expectation d_i and variance σ_p^2, i.e. $N(d_i, \sigma_p^2)$. That is, the subject's initial evaluation of the return to cooperation is influenced by her outside default d_i and this default varies across subjects (though we assume for simplicity that σ_p^2 is constant).[5]

However, by further cognitive introspection, she can gain a potentially more accurate estimate of π. We model this by assuming the subject receives a noisy signal s_i which is equal to the true value $\pi(\delta_0)$ plus noise ε_i, where $\varepsilon_i \sim N(0, \sigma_i^2)$,

$$s_i(\delta_0) = \pi(\delta_0) + \varepsilon_i. \tag{4}$$

The noisiness of the signal varies across individuals with σ_i^2 being the variance of the noise ε_i for individual i. The hypothesis is that the higher is the subject's cognitive ability, the lower is the variance and the more precise is the signal.

The subject's posterior of $\pi(\delta_0)$ is thus

$$P_i(\pi(\delta_0)|s_i) = \lambda_i s_i(\delta) + (1 - \lambda_i)d_i \tag{5}$$

where

$$\lambda_i = \frac{\sigma_p^2}{\sigma_p^2 + \sigma_i^2}.$$

Note that, as the cognitive noise σ_i^2 goes to zero, the weighting λ goes to one and the posterior P_i is closely clustered around the true value of the payoff π. However, for a subject with a high σ_i^2, the posterior is in fact very close to the individual's default d_i.

Remember that given our definition of π as the relative payoff to cooperation, the individual estimates that cooperation is preferable to defection if $P_i > 0$. Thus, when the subject faces a decision problem with an arbitrary continuation probability δ, the subject's probability of cooperation is the probability that the posterior P_i is positive which is,

$$C_i(\delta) = \Pr(\lambda_i s_i + (1 - \lambda_i)d_i > 0) = \Phi\left(\pi(\delta) + \frac{\sigma_i^2 d_i}{\sigma_p^2}\right) \tag{6}$$

where Φ is the normal CDF of ε_i, that is with variance σ_i^2. So, the individual's actions are given by a probit in which the probability of cooperation is influenced both by the true payoff and the individual specific default.

[5] In Gabaix (2019)'s original specification, there is an unknown state of the world which the agent seeks to match with her action. Modelling it as an unknown payoff is convenient as it directly implies a probit choice rule as we show below.

Further, one can see that those individuals with higher cognitive ability and so with lower cognitive noise σ_i^2 will place less weight on the default d_i and more weight on the true payoff p. Because $p(\delta)$ is increasing in δ, one can draw a similar conclusion: those with higher cognitive ability should be more sensitive to δ in their choice of cooperation.[6]

Hypothesis 2. *Cognitive Ability and Cooperation:*

1. *for high cognitive ability subjects the probability of cooperation will be less influenced by their default value of cooperation than for low ability subjects;*
2. *the probability of cooperation for high cognitive ability subjects will be more influenced by the true payoff to cooperation or the current continuation probability δ that they face than for low ability subjects.*

A related, natural hypothesis is that higher ability individuals earn higher payoffs. This is implied by the model in that the probability of cooperation C will be closer to its optimal value, the larger the relative weight on the true payoffs (holding the default d_i constant). As we have seen, this is the case when σ_i^2 is lower, which is associated with higher cognitive ability.

Hypothesis 3. *Cognitive Ability and Payoffs: subjects with higher cognitive ability will earn higher average payoffs than those with lower cognitive ability.*

3 Experimental Design

The main experimental task consisted of the play of 24 indefinitely repeated prisoner's dilemma games or "supergames" against a computer program known by subjects to play the Grim trigger strategy. The payoff matrix for the prisoner's dilemma stage game was held constant across all treatment conditions and is shown in (1). Subjects were instructed that the rows referred to their action and the columns referred to the computer opponent's actions and that the first number in each cell (in bold) was their payoff in points and the second number in each cell (in italics) was the computerized opponent's payoff in points.[7]

The 24 indefinitely repeated games were chosen with the following considerations. First, we wanted subjects to have some experience with the same continuation probability, and we also wanted to vary the continuation probability so as to assess the subject's attentiveness to the nature of the supergame they were playing. We chose to have them face 6 different continuation probabilities 4 times each, which yields the 24 supergame total.

The set of 6 continuation probabilities $\delta \in \{0.1, 0.25, 0.33, 0.4, 0.67, 0.7\}$ were selected using several criteria. First, with this set, the expected theoretical payoff is the same for

[6] Note that, specifically, $\partial C/\partial \delta$ is proportional to $\Phi'(\cdot)$ which is decreasing in σ_i, around the critical point $\pi(\delta) = 0$, by the properties of the normal distribution.

[7] We provided the computer program's payoff so that the game setup would be comparable to two player, human-to-human games, where both players' payoffs are common knowledge.

subjects who are biased towards always cooperating and for those biased towards always defecting. Second, the expected payoff from always following the theoretically optimal strategy relative to either of the fully biased strategies is substantial and results in a clear difference. Finally, since the threshold probability for sustaining cooperation in the stage game (1), $\delta^* = 0.5$, we did not want the simple heuristic of cooperating in 50% of the supergames to correspond to the optimal policy. Instead, optimal play would involve cooperating in round 1 of just 8 of the 24 supergames (those with $\delta = 0.67$ or 0.7) and always defecting in the other 16 supergames.

We ran the current experiment with Grim the only programmed strategy. Tit-for-Tat seems a reasonable alternative to Grim, but has the following difficulties. First, as it gives a weaker punishment than Grim, cooperation is only a best response for high continuation probabilities ($\delta^* = 0.75$ for current parameters). We would therefore have to run supergames with high expected length. Second, more importantly, it provides a much weaker restriction on optimal strategies. In particular, cooperation after having defected is not necessarily an error against Tit-for-Tat, while it is against Grim. Thus, the identification of optimal play would be significantly more difficult.

The experiment was computerized and conducted entirely online. It was programmed using oTree (Chen et al. (2016)). Example screenshots are provided in Appendix E. Subjects were always informed of the probability that the supergame (sequence) would continue with another round. They were also reminded of the strategy (X or Y) that their computer opponent would play in each round (following the Grim trigger strategy and based on the history of play in all prior rounds of the current supergame) on the *same* decision screen where they made their own action choice (X or Y) for that same round. Thus, any strategic uncertainty should have been eliminated.

Subjects were 100 undergraduate students, 52% female, recruited using Sona system from the Experimental Social Science subject pool at the University of California, Irvine. The mean age was 21.5 years with a range of 18-34. All subjects were university students from a diverse set of majors, with 36 subjects reported majoring in engineering, 25 in social sciences, 21 in life sciences, 9 in physical sciences, 7 in education, 5 in arts and humanities, and 3 in business studies (double majors double counted).

Subjects were first asked to provide demographic information. Next, they answered 7 personality questions on an 11-point Likert scale (taken from Falk et al. (2018)), followed by 7 cognitive reflection test (CRT) questions (based on Toplak et al. (2014) and Ackerman (2014)) (see Appendix D for these questions). They were then presented with written instructions regarding the 24 IRPD games (referred to neutrally as "sequences") they would play and they had to successfully complete a comprehension quiz that tested their understanding of payoff outcomes, their understanding of the Grim trigger strategy that the computer program would follow in various scenarios and their understanding of how the continuation probability affected the duration of the game. The next step involved elicitation of their belief as to proportion of times they would choose the cooperative action (referred to neutrally as action "X") in each of the *first* rounds of the 24 sequences (supergames) that they would face, given knowledge that they would face 4 supergames for each of the 6 different δ values. After this belief was elicited, they played the 24 supergames against the computer opponent

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For half of the subjects (50/100) or in 4 out of 8 sessions, the randomly chosen realizations for the 24 supergames (4 supergames for each continuation probability δ) and the corresponding number of rounds (in parentheses) were as follows: 0.67 (4), 0.33 (1), 0.4 (2), 0.25 (1), 0.7 (3), 0.33 (2), 0.7 (5), 0.4 (1), 0.67 (2), 0.1 (1), 0.25 (1), 0.1 (1), 0.25 (2), 0.1 (1), 0.4 (1), 0.67 (4), 0.33 (2), 0.25 (1), 0.7 (2), 0.4 (3), 0.67 (2), 0.1 (1), 0.7 (4), 0.33 (1), resulting in 48 decisions (see Figure 1 (left panel) and Table A2 in Appendix A).[8] For the other 50 subjects (or the remaining 4 out of 8 sessions), the order of these supergames was reversed.[9]

In addition to subjects' choices in the 24 IRPD games, we collected demographic and other data. Subjects were asked to answer 7 cognitive reflection test (CRT) questions based on Frederick (2005), Toplak et al. (2014) and Ackerman (2014) (see Appendix E for the list of questions). We use subjects' scores on this set of 7 CRT questions as a proxy measure for their cognitive abilities.

Subjects were instructed that at the end of the session, six supergames would be chosen from all 24 played, one from each of the six different values for δ. They were further instructed that their total point earnings from those six supergames would be multiplied by \$0.01 and this amount would comprise their monetary earnings from the repeated PD game.[10] Subjects were guaranteed \$7 for showing up and completing the study. Subjects' total earnings averaged \$17.90 for a 1 hour experiment.

4 Results

As the design involved 24 supergames, each subject faced 24 first round choices. Given the randomization, 7 supergames ended after a single round, and each subject made a further 24 choices in 17 supergames lasting 2-5 rounds (see Table A2). Given the parameters of our design, the theoretically optimal strategy involves choosing to cooperate in all rounds of the

[8]These supergame lengths were drawn using a random number generator. Subjects were instructed of this procedure. To reduce noise across subjects, we used the same supergame lengths across all subjects.

[9]See Appendix B for a discussion of order effects.

[10]Following the 24 repeated PD games, subjects were randomly paired to participate in a two-player task where they could earn an additional 15-100 points that were also convertible into dollars at \$0.01 per point which we do not report on in this paper.

8 supergames where $\delta = \{0.67, 0.7\}$, and to defect in all rounds of the other 16 supergames. Thus, perfect theoretically optimal behavior involves exactly 8 counts of cooperation across all first rounds of 24 supergames, and exactly 18 counts of cooperation in the subsequent 24 decisions, amounting to exactly 26 counts of cooperation overall, out of 48 choices (see Figure 1, also Table A2). That is, by design, the theoretically optimal choices should be skewed towards defection initially, since most δs are less than 0.5 and then skewed towards cooperation later on, as it is in the longer games where cooperation is the optimal policy. Over all rounds, the theoretically optimal strategy involves always defecting in 16 supergames with $\delta < 0.5$ and always cooperating in the remaining 8 supergames with $\delta > 0.5$ (the same prediction as for first round play).

4.1 Response to the Continuation Probability δ

We find that cooperation is strongly increasing in the continuation probability (see Figure 1 (top row), also Figure C2), further confirmed by mixed-effects probit regressions in Table 4., specifications (1)-(2)).

We also find that the first round cooperation rates are as low as 9.5% when $\delta = 0.1$ and as high as 76.25% when $\delta = 0.7$. This responsiveness is much greater than is observed in standard subject versus subject experiments.[11]

Finding 1. *For every round of a supergame, the rate of cooperation (defection) tends to increase (decrease) with the continuation probability δ.*

4.2 Choices to Cooperate vs. Theoretically Optimal Choices

As Figure 1 (top row) shows, subjects tend to excessively cooperate in the first round of each supergame, choosing to start almost half of the 24 supergames by cooperating. (see also Figure C1). The mean (st.dev.) count of cooperative choices is 11.53 (5.73) which significantly exceeds the theoretical prediction of 8 (p-value=0.000). As a result, the mean (st.dev.) count of theoretically optimal choices per subject is 16.81 (3.74), which is significantly short of the theoretical prediction of 24 (p-value=0.000) (see also Figure C1). Figure 2 (left) depicts two-dimensional distribution of per-subject counts of cooperation and of optimal choices in the first rounds across all 24 supergames.

Finding 2. *In the first rounds, subjects cooperate excessively by 44.1% on average compared to the theoretical optimum.*

[11] Using the probit estimates in (Dal Bó and Fréchette, 2018, p. 66, Table 4), we calculate that in subject to subject experiments that used our continuation probabilities, cooperation would be predicted to vary only from 45.5% (when $\delta = 0.1$) to 56% (when $\delta = 0.7$) among inexperienced subjects. Even after 25 supergames, cooperation in such experiments is predicted only to vary from 16.1% ($\delta = 0.1$) to 62.7% ($\delta = 0.7$).

Figure 1: Patterns of cooperation and defection using all data: 100 subjects, 2,400 supergames). Top row: Average per-subject counts of cooperation versus defection (left) and optimality versus suboptimality (right), split by δ, the first row of the horizontal axis scale and by round number, the second row of the horizontal axis scale. In the upper left panel cooperation counts, a distinction is made between undominated cooperation and dominated *cooperation after defection* (CaD). In the upper right panel suboptimal counts are divided between the error of CaD and other suboptimal choices. As the top row shows, later rounds were never reached for some δ values (see also Table A2 in Appendix A). Bottom row (left): Average per-subject counts of first defection *within* a supergame by δ and round number. Bottom row (right): The population shares of the behavioral patterns in a supergame, by δ value. By construction, the four strategies are mutually exclusive.

Across all 48 choices in all 24 supergames, the overall optimal choice counts are significantly short of the theoretical prediction of 48, with a mean (st.dev.) of 31.05 (8.06) (see Figures 1, top right, and C1). The mean (st.dev.) of the overall count of cooperative choices is only 24.09 (11.24), which is marginally lower than the theoretical prediction of 26 (one-sided $t = 1.670$, p-value=0.046) (see Figure 1, top left, and Figure C1). Figure 2 (right) depicts two-dimensional distribution of per-subject counts of cooperation and of optimal choices in all rounds across all 24 supergames.

While subjects start by cooperating excessively in the first rounds, the mean (st.dev.) of cooperation counts in the subsequent rounds (given by the difference in the overall and first round cooperation counts) is only 12.56 (6.29), which is significantly lower than the theoretical prediction of 18 (p-value=0.000). Note that this is despite the excessive cooperation of

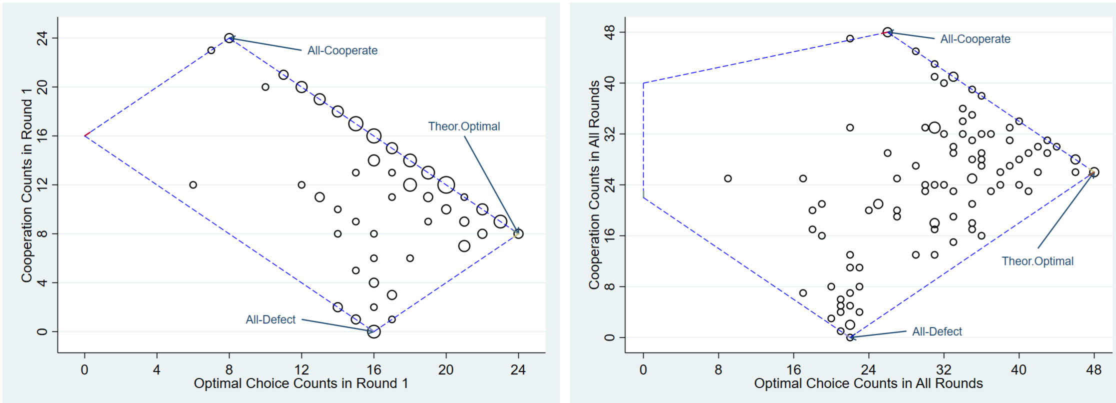

Figure 2: Two-dimensional distributions of per-subject counts of cooperation and of optimal choices across all 24 supergames, for the first rounds (left) and for all rounds (right). Bubble size proportional to the share of subjects, 100 subjects total. (See also Figure C1.)

1.82 counts per subject on average due to strategic errors described in the next Section 4.3.

Finding 3. *Compared with theoretical predictions, on average, subjects cooperate too much at the beginning of supergames with $\delta < 0.5$ and stop cooperating too early in supergames with $\delta > 0.5$, wuth only 64.69% of all choices being theoretically optimal.*

4.3 Strategic Error of Cooperating after Defection (CaD)

Since the robot opponent was programmed to play the Grim trigger strategy, a defection any time in a given supergame would trigger subsequent defection by the automated opponent in all remaining rounds. Thus, choosing to cooperate after defecting earlier within the *same* supergame (CaD) is *dominated* for any δ, and is a *strategic error*. In Figure 1, such suboptimal cooperation is split from un-dominated/non-erroneous cooperation (top left) and from other theoretically suboptimal choices (top right), and it amounts to 182 counts, or 7.58% of relevant observations (see also Figure C2 in Appendix C).

As Figure C3 (left) shows, only a bit less than half the subjects (48%) never made strategic errors (CaD), and 20% of subjects made at least 4 dominated choices. Some such choices could be intentional, e.g., a desire to verify the computer opponent's behavior.[12] Others could be due to a genuine "trembling hand" error of accidentally pressing the "defect" button without noticing it, In either case, an attentive payoff-maximizing subject would likely refrain from repeatedly making dominated choices in multiple supergames. Figure C3 (right) compares the total count of strategic errors (CaD) per subject (vertical axis) versus the count of supergames where such errors were made (horizontal axis). While most strategic errors were made only once in a supergame (as revealed by the bubbles located on

[12]Recall, however, that the computer program's action choice of X or Y, based on the history of play and following the grim trigger strategy, was shown to subjects in advance on their decision screen prior to their making a decision.

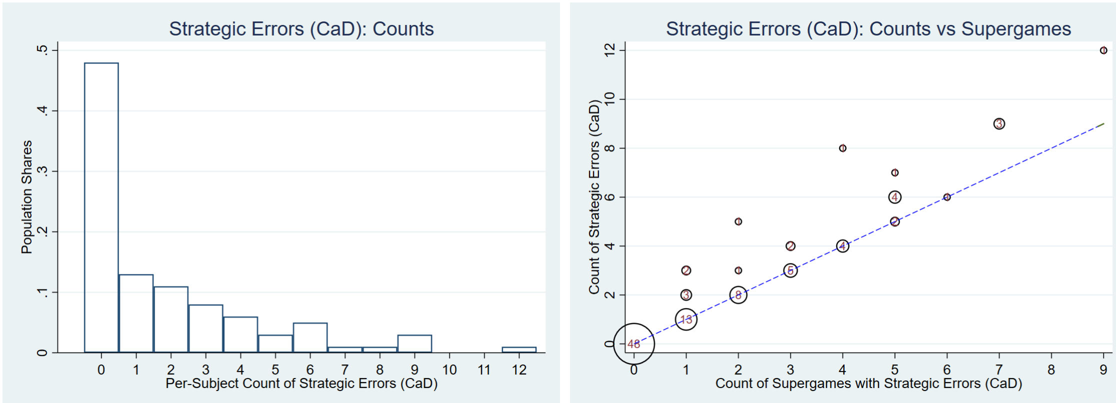

Figure 3: Strategic errors of dominated cooperation after defection (CaD). Left: Distribution of per-subject counts of instances of cooperation after defection (CaD), among 17 relevant supergames. Right: Per-subject counts of CaD instances vs. count of supergames with those instances (among 17 relevant supergames). (Bubble size is proportional to the share of subjects, number of subjects in the bubbles, 100 subjects total.)

the diagonal in the figure) the extent of strategic errors is non-trivial, with 24% of subjects making errors in at least 3 out of 17 relevant supergames (those lasting more than 1 round), suggesting that some of the dominated CaD behavior could instead be due to inattention or a lack of strategic understanding of the game.

While the prevalence of such strategic errors (CaD) is relatively small, it nevertheless complicates the interpretation of the deviations from the theoretically optimal behavior.

Finding 4. *A majority of subjects (52%) made at least one strategic error of choosing to cooperate after defecting earlier within the same supergame (CaD), i.e., after triggering a "grim" response. Overall, suboptimal, excessive cooperation amounts to 7.58% of relevant observations, with 24% of subjects making dominated choices in at least 3 out of 17 relevant supergames.*

4.4 Overall Point Totals

Let us turn to the overall total of awarded points (i.e., the sum of point earnings across all 48 decisions). As Figure 4 shows, the empirical range of overall point totals is $[3285, 4185]$ points, with a mean (st.dev.) of 3835.05 (203.38).

As Figure 6 (left) shows, strategic errors (CaD) reduce the overall point totals. In fact, 16 subjects could have achieved a strictly higher total of 3600 points by choosing either to always cooperate (All-C) or always defect (All-D), as by design, the expected payoff to these two extremely biased strategies is the same.

Note that the mode is at the theoretically optimal point total of 4050, and that the maximum point total is still higher. Overall, 19 subjects were able to achieve at least this optimal point value, despite only 2 subjects behaving in a way that was fully theoretically

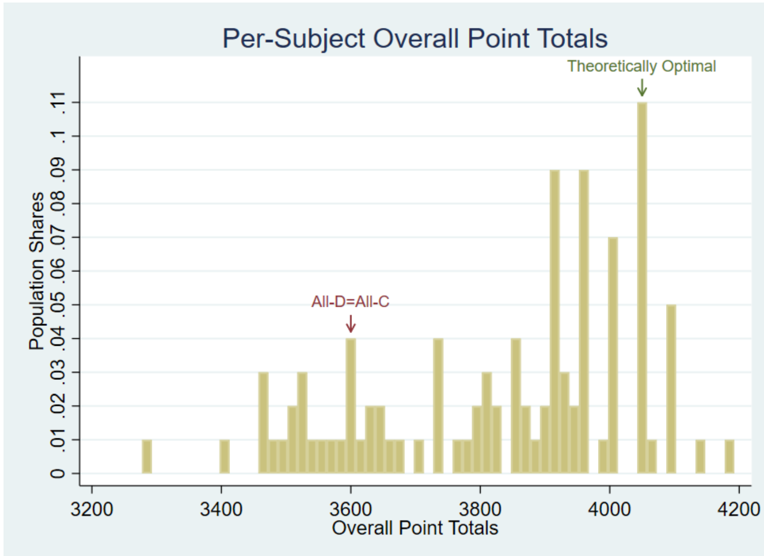

Figure 4: Distribution of overall point totals, or the sum of point earnings across all 48 decisions.

optimal. Thus, given the random realization of the supergames, some subjects were able to achieve at least as much as the theoretical payoff despite pursuing strategies that were not theoretically optimal (which will be explored in the next Section 4.5).

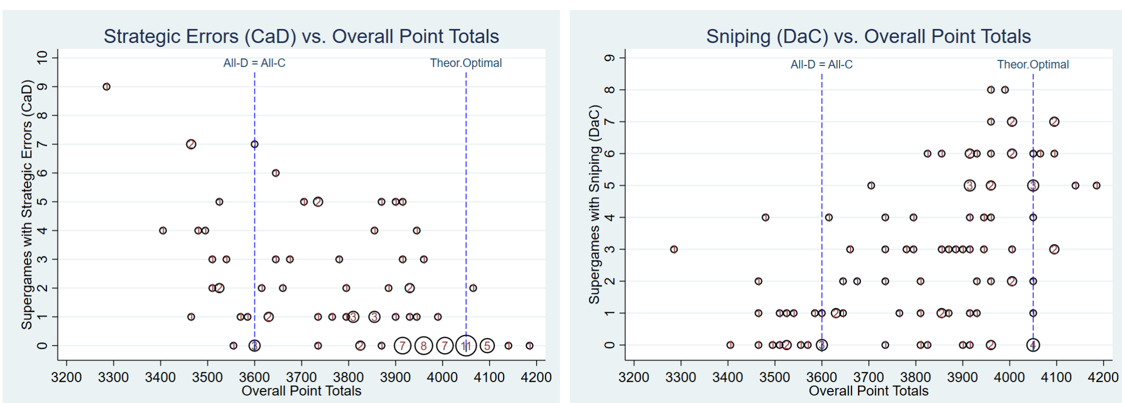

Figure 5: Supergames with non-constant play and the overall point totals. Left: the count of supergames with strategic errors (CaD) instances vs the overall point totals. Right: the count of supergames with sniping (DaC) instances vs the overall point totals. Bubble size is proportional to the share of subjects, number of subjects in the bubbles, 100 subjects total.

Finding 5. *16% of subjects earned less than what they could have achieved by either always cooperating or always defecting. 17% of subjects were able to achieve an overall payoff at least as high as the expected theoretical payoff without following the theoretically optimal strategy.*

4.5 "Sniping"

Note that when playing against a robot known to play the Grim trigger strategy, one could achieve up to 4680 points, a much higher point total than under the theoretically optimal strategy, *if one knew in advance exactly when each supergame would end* by always cooperating prior to the final round of a supergame, and defecting in the final round. Such a "sniping" strategy would allow one to earn the temptation payoff without triggering the "grim" punishment as the supergame ends.[13] Of course, subjects did not have such knowledge in our experiment, but they may have formed some expectations as to when a sequence (supergame) might end in an effort to employ such a strategy.

Indeed, Figure 1 (bottom left) shows that, for some δs, some subjects defect for the first time (thus triggering subsequent defection by the automated opponent) *later* in the sequence, rather than in the first round (if ever) as predicted by the theory.[14] We hypothesize that this pattern of behavior could be due to some subjects using a "sniping" strategy, which we define as consistently defecting after the earlier play of cooperation in the same supergame, or (DaC) for short. Such a sniping strategy is *risky*, as it is most profitable if the first defection happens in the final round of the supergame.

Furthermore, as Figure 1 (bottom right) shows, the shares of the supergames where subjects always defected (All-D) are declining as δ increases. However, this does not translate into an increase in the prevalence of the always cooperate (All-C) strategy as delta increases. Instead, as δ (and thus the expected duration of a supergame) increases, both the prevalence of strategic errors (CaD) and "sniping" (consistent DaC) strategies increases. Note that interpreting All-C strategies is complicated by attrition, as a subjects might have *intended* to snipe, but a supergame ended earlier than expected. Similarly, All-D strategies in low δ supergames could be not only due to theoretically optimal behavior, but also due to the intended use of a sniping strategy.

Indeed, if the behavior were theoretically optimal, then in the mixed-effects probit regressions in Table 4 (specifications 1-2), the coefficients on $\delta = \{0.25, 0.33, 0.4\}$ would have been insignificantly different from the baseline of $\delta = 0.1$, and would only be significantly different for $\delta = \{0.67, 0.7\}$. In addition, the round dummies would all be insignificantly different from the baseline of the first round. Instead, as this table demonstrates, subjects' tendency to choose cooperation increases with δ, and decreases with the round number, consistent with the use of the sniping strategy.

[13] While we refer to this type of behavior as sniping borrowing terminology from the auction literature, it is also an instance of "gambler's fallacy," Cowan (1969). This is the erroneous belief that the probability of some event is lowered when that event has occurred recently even though the probability of that event is known to be independent from one instance to the next.

[14] Note that the expected final round $\frac{1}{1-\delta}$ (as calculated from the perspective of round 1), as well as the average realized final round increase with δ - see Table A2. Mengel et al. (2021) report that subjects respond to the *realized* supergame length, and are more likely to cooperate when they have experienced supergames of longer duration.

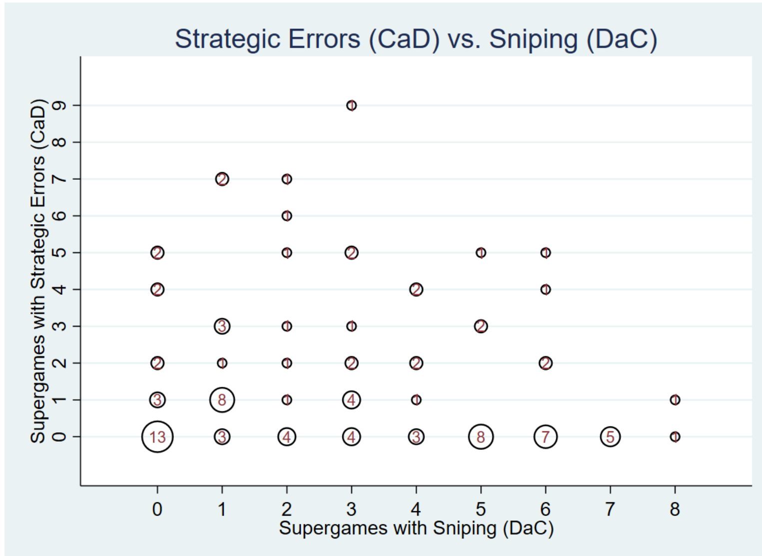

Figure 6: Supergames with non-constant play: supergames with strategic errors (CaD) vs. supergames with sniping (DaC). Bubble size is proportional to the share of subjects, number of subjects in the bubbles, 100 subjects total.

Furthermore, as Figure 6 (right) shows, there is a group of subjects with overall point total close or above the theoretically optimal payoff of 4050, who used the sniping strategy in at least one supergame. Comparing this to Figure 6 (left), one can note that only of few among these subjects made strategic errors (CaD). As Figure 6 shows, only 1 out of 7 subjects who sniped (DaC) in at least 7 out of 17 relevant supergames made strategic errors (CaD), confirming that for these subjects, sniping behaviour is intentional, rather than due to confusion. However, apparent sniping behaviour (DaC) may or may not be intentional. For example, among 22 subjects who appeared to snipe (DaC) in 5-6 supergames, 15 (68.2%) never made strategic errors (CaD) (and thus likely to do it intentionally), in conttrast to the remaining 7 subjects made strategic errors (CaD) in at least two supergames.

Finding 6. *Some subjects appear to use a "sniping" strategy, by trying to time their first defection with the unknown final round of a supergame. While following this strategy could lead to a higher payoff, only a few subjects earned more than the theoretically optimal payoff.*

4.6 Classifying the Patterns of Play Within Each Supergame

The complex pattern of non-constant intra-supergame play (discussed earlier in Section 4.5) highlights the difficulties in interpreting each type of play in isolation, calling for a more holistic approach. Indeed, our two design innovations allow us to interpret each subject's whole play across all supergames. It turns out, we can classify subjects' patterns of play within each supergame into 6 mutually exclusive types: optimal All-C, optimal All-D, suboptimal All-C, suboptimal All-D, strategic errors (CaD), and sniping (DaC).

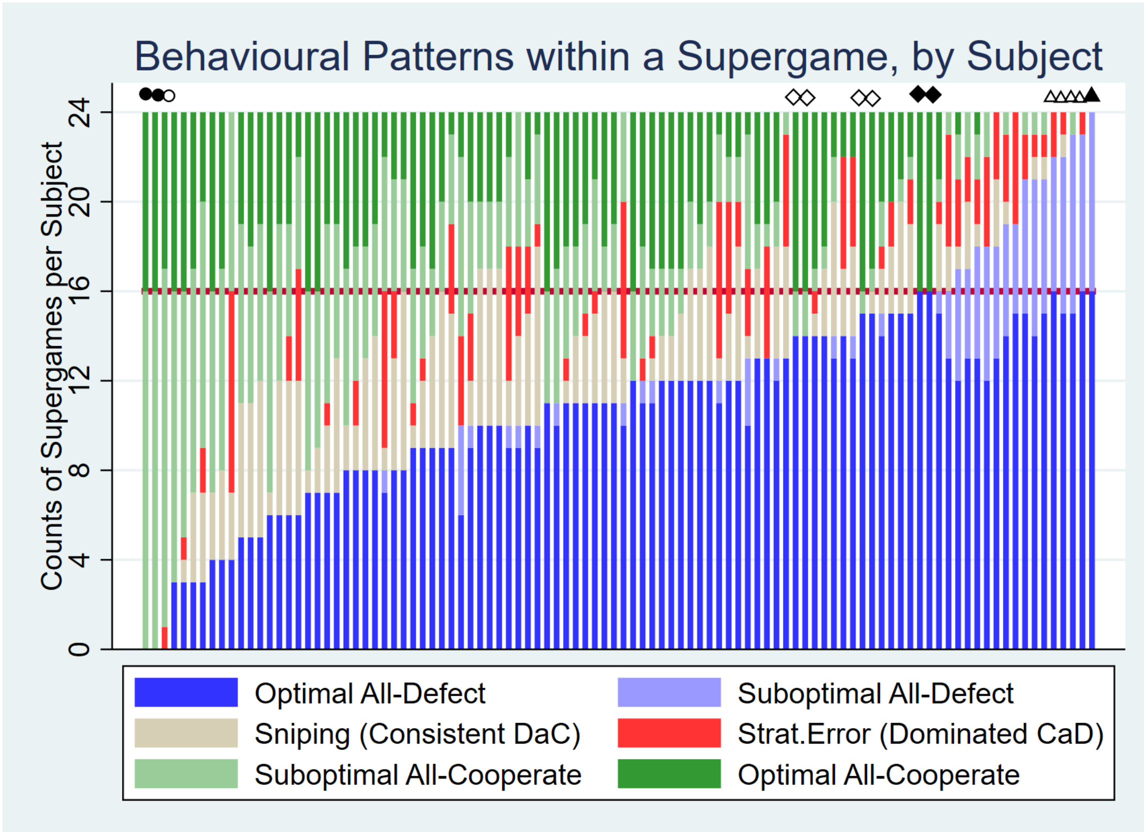

Figure 7: Subject heterogeneity in patterns of choices within supergames, out of 24 supergames, by subject, ordered by the count of supergames with All-Defect choices (100 subjects total). The theoretically optimal strategy involves always defecting in 16 supergames and always cooperating in the remaining 8 supergames (represented by a horizontal line). Diamonds, circles, and triangles represent subjects who made optimal, All-C, and All-D decisions, respectively, in at least 22 supergames, with solid markers representing those making such decisions in all 24 supergames.

As Figure 7, there is no prevalent pattern of subjects' play. Only two subjects (represented by solid diamonds) behaved fully theoretically optimally, and four more (represented by hollow diamonds) were only two supergames away from full optimality. Similarly, there are two solid circles and one hollow circle representing subjects who always and almost always cooperated, as well as one solid triangle and four hollow triangles representing subjects who always and almost always defected (see also Figure 2). Furthermore, as Figure 7 shoes, both types of non-constant play (CaD and DaC) as well as both optimal and suboptimal constant play (All-C and All-D) tend to co-exist in subjects' play.

Finding 7. *There is a notable heterogeneity in subjects' choices to cooperate or defect. Only two out of 100 subjects always followed the theoretically optimal strategy, and four more did so in 22 out of 23 supergames. Two (one) subjects are fully biased towards cooperation (defection), while one (four) are biased in 22 out of 23 supergames. The rest of the subjects appear to pursue strategies that are neither theoretically optimal nor purely biased.*

To get more insights into subjects' play, we perform factor analysis of these patterns of play. Due to singularity of correlation matrix, we dropped the Sniping pattern (DaC).[15] Factor analysis retains two latent factors, which can be meaningfully interpreted based on the interpretations of factor loadings (see Table 1).

Factors	Factor Cooperation	Factor Rationality	Uniqueness
Optimal All-C	0.7455	0.5361	0.1568
Sub-Optimal All-C	0.8675	-0.3920	0.0937
Optimal All-D	-0.8449	0.4724	0.0629
Sub-Optimal All-D	-0.6372	-0.2289	0.5416
Error/CaD	-0.3398	-0.5701	0.5595
Eigenvalues	2.5437	1.0417	

Table 1: Factor loadings on the five patterns. Snipe/DaC pattern is excluded due to singularity of correlation matrix of 6 patterns.

The first factor, "Cooperation", explains 68.6% of variation and can be interpreted as subjects' bias towards cooperation, with its negative interpreted as bias towards defection. The second factor, "Optimality", explains 28.1% of variation and can be interpreted as subjects' tendency to make theoretically optimal choices, with its negative being tendency to make strategic errors and suboptimal choices.[16] As Table 2 shows, these two latent factors are strongly correlated with overall point totals, with Factor Optimality having more than twice greater effect on overall point totals than Factor Optimality - as one would expect. (See also Figure C4 for the distribution of these two latent factors.)

Point Totals	(1)	(2)
Factor Cooperation	63.48****	61.80****
	(15.93)	(15.99)
Factor Optimality	155.82****	157.81****
	(15.34)	(16.21)
Order Long	17.73	20.96
	(27.46)	(44.78)
Constant	3826.18****	3813.11****
	(20.04)	(37.66)
Controls	No	Yes
F	49.89	16.65
p	0.00	0.00
Observations	100	100

Table 2: Overall point totals and factors. (Significance * 0.10 ** 0.05 *** 0.01 **** 0.001.)

Finding 8. *Subjects' patterns of play of indefinitely repeated prisoner's dilemma can be captured by two latent factors, with the stronger factor being bias towards cooperation/defection and the other factor being tendency to make theoretically optimal choices/errors. These factors are correlated with overall point totals, with Factor Optimality having stronger effect.*

[15] Singularity of correlation matrix is a common issue for compositional data analysis. Because of the high prevalence of zero-value problem, standard transformations (e.g., logarithmic) cannot be applied here.

[16] Excluding Snipe/DaC pattern results in the highest Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy of 0.50. We are aware that this value of KMO measure is at the border of acceptability, pointing at the limits of our analysis. Nevertheless we believe that using this dimensionality-reducing technique provides us with useful insights into subjects' play.

4.7 The Effect of Cognitive Abilities

As noted earlier, we asked all of our subjects to answer 7 cognitive reflection test (CRT) questions as part of the study. Subjects' total score on this 7-item, cognitive reflection test, CRT7, was used as a proxy for cognitive ability. The mean (st.dev.) of the CRT7 score was 3.78 (2.26) with a median of 4.

	Overall Point Totals (OLS)		Dominated(CaD) (Tobit, ll=0)		Theor.Optimal (Tobit, ul=24)		Sniping(DaC) (Tobit, ll=0)		Th.Opt.+Snipe(DaC) (Tobit, ul=24)	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Order Long	57.11	84.46	-0.22	0.66	0.87	2.33*	0.34	0.12	1.01	2.13
	(38.27)	(78.57)	(0.68)	(1.22)	(0.79)	(1.37)	(0.59)	(1.08)	(0.78)	(1.56)
Female	-65.92	-21.23	1.40**	0.92	0.09	1.52	-0.88	-0.63	-0.52	1.13
	(41.98)	(53.92)	(0.69)	(0.80)	(0.80)	(0.96)	(0.59)	(0.78)	(0.82)	(1.15)
Age	-4.85	-5.42	0.12	0.13	0.25	0.20	-0.24*	-0.23	0.07	0.04
	(9.17)	(9.72)	(0.14)	(0.12)	(0.18)	(0.17)	(0.14)	(0.14)	(0.18)	(0.18)
CRT7	26.37***	26.25***	-0.51***	-0.52***	0.32*	0.29	0.11	0.14	0.46**	0.47***
	(9.32)	(9.28)	(0.16)	(0.16)	(0.19)	(0.18)	(0.14)	(0.14)	(0.19)	(0.17)
Constant	3845.38****	3806.58****	-1.03	-1.25	7.46*	6.76*	7.47**	6.73**	13.78***	12.38***
	(212.24)	(235.42)	(3.06)	(2.91)	(3.95)	(4.00)	(3.09)	(3.24)	(4.19)	(4.42)
Controls	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes
F	5.47	2.80	4.52	2.78	1.44	2.26	1.80	0.93	2.72	4.04
p	0.00	0.00	0.00	0.00	0.23	0.02	0.14	0.51	0.03	0.00
Observations	100	100	100	100	100	100	100	100	100	100

Table 3: Individual differences in rationality. (Significance: * 0.10 ** 0.05 *** 0.01 **** 0.001). (See also Table **??**.)

As Table 3 shows, CRT7 predicts the rational aspects of subjects' behavior rather well. Specifically, it is positively correlated with their overall point payoff total (specifications 1-2) and negatively with a count of the number of supergames with strategic errors (dominated CaD) (specifications 3-4). Interestingly, neither the count of theoretically optimal choices (specifications 5-6), nor the count of apparent sniping (consistent DaC) (specifications 7-8) are correlated with the CRT7 score. By construction, these two counts are *mutually exclusive*. However, as discussed above, some choices which are consistent with following the theoretically optimal strategy, could instead be part of an intended sniping strategy. Thus, it is not a surprise that the combined count of whether subjects follow the theoretically optimal strategy (which involves either All-D for $\delta < 0.5$ or All-C for $\delta > 0.5$), or engage in sniping (which involves consistent defection after cooperation, or DaC) *is* correlated with the CRT7 score (see specifications 9-10).

In contrast, CRT7 on its own has no effect on choice to cooperate. This can be seen in the specifications 3-4 in Table 4, which contains average marginals (dy/dx) for mixed-effects probit regressions of the choice to cooperate or defect in all 48 rounds of prisoners' dilemma, controlling for demographics, CRT7, and personal characteristics.[17] Note that while the coefficient on the female dummy in that specification is significantly negative, and the CRT7 score is negatively correlated with being female ($r = -0.2365, pvalue = 0.0178$), the coefficient on the CRT7 score remains insignificant if we exclude the age and gender

[17] Note that Table 4 presents marginals, rather than odds, so that the same explanatory variable in different models can have different statistical significance despite similar coefficients and robust errors.

demographic variables (results available on request).

Finding 9. *Subjects with higher proxy values for cognitive ability are more likely to behave in a payoff-maximizing fashion, and engage in sniping.*

4.8 Inattention

Recall the main hypotheses of the simple inattention theory presented in Section 2.1. Specifically, that in their choices whether to cooperate or defect, the individuals with lower cognitive ability will tend to be influenced more by their default values. In contrast, those with higher cognitive ability will tend to be influenced by the structure of the game.

To explore these hypotheses, we split the sample according based on the median CRT7 score. We find that subjects with relatively high proxies for cognitive ability (CRT7>4), tend to respond more strongly to the continuation probability δ (particularly for the highest δ value 0.7) and exhibit a stronger tendency for following the "sniping" strategy, as their coefficients on the round dummies tend to be more strongly significant. Subjects with relatively lower proxies for cognitive ability (CRT7≤ 4) do not exhibit any systematic sensitivity to the round number.

As Figure 8 shows, the two groups of subjects exhibit different patterns of play. Relatively more subjects from the lower CRT7 group make frequent strategic errors (CaD) and engage in suboptimal consistent defecting (Suboptimal All-D). In contrast, more subjects in the higher CRT7 group behave close to theoretical optimality and snipe more often.

As Table 4 shows, in addition to the differential effects of the structure of the game, the two group each have a single strongly significant correlate of their choices cooperate. In the lower CRT7 group (Table 4, specifications 5-6), those with higher self-reported patience tend to cooperate more frequently (and, vice versa, those with higher self-reported impatience tend to defect more).[18] Importantly, the Patience measure was marginally higher for higher CRT7 group ($t = 1.3718$, $p = 0.0866$).

In contrast, in the higher CRT7 group (Table 4, specifications 7-8), there are no personal characteristic which explains their choices cooperate - as a rational inattention theory would predict. Instead, their choices in Round 1 are correlated with their proxy for posterior "Prediction/10" (elicited from subjects before any choices were made - see 3), possibly reflecting their understanding of the task.[19]

The differences between these two groups can further be seen in the Table 5 which presents individual correlates of the two latent factors, for all subjects, as well as split by the median CRT7.

[18]The proxy for patience is taken from Falk et al. (2018): "How willing are you to give up something that is beneficial for you today in order to benefit more from that in the future?" (see Appendix D).

[19]"Prediction/10" was elicited from the subjects before any choices were made by asking about what share of their Round 1 choices across all 24 supergames would be cooperative.

Cooperate (Marginals, dy/dx)	All (1)	All (2)	All (3)	All (4)	$CRT7 \leq 4$ (5)	$CRT7 \leq 4$ (6)	$CRT7 > 4$ (7)	$CRT7 > 4$ (8)
δ=0.25	0.23****	0.22****	0.22****	0.22****	0.24****	0.24****	0.18****	0.18****
	(0.03)	(0.03)	(0.03)	(0.03)	(0.04)	(0.04)	(0.04)	(0.04)
δ=0.33	0.31****	0.31****	0.30****	0.30****	0.31****	0.31****	0.28****	0.28****
	(0.03)	(0.03)	(0.03)	(0.03)	(0.05)	(0.05)	(0.05)	(0.04)
δ=0.4	0.47****	0.47****	0.46****	0.46****	0.44****	0.44****	0.46****	0.46****
	(0.04)	(0.04)	(0.04)	(0.04)	(0.05)	(0.05)	(0.05)	(0.05)
δ=0.67	0.66****	0.66****	0.65****	0.65****	0.61****	0.61****	0.68****	0.68****
	(0.04)	(0.04)	(0.04)	(0.04)	(0.06)	(0.06)	(0.06)	(0.06)
δ=0.7	0.69****	0.69****	0.68****	0.68****	0.62****	0.62****	0.73****	0.73****
	(0.04)	(0.04)	(0.04)	(0.04)	(0.06)	(0.06)	(0.06)	(0.06)
Round 2	-0.04	-0.03	-0.04	-0.04	-0.00	-0.00	-0.09**	-0.09**
	(0.02)	(0.02)	(0.02)	(0.02)	(0.03)	(0.03)	(0.04)	(0.04)
Round 3	-0.12****	-0.12****	-0.12****	-0.12****	-0.06	-0.06	-0.20****	-0.20****
	(0.03)	(0.03)	(0.03)	(0.03)	(0.04)	(0.04)	(0.05)	(0.05)
Round 4	-0.19****	-0.18****	-0.18****	-0.18****	-0.10*	-0.10*	-0.28****	-0.28****
	(0.04)	(0.04)	(0.04)	(0.04)	(0.05)	(0.06)	(0.06)	(0.05)
Round 5	-0.17***	-0.17***	-0.17***	-0.17***	-0.13*	-0.13*	-0.23***	-0.22***
	(0.05)	(0.05)	(0.05)	(0.05)	(0.07)	(0.07)	(0.08)	(0.08)
Supergame	-0.00***	-0.00***	-0.00***	-0.00***	-0.00***	-0.00***	-0.00	-0.00
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Order Long	0.05	0.04	0.06	-0.00	0.07	-0.02	0.04	-0.12
	(0.04)	(0.10)	(0.04)	(0.09)	(0.06)	(0.08)	(0.04)	(0.13)
Prior Defection	-0.20****	-0.20****	-0.20****	-0.20****	-0.17****	-0.17****	-0.23****	-0.23****
	(0.03)	(0.03)	(0.03)	(0.03)	(0.04)	(0.04)	(0.05)	(0.05)
CRT7			-0.00	-0.00	0.01	0.00	0.01	0.00
			(0.01)	(0.01)	(0.02)	(0.02)	(0.03)	(0.03)
Female			-0.08**	-0.10*	-0.08	-0.08	-0.07	-0.10
			(0.04)	(0.06)	(0.06)	(0.08)	(0.05)	(0.10)
Age			-0.01	-0.01	-0.01	-0.01	-0.01	-0.01
			(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Prediction/10			0.02***	0.02**	0.02	0.02	0.02****	0.03****
			(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Risk			-0.00	-0.00	-0.01	-0.01	0.00	0.02
			(0.01)	(0.01)	(0.02)	(0.02)	(0.02)	(0.02)
Patience			0.02	0.02	0.04***	0.04****	-0.02	-0.03*
			(0.01)	(0.01)	(0.01)	(0.01)	(0.02)	(0.02)
Punishment			0.00	0.00	0.01	0.01	-0.00	-0.01
			(0.01)	(0.01)	(0.02)	(0.02)	(0.01)	(0.02)
Altruism			-0.02	-0.02*	-0.02	-0.03*	-0.02	-0.01
			(0.01)	(0.01)	(0.02)	(0.02)	(0.02)	(0.01)
Reciprocity			0.02	0.02	0.01	0.02	0.05	0.03
			(0.02)	(0.02)	(0.02)	(0.02)	(0.04)	(0.03)
Retribution			-0.01	-0.00	0.00	0.01	-0.02**	-0.01
			(0.01)	(0.01)	(0.02)	(0.02)	(0.01)	(0.01)
Trust			0.00	-0.00	-0.01	-0.01	0.02*	0.02**
			(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Controls	No	Yes	No	Yes	No	Yes	No	Yes
chi2	266.09	276.82	406.22	399.69	226.64	337.74	209.58	506.67
p	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
N	4800	4800	4800	4800	2688	2688	2112	2112

Table 4: Choices to cooperate: mixed-effects probit regressions, marginals (dy/dx), robust errors in parentheses. "Supergame" is the number of the supergame in the sequence of supergames, "Order Long" is a dummy variable for whether the first supergame in the sequence had $\delta = 0.67$, "Prior Defection" is a dummy variable for whether the subject defected in prior rounds of a given supergame, "Prediction/10" is the subjects' predictions of the share of their own cooperative choices in Round 1 across all 24 supergames. Controls stands for session controls. Chi2 and corresponding p-values are from the odds regressions (see Table C3). (Significance * 0.10 ** 0.05 *** 0.01 **** 0.001.)

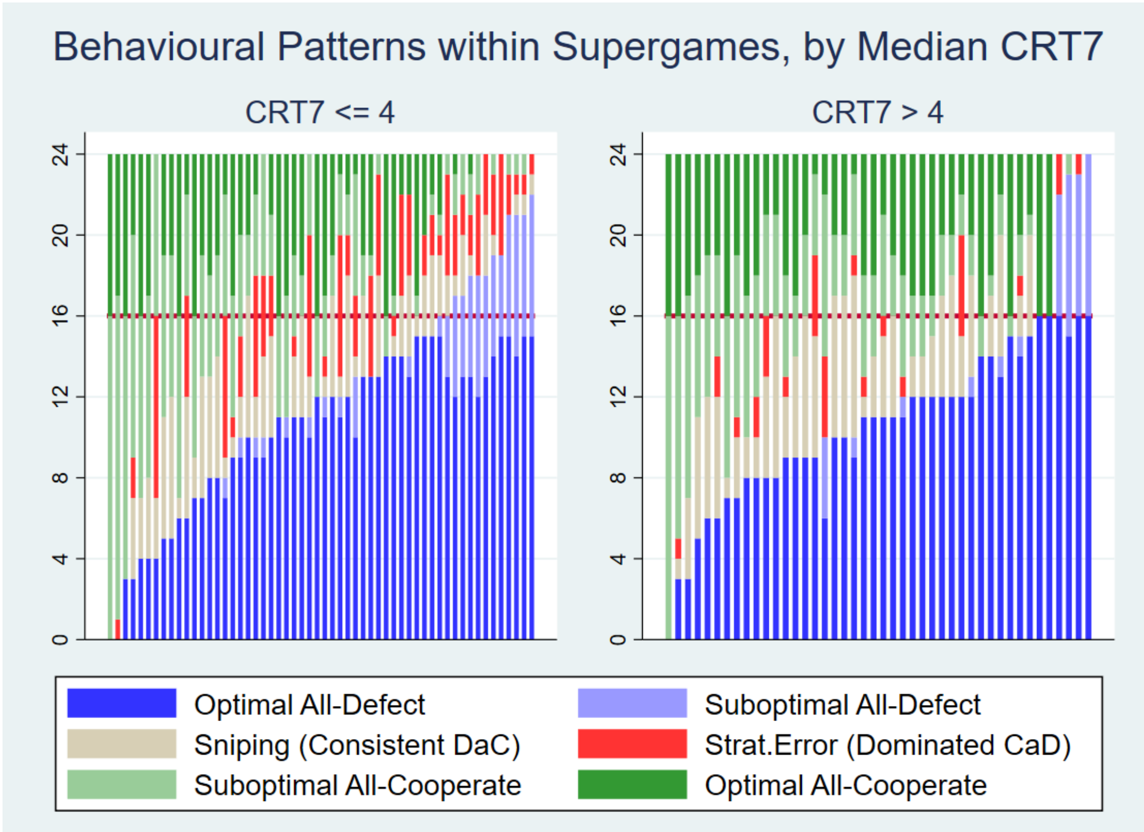

Figure 8: Inattention: subjects' patterns of choices within supergames (out of 24 supergames), split by median $CRT7$. Patterns are presented by subject, ordered by the count of supergames with All-Defect choices (100 subjects total). The theoretically optimal strategy involves always defecting in 16 supergames and always cooperating in the remaining 8 supergames (represented by a horizontal line).

Finding 10. *Subjects behaviour is broadly consistent with a simple model of inattention. Cooperative choices by subjects with lower proxy for cognitive ability (higher cognitive costs) correlated with their proxy for patience. In contrast, cooperative choices by those with higher proxy for cognitive ability (lower cognitive costs) are more affected by the structure of the game, and do not correlate with their individual characteristics, but with the elicited proxy for their posterior.*

5 Conclusions

In this paper, we report on an experiment in which subjects play the repeated prisoner's dilemma against a robot player known to play the Grim trigger strategy. This design converts the original strategic situation into a single-person decision problem, for which there is a unique optimal strategy. We use a within-subject design in which subjects play many different supergames with differing continuation probabilities. Our design also allows us to

Factor Cooperation	All (1)	All (2)	$CRT7 \leq 4$ (3)	$CRT7 \leq 4$ (4)	$CRT7 > 4$ (5)	$CRT7 > 4$ (6)
Order Long	0.16	-0.10	0.16	-0.43	0.15	-0.31
	(0.20)	(0.46)	(0.28)	(0.47)	(0.26)	(0.70)
CRT7	-0.00	-0.01	-0.01	-0.05	0.08	0.01
	(0.05)	(0.05)	(0.12)	(0.10)	(0.17)	(0.19)
Female	-0.50**	-0.59*	-0.45	-0.38	-0.44	-0.65
	(0.24)	(0.32)	(0.33)	(0.41)	(0.36)	(0.61)
Age	-0.03	-0.03	-0.04	-0.02	-0.05	-0.05
	(0.04)	(0.04)	(0.07)	(0.07)	(0.06)	(0.05)
Risk	-0.00	0.01	-0.00	-0.00	0.01	0.07
	(0.07)	(0.07)	(0.11)	(0.10)	(0.09)	(0.09)
Patience	0.09	0.08	0.17***	0.17***	-0.09	-0.13
	(0.05)	(0.06)	(0.06)	(0.06)	(0.10)	(0.11)
Punishment	-0.00	-0.01	-0.03	-0.05	0.02	-0.01
	(0.06)	(0.06)	(0.10)	(0.11)	(0.08)	(0.10)
Altruism	-0.05	-0.09	-0.07	-0.11	-0.09	-0.08
	(0.06)	(0.06)	(0.08)	(0.09)	(0.10)	(0.09)
Reciprocity	0.08	0.08	0.03	0.08	0.28	0.17
	(0.09)	(0.09)	(0.13)	(0.14)	(0.19)	(0.14)
Retribution	-0.03	-0.01	0.06	0.11	-0.14*	-0.12
	(0.05)	(0.06)	(0.08)	(0.08)	(0.07)	(0.09)
Trust	-0.01	-0.01	-0.05	-0.07	0.08	0.09
	(0.04)	(0.04)	(0.05)	(0.06)	(0.06)	(0.07)
Constant	0.06	0.53	0.16	-0.21	-0.36	1.55
	(1.05)	(1.19)	(1.66)	(1.92)	(2.32)	(2.41)
Controls	No	Yes	No	Yes	No	Yes
F	1.86	1.75	1.41	2.08	2.36	1.60
p	0.06	0.05	0.20	0.03	0.03	0.14
Observations	100	100	56	56	44	44

Factor Optimality	All (1)	All (2)	$CRT7 \leq 4$ (3)	$CRT7 \leq 4$ (4)	$CRT7 > 4$ (5)	$CRT7 > 4$ (6)
Order Long	0.25	0.57*	0.05	0.68	0.56*	0.32
	(0.18)	(0.34)	(0.27)	(0.49)	(0.30)	(0.64)
CRT7	0.08*	0.08*	0.10	0.14	-0.21	-0.17
	(0.04)	(0.04)	(0.09)	(0.08)	(0.14)	(0.16)
Female	-0.08	0.18	0.23	0.60*	-0.28	-0.50
	(0.22)	(0.26)	(0.27)	(0.34)	(0.35)	(0.56)
Age	0.04	0.04	0.10	0.09*	-0.00	-0.00
	(0.05)	(0.04)	(0.07)	(0.05)	(0.10)	(0.08)
Risk	0.00	0.00	-0.02	-0.03	0.06	0.05
	(0.07)	(0.06)	(0.10)	(0.08)	(0.09)	(0.11)
Patience	0.06	0.06	0.05	0.04	0.10	0.05
	(0.04)	(0.04)	(0.05)	(0.05)	(0.10)	(0.12)
Punishment	0.04	0.05	0.04	0.05	0.01	0.00
	(0.05)	(0.05)	(0.10)	(0.09)	(0.07)	(0.10)
Altruism	-0.06	-0.02	-0.09	-0.01	-0.00	0.04
	(0.05)	(0.05)	(0.07)	(0.08)	(0.07)	(0.08)
Reciprocity	0.03	0.01	0.07	-0.04	-0.09	-0.04
	(0.09)	(0.07)	(0.10)	(0.08)	(0.16)	(0.16)
Retribution	-0.05	-0.07	-0.02	-0.07	-0.06	-0.12
	(0.07)	(0.07)	(0.11)	(0.09)	(0.09)	(0.11)
Trust	0.00	0.00	-0.02	-0.02	0.03	0.00
	(0.05)	(0.05)	(0.07)	(0.06)	(0.08)	(0.10)
Constant	-1.63	-1.93*	-2.91	-2.63	1.08	0.95
	(1.20)	(1.13)	(1.84)	(1.80)	(2.23)	(2.46)
Controls	No	Yes	No	Yes	No	Yes
F	1.29	2.04	0.94	1.94	1.26	2.08
p	0.24	0.02	0.51	0.04	0.29	0.05
Observations	100	100	56	56	44	44

Table 5: Correlates of the two latent factors. OLS regressions. (Significance * 0.10 ** 0.05 *** 0.01 **** 0.001.)

classify the within-supergame play into 6 mutually exclusive patterns, and separate theoretically optimal behaviour from bias. We can therefore identify systematic errors made by subjects and relate them to individual characteristics, and, in particular, cognitive abilities.

Our novel design has revealed several important and interesting findings. First, we find that a majority (52%) of our subjects make at least one strategic error of cooperating after defection. Second, some subjects employ a sniping strategy, consistently defecting after initially choosing to cooperate (DaC) in the same supergame that can yield them higher payoffs than the theoretically optimal strategy. Third, we show that these different behaviors are correlated with our proxy measure for cognitive ability. Finally, we find a qualitative difference between subjects with high and low proxies of cognitive abilities, and this is consistent with a simple model of inattention. We hope that these findings will be useful in differentiating intentional strategies from errors in repeated games more generally.

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Appendices (Not Intended for Publication)

A Continuation Probabilities and Realizations

	OrderShort		OrderLong	
Sequence	$p =$	No.Rounds	$p =$	No. Rounds
1	0.33	1	0.67	4
2	0.7	4	0.33	1
3	0.1	1	0.4	2
4	0.67	2	0.25	1
5	0.4	3	0.7	3
6	0.7	2	0.33	2
7	0.25	1	0.7	5
8	0.33	2	0.4	1
9	0.67	4	0.67	2
10	0.4	1	0.1	1
11	0.1	1	0.25	1
12	0.25	2	0.1	1
13	0.1	1	0.25	2
14	0.25	1	0.1	1
15	0.1	1	0.4	1
16	0.67	2	0.67	4
17	0.4	1	0.33	2
18	0.7	5	0.25	1
19	0.33	2	0.7	2
20	0.7	3	0.4	3
21	0.25	1	0.67	2
22	0.4	2	0.1	1
23	0.33	1	0.7	4
24	0.67	4	0.33	1
Totals		48		48

Table A1: Continuation probabilities, p, and the number of rounds played for each of the 24 sequences, both treatment orders (one order is just the reverse of the other).

Delta	Duration		Duration (Rounds)					Number of	
δ	Expected $\left(\frac{1}{1-\delta}\right)$	realized (Ave.)	1	2	3	4	5	Supergames	Choices
.1	1.11	1.00	4	0	0	0	0	4	4
.25	1.33	1.25	3	1	0	0	0	4	5
.33	1.49	1.50	2	2	0	0	0	4	6
.4	1.67	1.75	2	1	1	0	0	4	7
.67	3.03	3.00	0	2	0	2	0	4	12
.7	3.33	3.50	0	1	1	1	1	4	14
Total Supergames			11	7	2	3	1	24	
Total Choices			24	13	6	4	1		48

Table A2: The distribution of the supergames, split by continuation probability δ. The average theoretical and realized supergame durations are 1.99 rounds and 2 rounds, respectively.

B Order Effects

As was documented recently by Mengel et al. (2021) early exposure to relatively long sequences could affect subsequent behavior in the prisoner's dilemma. While the mean (st.dev.) first round per-subject counts of cooperation in the long and reverse orders are 10.96 (6.48) and 12.10 (4.86), respectively (out of 24), this difference is insignificant ($t = 1.00$, Kolmogorov-Smirnov one-sided p-value= 0.278). The corresponding mean (st.dev.) overall counts are, respectively, 25.52 (9.29) and 22.66 (12.83) (out of 48), with the difference remaining insignificant ($t = 1.28$, Kolmogorov-Smirnov one-sided p-value= 0.198).

As for the optimal choices, the first round counts are higher in the long treatment, with mean (st.dev.) being, respectively, 16.2 (3.49) and 17.42 (3.91), but this difference is marginally significant only according to the Kolmogorov-Smirnov test (one-sided p-value= 0.034), but not according to t-test ($t = 1.65$, p-value= 0.051). The overall optimal choice counts are, again, higher in the long order treatment (with mean (st.dev.) of 32.54 (8.16) in long order, and 29.56 (7.76) in reverse), but this is marginally significant only according to t-test ($t = 1.87$, p-value= 0.032), but not according to Kolmogorov-Smirnov test (one-sided p-value= 0.135. The order effect disappears in mixed effects panel regressions in Table 4.

C Further Results

As Figure C1 shows, there is a significant heterogeneity is subjects' behavior, without any clear "representative" pattern. The top right panels of each figure provide two-dimensional distributions of the cooperative and optimal choices, where the possible choice combinations are restricted to the polygons delineated by the dashed lines. The shape of the polygon for the overall choices in the bottom panel is due to the possibility of dominated choices).

As Figure C1 (top panel) shows, subjects tend to excessively cooperate in the first round of each supergame, with the largest number of subjects choosing to start half of the supergames by cooperating. This early excessive cooperation in the first round is followed by the subsequent defection, represented in Figure C1. As the top right of bottom panel of Figure C1 shows, there are three equally sized clusters at each of the three corners of the polygon. There are only two subjects at the far right corner, who behaved fully theoretically optimally (all 48 rounds) and three subjects who made only 2 theoretically suboptimal choices. In the top corner, there are two subjects who always cooperated, and two subjects who defected only once and three times, respectively. In the bottom corner, there is a single subject who always defected, and one, two, and one subjects who cooperated once, twice, and three times, respectively. The presence of strategic errors (CaD) complicates the interpretation of the remaining 85% of subjects, most of whom are located away from the boundaries, in the center of the figure. Many of those observations represent the overall early excessive cooperation in the first rounds followed by the subsequent defections within a supergame, possibly due to some form of a sniping strategy.

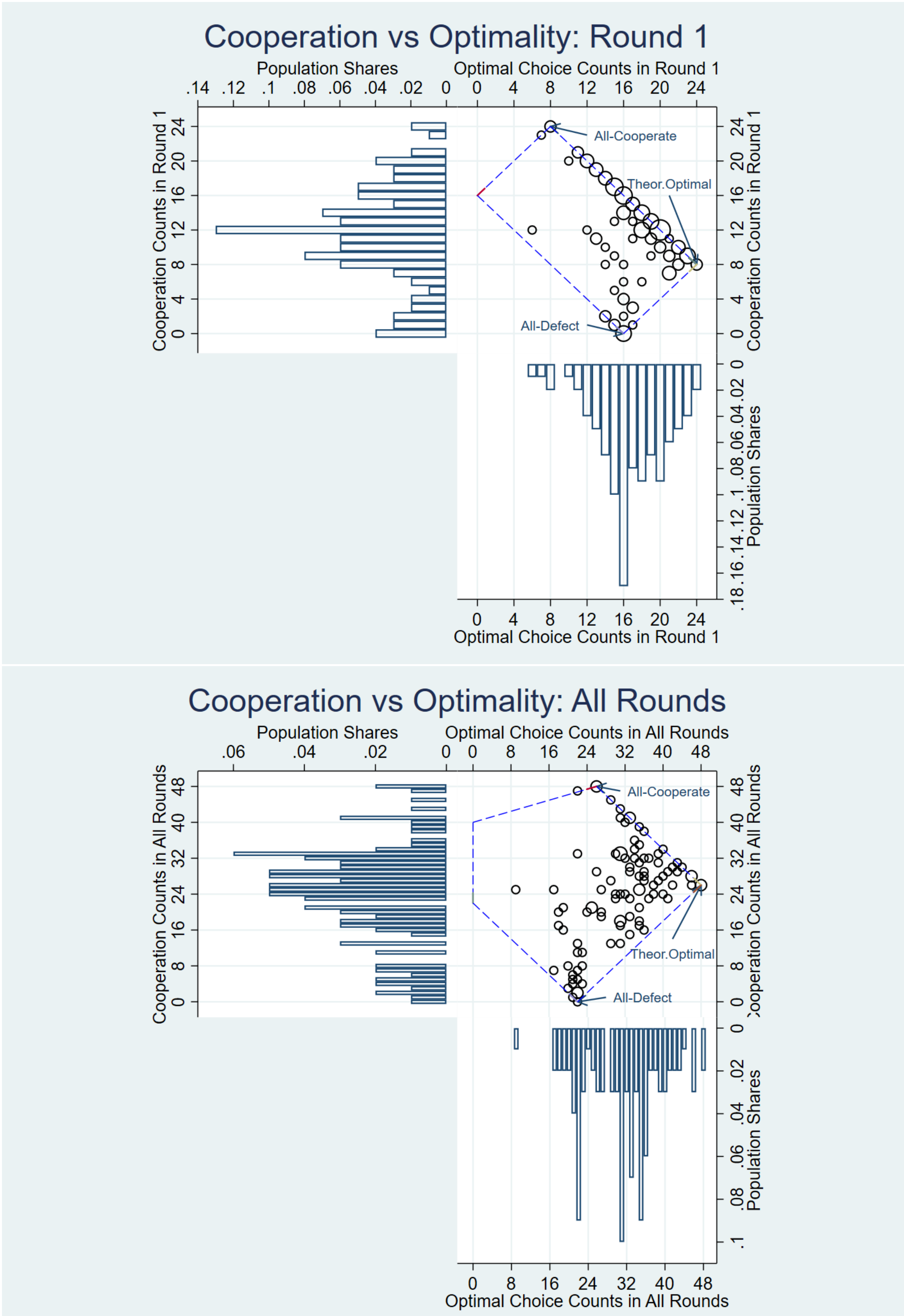

Figure C1: Polygons of Rationality: choices in the first rounds (top panel) and all rounds (bottom panel) across all 24 supergames. In each panel: Distributions of counts of cooperation (top left), of optimal choices (bottom right), and combination of these two distributions (top right). Bubble size is proportional to the share of subjects, 100 subjects total.

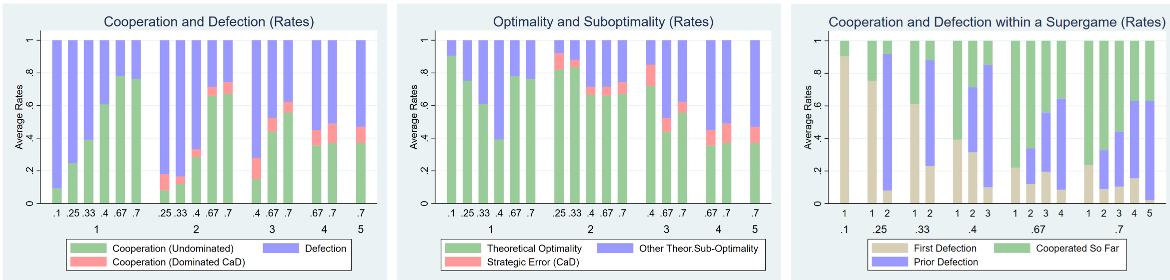

Figure C2: Patterns of cooperation and optimality (rates) (total 2,400 observations of supergames, for all 100 subjects). Shares of observations of cooperation vs defection (left) and optimality vs suboptimality (middle), split by round and δ. Right: average per-subject rates of first defection within a supergame for each round of each δ. (See Figure 1 for choice counts.)

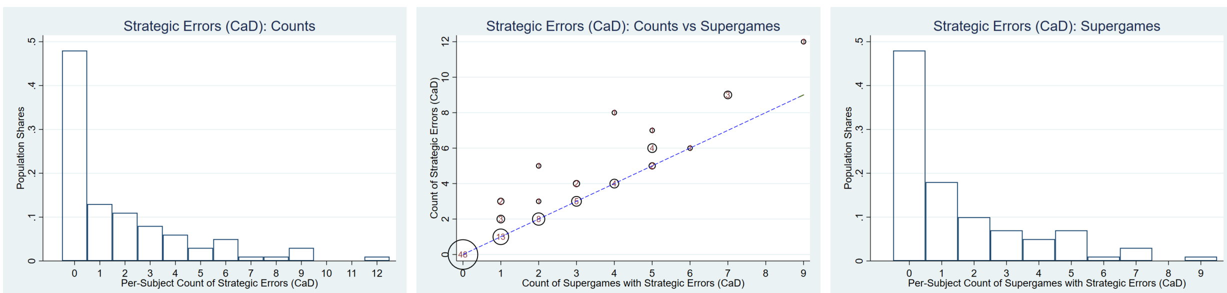

Figure C3: Strategic errors of dominated cooperation after defection (CaD), among 17 relevant supergames. Left: Distribution of per-subject CaD counts. Middle: Per-subject counts of CaD instances vs. count of supergames with those instances. (Bubble size is proportional to the share of subjects, number of subjects in the bubbles, 100 subjects total.) Right: Distribution of per-subject counts of supergames with CaD.

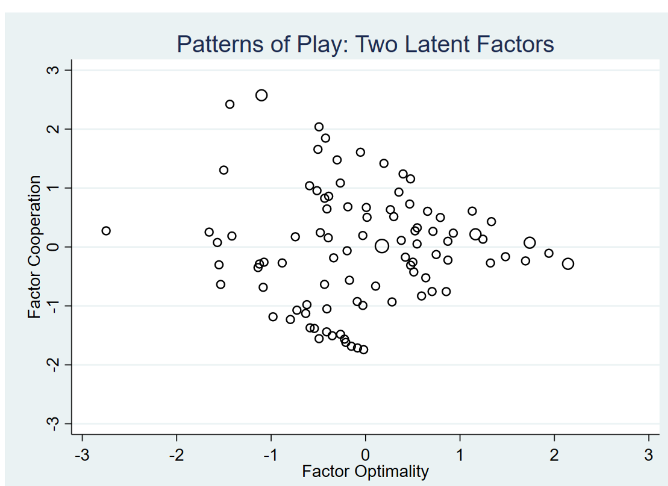

Figure C4: Two-dimensional distribution of two latent factors. Bubble size is proportional to the share of subjects, number of subjects in the bubbles, 100 subjects total.

Cooperate	All				$CRT7 \leq 4$		$CRT7 > 4$	
(Odds)	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
δ=0.25	0.90****	0.90****	0.89****	0.89****	0.92****	0.92****	0.87****	0.88****
	(0.14)	(0.14)	(0.13)	(0.14)	(0.17)	(0.17)	(0.23)	(0.24)
δ=0.33	1.23****	1.23****	1.22****	1.23****	1.17****	1.17****	1.36****	1.37****
	(0.15)	(0.15)	(0.15)	(0.15)	(0.20)	(0.20)	(0.25)	(0.26)
δ=0.4	1.88****	1.88****	1.87****	1.87****	1.67****	1.67****	2.22****	2.23****
	(0.17)	(0.17)	(0.17)	(0.17)	(0.20)	(0.20)	(0.33)	(0.33)
δ=0.67	2.65****	2.65****	2.65****	2.65****	2.30****	2.30****	3.29****	3.30****
	(0.21)	(0.21)	(0.21)	(0.21)	(0.25)	(0.25)	(0.40)	(0.41)
δ=0.7	2.76****	2.76****	2.76****	2.76****	2.32****	2.33****	3.53****	3.55****
	(0.22)	(0.22)	(0.22)	(0.22)	(0.26)	(0.26)	(0.44)	(0.44)
Round 2	-0.14	-0.14	-0.14	-0.14	-0.02	-0.02	-0.43**	-0.43**
	(0.10)	(0.10)	(0.10)	(0.10)	(0.12)	(0.12)	(0.20)	(0.20)
Round 3	-0.47****	-0.47****	-0.47****	-0.47****	-0.22	-0.22	-0.98****	-0.97****
	(0.14)	(0.14)	(0.14)	(0.14)	(0.17)	(0.17)	(0.26)	(0.26)
Round 4	-0.74****	-0.74****	-0.75****	-0.74****	-0.39*	-0.39*	-1.37****	-1.37****
	(0.17)	(0.17)	(0.17)	(0.17)	(0.21)	(0.21)	(0.30)	(0.30)
Round 5	-0.69***	-0.69***	-0.70***	-0.70***	-0.48*	-0.48*	-1.09***	-1.09***
	(0.22)	(0.22)	(0.22)	(0.22)	(0.28)	(0.28)	(0.40)	(0.40)
Supergame	-0.01***	-0.01***	-0.01***	-0.01***	-0.01***	-0.01***	-0.01	-0.01
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.01)	(0.01)
Order Long	0.18	0.15	0.22	-0.01	0.27	-0.08	0.20	-0.58
	(0.17)	(0.39)	(0.16)	(0.38)	(0.21)	(0.30)	(0.21)	(0.64)
Prior Defection	-0.81****	-0.81****	-0.80****	-0.80****	-0.64****	-0.65****	-1.13****	-1.13****
	(0.12)	(0.12)	(0.12)	(0.12)	(0.14)	(0.14)	(0.22)	(0.22)
CRT7			-0.00	-0.01	0.03	0.00	0.07	0.02
			(0.04)	(0.04)	(0.08)	(0.07)	(0.13)	(0.15)
Female			-0.33*	-0.41	-0.32	-0.32	-0.33	-0.50
			(0.17)	(0.25)	(0.23)	(0.32)	(0.26)	(0.51)
Age			-0.03	-0.02	-0.03	-0.02	-0.05	-0.05
			(0.02)	(0.02)	(0.04)	(0.04)	(0.04)	(0.04)
Prediction/10			0.10***	0.09**	0.07	0.08	0.11***	0.13****
			(0.04)	(0.04)	(0.05)	(0.05)	(0.04)	(0.04)
Risk			-0.01	-0.00	-0.03	-0.03	0.02	0.08
			(0.06)	(0.06)	(0.09)	(0.08)	(0.09)	(0.08)
Patience			0.07	0.06	0.13***	0.14****	-0.10	-0.16*
			(0.04)	(0.04)	(0.04)	(0.04)	(0.09)	(0.09)
Punishment			0.01	0.00	0.03	0.02	-0.02	-0.06
			(0.05)	(0.05)	(0.07)	(0.07)	(0.06)	(0.08)
Altruism			-0.06	-0.09*	-0.09	-0.12*	-0.09	-0.06
			(0.05)	(0.05)	(0.06)	(0.07)	(0.08)	(0.07)
Reciprocity			0.07	0.08	0.04	0.08	0.25	0.16
			(0.07)	(0.07)	(0.08)	(0.09)	(0.18)	(0.12)
Retribution			-0.04	-0.02	0.00	0.03	-0.10*	-0.07
			(0.04)	(0.04)	(0.06)	(0.06)	(0.05)	(0.07)
Trust			0.01	-0.00	-0.03	-0.04	0.09*	0.10*
			(0.03)	(0.03)	(0.04)	(0.04)	(0.05)	(0.05)
Constant	-1.61****	-1.55****	-2.05***	-1.69*	-1.66	-2.02	-2.61	-0.74
	(0.19)	(0.39)	(0.78)	(0.92)	(1.08)	(1.25)	(1.97)	(1.96)
Controls	No	Yes	No	Yes	No	Yes	No	Yes
chi2	266.09	276.82	406.22	399.69	226.64	337.74	209.58	506.67
p	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
N	4800	4800	4800	4800	2688	2688	2112	2112

Table C3: Choices to cooperate: mixed-effects probit regressions, odds, robust errors in parentheses. "Supergame" is the number of the supergame in the sequence of supergames, "Order Long" is a dummy variable for whether the first supergame in the sequence had $\delta = 0.67$, "Prior Defection" is a dummy variable for whether the subject defected in prior rounds of a given supergame, "Prediction/10" is the subjects' predictions of the share of their own cooperative choices in Round 1 across all 24 supergames. Controls stands for session controls. (Significance * 0.10 ** 0.05 *** 0.01 **** 0.001.)

Cooperate	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
δ=0.25	0.23***	0.22***	0.22***	0.22***	0.22***	0.22***	0.22***	0.22***	0.22***	0.22***	0.22***	0.22***	0.22***	0.22***	0.22***	0.22***
	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)
δ=0.33	0.31***	0.31***	0.31***	0.31***	0.31***	0.31***	0.31***	0.30***	0.30***	0.30***	0.31***	0.31***	0.30***	0.30***	0.30***	0.30***
	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)
δ=0.4	0.47***	0.47***	0.47***	0.47***	0.47***	0.47***	0.47***	0.47***	0.47***	0.46***	0.47***	0.47***	0.47***	0.46***	0.46***	0.46***
	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)
δ=0.67	0.66***	0.66***	0.66***	0.66***	0.66***	0.66***	0.66***	0.66***	0.66***	0.66***	0.66***	0.66***	0.66***	0.66***	0.65***	0.65***
	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)
δ=0.7	0.69***	0.69***	0.69***	0.69***	0.69***	0.69***	0.69***	0.68***	0.69***	0.68***	0.69***	0.69***	0.68***	0.68***	0.68***	0.68***
	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)
Round 2	-0.04	-0.03	-0.04	-0.04	-0.04	-0.03	-0.04	-0.04	-0.04	-0.03	-0.04	-0.03	-0.04	-0.03	-0.04	-0.04
	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)
Round 3	-0.12***	-0.12***	-0.12***	-0.12***	-0.12***	-0.12***	-0.12***	-0.12***	-0.12***	-0.12***	-0.12***	-0.12***	-0.12***	-0.12***	-0.12***	-0.12***
	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)
Round 4	-0.19***	-0.18***	-0.19***	-0.18***	-0.18***	-0.18***	-0.18***	-0.18***	-0.18***	-0.18***	-0.18***	-0.18***	-0.18***	-0.18***	-0.18***	-0.18***
	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)
Round 5	-0.17***	-0.17***	-0.17***	-0.17***	-0.17***	-0.17***	-0.17***	-0.17***	-0.17***	-0.17***	-0.17***	-0.17***	-0.17***	-0.17***	-0.17***	-0.17***
	(0.05)	(0.05)	(0.05)	(0.05)	(0.05)	(0.05)	(0.05)	(0.05)	(0.05)	(0.05)	(0.05)	(0.05)	(0.05)	(0.05)	(0.05)	(0.05)
Supergame	-0.00***	-0.00***	-0.00***	-0.00***	-0.00***	-0.00***	-0.00***	-0.00***	-0.00***	-0.00***	-0.00***	-0.00***	-0.00***	-0.00***	-0.00***	-0.00***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Order Long	0.05	0.04	0.04	0.03	0.05	-0.00	0.05	0.01	0.05	0.03	0.05	-0.00	0.05	-0.01	0.06	-0.00
	(0.04)	(0.10)	(0.04)	(0.10)	(0.04)	(0.09)	(0.04)	(0.10)	(0.04)	(0.09)	(0.04)	(0.10)	(0.04)	(0.10)	(0.04)	(0.09)
Prior Defect	-0.20***	-0.20***	-0.20***	-0.20***	-0.20***	-0.20***	-0.20***	-0.20***	-0.20***	-0.20***	-0.20***	-0.20***	-0.20***	-0.20***	-0.20***	-0.20***
	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)
CRT7			0.01	0.01							0.00	0.00	-0.00	-0.01	-0.00	-0.00
			(0.01)	(0.01)							(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Female					-0.12***	-0.15**					-0.12***	-0.15**	-0.11**	-0.14**	-0.08**	-0.10*
					(0.04)	(0.06)					(0.04)	(0.06)	(0.05)	(0.07)	(0.04)	(0.06)
Age					-0.00	-0.00					-0.00	-0.00	-0.00	-0.00	-0.01	-0.01
					(0.01)	(0.01)					(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Risk							0.01	0.01					0.00	0.00	-0.00	-0.00
							(0.01)	(0.01)					(0.01)	(0.01)	(0.01)	(0.01)
Patience							0.02	0.02					0.02	0.02	0.02	0.02
							(0.01)	(0.01)					(0.01)	(0.01)	(0.01)	(0.01)
Punishment							0.00	-0.00					-0.00	-0.00	0.00	0.00
							(0.01)	(0.01)					(0.01)	(0.01)	(0.01)	(0.01)
Altruism							-0.02*	-0.03*					-0.02	-0.03**	-0.02	-0.02*
							(0.01)	(0.01)					(0.01)	(0.01)	(0.01)	(0.01)
Reciprocity							0.02	0.02					0.02	0.02	0.02	0.02
							(0.02)	(0.02)					(0.02)	(0.02)	(0.02)	(0.02)
Retribution							-0.00	0.00					-0.01	-0.00	-0.01	-0.00
							(0.01)	(0.01)					(0.01)	(0.01)	(0.01)	(0.01)
Trust							-0.00	-0.00					0.00	0.00	0.00	-0.00
							(0.01)	(0.01)					(0.01)	(0.01)	(0.01)	(0.01)
Prediction/10									0.03***	0.03***					0.02***	0.02**
									(0.01)	(0.01)					(0.01)	(0.01)
Controls	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes
chi2	266.09	276.82	275.16	297.10	306.33	304.07	307.88	303.52	267.78	304.15	318.74	318.47	388.84	390.29	406.22	399.69
p	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table C4: Choices to cooperate by all 100 subjects (4800 observations): mixed-effects probit regressions, marginals (dy/dx), robust errors in parentheses. "Supergame" stands for the number of the supergame in the sequence, "Order Long" stands for the order with the first supergame involving $\delta = 0.67$, "Ever Defected" stands for whether the subject defected in prior rounds of a given supergame. Controls stands for session controls. Chi2 and corresponding p-values are for the odds regressions (see Table **??**). (Significance * 0.10 ** 0.05 *** 0.01 **** 0.001.)

Cooperate	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
δ=0.25	0.25***	0.25***	0.25***	0.25***	0.25***	0.25***	0.25***	0.25***	0.25***	0.25***	0.25***	0.25***	0.25***	0.25***	0.24***	0.24***
	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)
δ=0.33	0.31***	0.31***	0.31***	0.31***	0.31***	0.31***	0.31***	0.31***	0.31***	0.31***	0.31***	0.31***	0.31***	0.31***	0.31***	0.31***
	(0.05)	(0.05)	(0.05)	(0.05)	(0.05)	(0.05)	(0.05)	(0.05)	(0.05)	(0.05)	(0.05)	(0.05)	(0.05)	(0.05)	(0.05)	(0.05)
δ=0.4	0.45***	0.45***	0.45***	0.45***	0.45***	0.45***	0.44***	0.44***	0.45***	0.45***	0.45***	0.45***	0.44***	0.44***	0.44***	0.44***
	(0.05)	(0.05)	(0.05)	(0.05)	(0.05)	(0.05)	(0.05)	(0.05)	(0.05)	(0.05)	(0.05)	(0.05)	(0.05)	(0.05)	(0.05)	(0.05)
δ=0.67	0.62***	0.62***	0.62***	0.62***	0.62***	0.62***	0.61***	0.61***	0.62***	0.61***	0.62***	0.61***	0.61***	0.61***	0.61***	0.61***
	(0.06)	(0.06)	(0.06)	(0.06)	(0.06)	(0.06)	(0.06)	(0.06)	(0.06)	(0.06)	(0.06)	(0.06)	(0.06)	(0.06)	(0.06)	(0.06)
δ=0.7	0.62***	0.62***	0.62***	0.62***	0.62***	0.62***	0.62***	0.62***	0.62***	0.62***	0.62***	0.62***	0.62***	0.62***	0.62***	0.62***
	(0.06)	(0.06)	(0.06)	(0.06)	(0.06)	(0.06)	(0.06)	(0.06)	(0.06)	(0.06)	(0.06)	(0.06)	(0.06)	(0.06)	(0.06)	(0.06)
Round 2	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00
	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)
Round 3	-0.06	-0.06	-0.06	-0.06	-0.06	-0.06	-0.06	-0.06	-0.06	-0.06	-0.06	-0.06	-0.06	-0.06	-0.06	-0.06
	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)
Round 4	-0.10*	-0.10*	-0.10*	-0.10*	-0.10*	-0.10*	-0.10*	-0.10*	-0.10*	-0.10*	-0.10*	-0.10*	-0.10*	-0.10*	-0.10*	-0.10*
	(0.06)	(0.06)	(0.06)	(0.06)	(0.06)	(0.06)	(0.05)	(0.06)	(0.06)	(0.06)	(0.06)	(0.06)	(0.05)	(0.05)	(0.05)	(0.06)
Round 5	-0.13*	-0.13*	-0.13*	-0.13*	-0.13*	-0.13*	-0.13*	-0.13*	-0.13*	-0.13*	-0.13*	-0.13*	-0.13*	-0.13*	-0.13*	-0.13*
	(0.07)	(0.07)	(0.07)	(0.07)	(0.07)	(0.07)	(0.07)	(0.07)	(0.07)	(0.07)	(0.07)	(0.07)	(0.07)	(0.07)	(0.07)	(0.07)
Supergame	-0.00***	-0.00***	-0.00***	-0.00***	-0.00***	-0.00***	-0.00***	-0.00***	-0.00***	-0.00***	-0.00***	-0.00***	-0.00***	-0.00***	-0.00***	-0.00***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Order Long	0.03	-0.04	0.04	-0.04	0.05	-0.04	0.04	-0.05	0.04	-0.03	0.05	-0.04	0.05	-0.05	0.07	-0.02
	(0.06)	(0.09)	(0.06)	(0.09)	(0.06)	(0.09)	(0.06)	(0.09)	(0.06)	(0.08)	(0.06)	(0.08)	(0.06)	(0.09)	(0.06)	(0.08)
Prior Defect	-0.17***	-0.17***	-0.17***	-0.17***	-0.17***	-0.17***	-0.17***	-0.17***	-0.17***	-0.17***	-0.17***	-0.17***	-0.17***	-0.17***	-0.17***	-0.17***
	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)
CRT7			0.01	0.01							0.01	0.01	0.00	-0.01	0.01	0.00
			(0.02)	(0.02)							(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)
Female					-0.11	-0.11					-0.11	-0.11	-0.08	-0.08	-0.08	-0.08
					(0.07)	(0.11)					(0.07)	(0.11)	(0.06)	(0.08)	(0.06)	(0.08)
Age					-0.00	-0.00					-0.01	-0.00	-0.00	-0.00	-0.01	-0.01
					(0.01)	(0.01)					(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Risk							-0.00	-0.00					-0.01	-0.00	-0.01	-0.01
							(0.02)	(0.02)					(0.02)	(0.02)	(0.02)	(0.02)
Patience							0.04***	0.04***					0.04***	0.04***	0.04***	0.04***
							(0.01)	(0.01)					(0.01)	(0.01)	(0.01)	(0.01)
Punishment							-0.00	-0.01					-0.00	-0.01	0.01	0.01
							(0.02)	(0.02)					(0.02)	(0.02)	(0.02)	(0.02)
Altruism							-0.02	-0.02					-0.02	-0.03	-0.02	-0.03*
							(0.02)	(0.02)					(0.02)	(0.02)	(0.02)	(0.02)
Reciprocity							0.01	0.02					0.01	0.02	0.01	0.02
							(0.02)	(0.03)					(0.02)	(0.03)	(0.02)	(0.02)
Retribution							0.02	0.02					0.01	0.02	0.00	0.01
							(0.02)	(0.02)					(0.02)	(0.02)	(0.02)	(0.02)
Trust							-0.02	-0.02					-0.01	-0.02	-0.01	-0.01
							(0.01)	(0.01)					(0.01)	(0.01)	(0.01)	(0.01)
Prediction/10									0.02	0.02					0.02	0.02
									(0.02)	(0.02)					(0.01)	(0.01)
Controls	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes
chi2	147.22	172.01	146.96	171.20	176.54	189.04	183.27	243.47	148.29	187.52	175.91	188.92	206.34	262.98	226.64	337.74
p	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table C5: Choices to cooperate by 56 subjects with $CRT7 \leq 4$ (2688 observations): mixed-effects probit regressions, marginals (dy/dx), robust errors in parentheses. "Supergame" stands for the number of the supergame in the sequence, "Order Long" stands for the order with the first supergame involving $\delta = 0.67$, "Ever Defected" stands for whether the subject defected in prior rounds of a given supergame. Controls stands for session controls. Chi2 and corresponding p-values are for the odds regressions (see Table **??**). (Significance * 0.10 ** 0.05 *** 0.01 **** 0.001.)

Cooperate	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
δ=0.25	0.19***	0.18***	0.19***	0.18***	0.18***	0.18***	0.18***	0.18***	0.18***	0.18***	0.18***	0.18***	0.18***	0.18***	0.18***	0.18***
	(0.05)	(0.05)	(0.05)	(0.05)	(0.05)	(0.05)	(0.04)	(0.04)	(0.04)	(0.04)	(0.05)	(0.05)	(0.04)	(0.04)	(0.04)	(0.04)
δ=0.33	0.29***	0.29***	0.29***	0.29***	0.29***	0.29***	0.28***	0.28***	0.28***	0.28***	0.29***	0.29***	0.28***	0.28***	0.28***	0.28***
	(0.05)	(0.05)	(0.05)	(0.05)	(0.05)	(0.05)	(0.05)	(0.04)	(0.05)	(0.04)	(0.05)	(0.05)	(0.05)	(0.05)	(0.05)	(0.04)
δ=0.4	0.47***	0.47***	0.47***	0.47***	0.47***	0.47***	0.46***	0.46***	0.47***	0.46***	0.47***	0.47***	0.46***	0.46***	0.46***	0.46***
	(0.06)	(0.06)	(0.06)	(0.06)	(0.06)	(0.06)	(0.05)	(0.05)	(0.06)	(0.05)	(0.06)	(0.06)	(0.05)	(0.05)	(0.05)	(0.05)
δ=0.67	0.70***	0.70***	0.70***	0.70***	0.69***	0.69***	0.69***	0.68***	0.69***	0.69***	0.69***	0.69***	0.68***	0.68***	0.68***	0.68***
	(0.06)	(0.06)	(0.06)	(0.06)	(0.06)	(0.06)	(0.06)	(0.06)	(0.06)	(0.06)	(0.06)	(0.06)	(0.06)	(0.06)	(0.06)	(0.06)
δ=0.7	0.75***	0.75***	0.75***	0.75***	0.75***	0.74***	0.74***	0.73***	0.74***	0.74***	0.75***	0.74***	0.73***	0.73***	0.73***	0.73***
	(0.06)	(0.06)	(0.06)	(0.06)	(0.06)	(0.06)	(0.06)	(0.06)	(0.06)	(0.06)	(0.06)	(0.06)	(0.06)	(0.06)	(0.06)	(0.06)
Round 2	-0.09**	-0.09**	-0.09**	-0.09**	-0.09**	-0.09**	-0.09**	-0.09**	-0.09**	-0.09**	-0.09**	-0.09**	-0.09**	-0.09**	-0.09**	-0.09**
	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)
Round 3	-0.21***	-0.20***	-0.21***	-0.20***	-0.21***	-0.20***	-0.20***	-0.20***	-0.20***	-0.20***	-0.21***	-0.20***	-0.20***	-0.20***	-0.20***	-0.20***
	(0.05)	(0.05)	(0.05)	(0.05)	(0.05)	(0.05)	(0.05)	(0.05)	(0.05)	(0.05)	(0.05)	(0.05)	(0.05)	(0.05)	(0.05)	(0.05)
Round 4	-0.29***	-0.29***	-0.29***	-0.29***	-0.29***	-0.29***	-0.29***	-0.29***	-0.29***	-0.28***	-0.29***	-0.29***	-0.29***	-0.28***	-0.28***	-0.28***
	(0.06)	(0.06)	(0.06)	(0.06)	(0.06)	(0.06)	(0.06)	(0.05)	(0.06)	(0.06)	(0.06)	(0.06)	(0.06)	(0.05)	(0.06)	(0.05)
Round 5	-0.23***	-0.23***	-0.23***	-0.23***	-0.23***	-0.23***	-0.23***	-0.23***	-0.23***	-0.22***	-0.23***	-0.23***	-0.23***	-0.23***	-0.23***	-0.22***
	(0.08)	(0.08)	(0.08)	(0.08)	(0.08)	(0.08)	(0.08)	(0.08)	(0.08)	(0.08)	(0.08)	(0.08)	(0.08)	(0.08)	(0.08)	(0.08)
Supergame	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Order Long	0.06	0.08	0.05	0.06	0.05	0.01	0.05	-0.01	0.05	-0.02	0.04	0.01	0.04	-0.08	0.04	-0.12
	(0.06)	(0.19)	(0.06)	(0.19)	(0.06)	(0.19)	(0.06)	(0.15)	(0.05)	(0.17)	(0.06)	(0.19)	(0.05)	(0.13)	(0.04)	(0.13)
Prior Defect	-0.24***	-0.24***	-0.24***	-0.24***	-0.24***	-0.24***	-0.24***	-0.23***	-0.24***	-0.24***	-0.24***	-0.24***	-0.23***	-0.23***	-0.23***	-0.23***
	(0.05)	(0.05)	(0.05)	(0.05)	(0.05)	(0.05)	(0.05)	(0.05)	(0.05)	(0.05)	(0.05)	(0.05)	(0.05)	(0.05)	(0.05)	(0.05)
CRT7			0.04	0.03							0.03	0.02	0.01	0.00	0.01	0.00
			(0.03)	(0.03)							(0.03)	(0.03)	(0.03)	(0.04)	(0.03)	(0.03)
Female					-0.13**	-0.16					-0.13**	-0.15	-0.11*	-0.17	-0.07	-0.10
					(0.06)	(0.11)					(0.06)	(0.11)	(0.06)	(0.11)	(0.05)	(0.10)
Age					-0.00	0.00					-0.00	0.00	-0.01	-0.01	-0.01	-0.01
					(0.01)	(0.01)					(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Risk							0.01	0.02					0.01	0.02	0.00	0.02
							(0.02)	(0.02)					(0.02)	(0.02)	(0.02)	(0.02)
Patience							-0.02	-0.03					-0.03	-0.04*	-0.02	-0.03*
							(0.02)	(0.02)					(0.02)	(0.02)	(0.02)	(0.02)
Punishment							0.01	0.00					0.00	-0.00	-0.00	-0.01
							(0.02)	(0.01)					(0.02)	(0.02)	(0.01)	(0.02)
Altruism							-0.03*	-0.03**					-0.03	-0.02	-0.02	-0.01
							(0.02)	(0.02)					(0.02)	(0.02)	(0.02)	(0.01)
Reciprocity							0.07**	0.05*					0.07**	0.05**	0.05	0.03
							(0.03)	(0.03)					(0.03)	(0.02)	(0.04)	(0.03)
Retribution							-0.03**	-0.03*					-0.03**	-0.03*	-0.02**	-0.01
							(0.01)	(0.02)					(0.01)	(0.02)	(0.01)	(0.01)
Trust							0.02	0.02*					0.02*	0.02*	0.02*	0.02**
							(0.01)	(0.01)					(0.01)	(0.01)	(0.01)	(0.01)
Prediction/10									0.03***	0.03***					0.02***	0.03***
									(0.01)	(0.01)					(0.01)	(0.01)
Controls	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes
chi2	159.96	169.21	159.77	172.10	163.17	182.80	167.67	229.89	160.16	186.35	163.70	180.21	186.67	269.28	209.58	506.67
p	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table C6: Choices to cooperate by 44 subjects with $CRT7 > 4$ (2112 observations): mixed-effects probit regressions, marginals (dy/dx), robust errors in parentheses. "Supergame" stands for the number of the supergame in the sequence, "Order Long" stands for the order with the first supergame involving $\delta = 0.67$, "Ever Defected" stands for whether the subject defected in prior rounds of a given supergame. Controls stands for session controls. Chi2 and corresponding p-values are for the odds regressions (see Table **??**). (Significance * 0.10 ** 0.05 *** 0.01 **** 0.001.)

D Appendix: Experimental Design

Personality Questions

Subjects were asked to complete the following "questionnaire" by clicking on radio buttons from 0,1,2,..10 to report their answers to each question.[20]

Questionnaire

We now ask for your willingness to act in a certain way in 2 different areas. Please indicate your answer on a scale from 0 to 10, where 0 means you are "completely unwilling to do so" and a 10 means you are "very willing to do so". You can also use any numbers between 0 and 10 to indicate where you fall on the scale, like 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10.

1. In general, how willing are you to take risks?
2. How willing are you to give up something that is beneficial for you today in order to benefit more from that in the future?
3. How willing are you to punish someone who treats you unfairly, even if there may be costs for you?
4. How willing are you to give to good causes without expecting anything in return?

How well do the following statements describe you as a person? Please indicate your answer on a scale from 0 to 10. A 0 means "does not describe me at all" and a 10 means "describes me perfectly". You can also use any numbers between 0 and 10 to indicate where you fall on the scale, like 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10.

5. When someone does me a favor I am willing to return it.
6. If I am treated very unjustly, I will take revenge at the first occasion, even if there is a cost to do so.
7. I assume that people have only the best intentions.

CRT questions

Subjects were asked to provide numerical answers to the following cognitive reflection test (CRT) questions.[21]

[20] Taken from Falk et al. (2018).
[21] Based on Toplak et al. (2014) and Ackerman (2014).

1. The ages of Anna and Barbara add up to 30 years. Anna is 20 years older than Barbara. How old is Barbara?
2. If it takes 2 nurses 2 minutes to check 2 patients, how many minutes does it take 40 nurses to check 40 patients?
3. On a loaf of bread, there is a patch of mold. Every day, the patch doubles in size. If it takes 24 days for the patch to cover the entire loaf of bread, how many days would it take for the patch to cover half of the loaf of bread?
4. If John can drink one barrel of water in 6 days, and Mary can drink one barrel of water in 12 days, how many days would it take them to drink one barrel of water together?
5. A man buys a pig for $60, sells it for $70, buys it back for $80, and sells it finally for $90. How much profit has he made, in dollars?
6. Jerry received both the 15th highest and the 15th lowest mark in the class. How many students are in the class?
7. A turtle starts crawling up a 6-yard-high rock wall in the morning. During each day it crawls 3 yards and during the night it slips back 2 yards. How many days will it take the turtle to reach the top of the wall?

Repeated PD Game Instructions

You will participate in 24 sequences. Each sequence consists of one or more rounds.

In each round, you play a game.

Specifically, you will have to choose between action X or action Y. Your opponent also chooses between action X or action Y.

The combination of your action choice and that of your opponent results in one of the four cells shown in the payoff table below (which will be the same table in each round).

	X	Y
X	**75**, *75*	**15**,*120*
Y	**120**, *15*	**30**, *30*

In this table, the rows refer to your action and the columns refer to your opponent's actions. The first number in each cell (in bold) is your payoff in points and the second number in each cell (in italics) is your opponent's payoff in points. Thus for example, if you choose X and your opponent chooses Y, then you earn 15 points and your opponent earns 120 points.

In all 24 sequences, you will play this game against the computer. That is, your opponent is a computer program.

The rule the computer follows in choosing between action X or Y is this:

- In the first round of each sequence the computer will always choose X.
- Starting from the second round of each sequence, the computer's choice will be completely determined by your previous choices in that sequence:
  - If you have ever chosen Y in previous round(s) of the current sequence, the computer will choose Y in all remaining rounds of the current sequence.
  - Otherwise, the computer will choose X.

There is no randomness in the computer's choice, and its choice does not depend on your choices in any sequences other than the current one.

After choices are made by you and the computer, you learn the results of the round, specifically, your point earnings and those earned by the computer. A random number generator is used to determine whether the current sequence continues on with another round, or if the current round is the last round of the sequence.

Whether the sequence continues with another round or not depends on the probability (or chance) of continuation for the sequence. This continuation probability for a sequence is prominently displayed on your decision screen and remains constant for all rounds of a given sequence. However, this continuation probability can change at the start of each new sequence, so please pay careful attention to announcements about the continuation probability for each new sequence. Whether a sequence continues depends on whether at the end of a round the random number generator drew a number in the interval [1,100] that is less than or equal to the continuation probability (in percent).

For example, if the continuation probability in a sequence is 40%, then, after round 1 of the sequence, which is always played, there is a 40% chance that the sequence continues on to round 2 and a 60% chance that round 1 is the last round of the sequence. Whether continuation occurs depends on whether the random number generator drew a number from 1 to 100 that is less than or equal to 40. If it did, then the sequence continues on to round 2. If it did not, then round 1 is the final round of the sequence. If the sequence continues on to round 2, then after that round is played, there is again a 40% chance that the sequence continues on to round 3 and a 60% chance that round 2 is the last round of the sequence, again determined by the random number generator for that round. And so on.

Thus, the higher is the continuation probability (chance), the more rounds you should expect to play in the sequence. But since the continuation probability is always less than 100%, there is no guarantee that any sequence continues beyond round 1.

At the end of the experiment, you will be paid your point earnings from six sequences, randomly selected so that each selected sequence has a different continuation probability. Each point you earn over all rounds in each of the 6 randomly selected sequences is worth

$0.01 in US dollars, that is, the greater are your point earnings, the greater are your money earnings.

Comprehension quiz

Now that you have read the instructions, before proceeding, we ask that you answer the following comprehension questions. For your convenience, we repeat the payoff table below, which you will need to answer some of these questions. In this table, the rows indicate your choice and the columns indicate the computer's choices.

	X	Y
X	**75**, *75*	**15**,*120*
Y	**120**, *15*	**30**, *30*

The first number in each cell (in bold) is your payoff in points and the second number in each cell (in italics) is the computer's payoff in points.

Questions

1. If, in a round, you chose X and the computer program chose X, what is your payoff in points for the round? What is the computer program's payoff?
2. If, in a round, you chose Y and the computer program chose X, what is your payoff in points for the round? What is the computer program's payoff?
3. If, in a round, you chose Y and the computer program chose Y, what is your payoff in points for the round? What is the computer program's payoff?
4. If you have chosen Y in any prior round of the current sequence, what will the computer program choose in the current round of the sequence? Choose: X or Y
5. True or false: At the start of each sequence, you will know exactly how many rounds will be played in the sequence. Choose: True or False
6. True or false: If, in a sequence, the continuation probability is 75%, then you can expect that there will be more rounds in that sequence, on average, than in a sequence with a continuation probability of 25%. Choose True or False

Repeated PD Games

After a subject had successfully completed all quiz questions, the experiment proceeded on to the first indefinitely repeated PD game. For each such game, subjects were instructed clearly about the continuation probability for that repeated game. For instance, Figures D5-D9 show illustrative screenshots from the first indefinitely repeated game of the "orderlong" treatment. Table A1 reports on the continuation probability for each of the 24 sequences along with the actual number of rounds played for the two treatment orders.

Sequence Start

Sequence 1 has begun.

In the first round of this and every sequence, the computer chooses X, but whether the computer continues to choose X depends on the choices that you make.

In each round of this sequence, there is a 67.0% chance that the sequence continues to another round, and a 33.0% chance that this round will be the last round of the sequence.

Next

Figure D5: Start screen for a new sequence

Sequence 1, round 1

The chance of continuing to another round in this sequence is 67.0%.

Remember, in the payoff table below, the row indicates your choice and the column indicates the computer's choice.

The first number in each cell in **boldface** is your payoff and the second number in *italics* is the computer program's payoff.

	X	Y
X	**75** *75*	**15** *120*
Y	**120** *15*	**30** *30*

Since this is the first round of a sequence, the computer will always choose **X**.

Please make your choice for this round by clicking the button "X" or "Y" in the table above.

Figure D6: Main decision screen for a period in the sequence

Results of sequence 1, round 1

You chose Y this round.

Following its rule, the computer has chosen X.

Therefore, your payoff this round is 120.0 points.

Based on the random number drawn, sequence 1 will CONTINUE with another round.

Next

History of Rounds in this Sequence

Sequence	Chance to Continue	Round	Your choice	Computer's Choice	Payoff
1	0.67	1	Y	X	120.0 points

Figure D7: Results screen for a period in the sequence

Sequence 1, round 2

The chance of continuing to another round in this sequence is 67.0%.

Remember, in the payoff table below, the row indicates your choice and the column indicates the computer's choice.

The first number in each cell in **boldface** is your payoff and the second number in *italics* is the computer program's payoff.

	X	Y
X	**75** *75*	**15** *120*
Y	**120** *15*	**30** *30*

Based on your choices in previous rounds of this sequence, the computer will choose **Y.**

Please make your choice for this round by clicking the button "X" or "Y" in the table above.

History of Rounds in this Sequence

Sequence	Chance to Continue	Round	Your choice	Computer's Choice	Payoff
1	0.67	1	Y	X	120.0 points

Figure D8: Decision screen for a continuation period in the sequence, noting what the robot player will do, based on the history of play

Results of sequence 1, round 4

You chose Y this round.

Following its rule, based on your choices in previous rounds, the computer has chosen Y.

Therefore, your payoff this round is 30.0 points.

Based on the random number drawn, sequence 1 has ENDED.

Next

History of Rounds in this Sequence

Sequence	Chance to Continue	Round	Your choice	Computer's Choice	Payoff
1	0.67	1	Y	X	120.0 points
1	0.67	2	Y	Y	30.0 points
1	0.67	3	Y	Y	30.0 points
1	0.67	4	Y	Y	30.0 points

Figure D9: Screen for the final period of a sequence noting that based on the random drawn, the sequence has ended.