ESSAYS ON CONDITIONAL COOPERATION

By

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A thesis submitted for the degree of

Doctor of Philosophy in Economics

Department of Economics

University of Essex

July 2025

Author's declaration

I, Yi Shi, confirm that the work presented in this thesis is my own. Where information has been derived from other sources, I confirm that this has been indicated in the thesis.

I declare that the work in this thesis was carried out in accordance with the requirements of the University's Regulations and that it has not been submitted for any other academic award.

All errors remain mine.

Signed by: Yi Shi
Date: July 28, 2025

Acknowledgements

First and foremost, I would like to express my deepest gratitude to my supervisors, Professor Jayant Ganguli and Dr Mikhail Freer, for their continuous support and advice throughout my PhD journey. Their insightful guidance and discussions have been invaluable to my growth as a researcher. I feel very privileged to have such great supervisors.

I am also very grateful to the faculty members in the Department of Economics. During my time at Essex, I benefited countless times from discussions and conversations with them. In particular, Lucas Siga, Dennie Van Dolder, Friederike Mengel, and Albin Erlanson for their helpful comments and suggestions.

Moreover, I would like to thank my wonderful colleagues and friends for their company and support throughout my studies. In particular, Yiwei Li, Camila Comunello, Bin Yu, Pavlos Balamatsias, Mullika Jantakad, Lu Liu, Panupong Sukkerd, Paulo Morais.

Finally, to my parents and sister, for their unconditional love and support. To Lizhu Fu—your presence and company have made this long journey so much smoother and easier, for which I am truly grateful.

Funding Statement

The experimental work reported in Chapter 2 of this thesis was made possible by Seedcorn Funding from the Essex Behavioural Science Lab (ESSEXLab), for which I am sincerely grateful.

Abstract

This thesis consists of three chapters, studying the role of reciprocity and the nature of conditional cooperation.

In Chapter 1, we theoretically investigate how reciprocity can be modelled so that it remains compatible with a wide range of experimental findings. We introduce a new definition of kindness with two components in our model: intentional kindness and consequential kindness. We also propose a new definition of efficient strategy that resolves paradoxes found in earlier behavioural models. Finally, we show that our framework reflects the results of a host of laboratory games, including the ultimatum game and the sequential prisoner's dilemma, which neither standard theory nor existing reciprocity models can fully explain.

In Chapter 2, we experimentally study conditional cooperation, an instance of reciprocity that is particularly applicable to social dilemmas. Reciprocity can be broadly defined as taking a more altruistic action in response to a more generous action. This chapter aims to better understand the nature of conditional cooperation and in turn the nature of reciprocity, given that existing models of reciprocity fail to explain some of the empirical regularities. We use sequential prisoner's dilemma games to conduct a thorough study on payoffs that can potentially affect conditional cooperation. We experimentally investigate conditional cooperation by considering generosity separately in terms of first-mover payoffs and second-mover payoffs, which has not been done previously. We find that both aspects of generosity are present and affect the choices of the second-mover. The findings suggest the need for richer frameworks of reciprocity than those are currently used.

In Chapter 3, we further analyze the nature of conditional cooperation in sequential prisoner's dilemma games using revealed preference methods. We disentangle context-free quasi-monotone preferences—where individuals prefer choices that improve their own payoff at least as much as they do for others—from conditional cooperation. By definition, conditional cooperation is context-dependent and closely tied to reciprocity. To capture this, we propose the concept of reciprocal preferences, which reflects how varying contexts affect conditional cooperation. Our model offers a method for identifying conditional cooperation in experimental settings.

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CHAPTER 1

Kindness Matters: A Theory of Reciprocity

1.1 Introduction

There is considerable laboratory and real-world evidence suggesting that people care about the behavioural intentions and consequences of others. They are willing to bear a personal cost to reward kind behaviour (known as positive reciprocity) and, conversely, to punish unkind behaviour (known as negative reciprocity). For example, tourists tip the tour guide after a pleasant journey even though they are unlikely to encounter the tour guide again, charities can increase the propensity of potential donors to donate when solicitation letters are accompanied by gifts (Falk, 2007), while responders may reject unfair offers in ultimatum games, even though the theoretically optimal response would be to accept them (Güth et al., 1982). In the growing body of work on experimental games over the last three decades, reciprocity considerations have cast doubt on the classic assumptions of rationality and material self-interest[1]. All these observations raise a fundamental question: What determines kind and unkind behavior?

[1]See, for example, work on the dictator game (Andreoni & Bernheim, 2009), the ultimatum game (Güth et al., 1982, Thaler, 1988, Falk et al., 2003, Falk & Fischbacher, 2006), the prisoner's dilemma (Clark & Sefton, 2001, Ahn et al., 2007, Dhaene & Bouckaert, 2010, Klempt, 2012, Charness et al., 2016, Engel & Zhurakhovska, 2016, Orhun, 2018, Baader et al., 2024), and the gift-exchange game (Fehr & Schmidt, 1999, Berg et al., 1995).

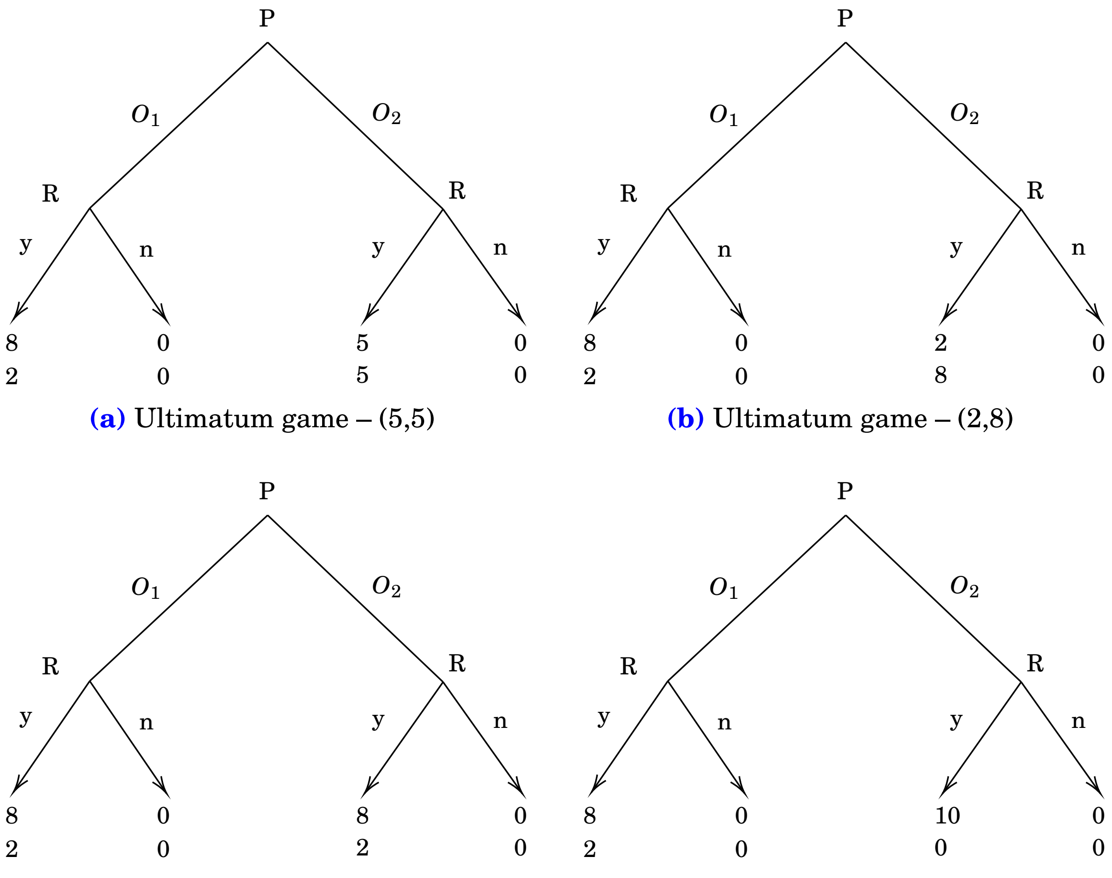
There have been papers that aim to answer this question. Among these studies, two prominent classes can be distinguished: one is models on distributional concerns (Fehr & Schmidt, 1999, Bolton & Ockenfels, 2000), which focus more on *the consequences of the behaviour*. Such models suggest that decision makers care not only about their own final material payoffs but also about the final material payoffs of other players. This raises a problem for some experimental studies (Falk et al., 2003, Dhaene & Bouckaert, 2010), as individuals in fact also take into account the intentions of other players. This leads to the second class of models, which centers on intentional concerns (Rabin, 1993, Dufwenberg & Kirchsteiger, 2004), emphasizing *the intentions of the behaviour*. Such models highlight that decision makers consider the intentions behind other players' actions.

In his seminal paper, Rabin (1993) introduces the intention-based reciprocity model for simultaneous-move games, proposing a formal definition of kindness based on beliefs and the reference point. Building on this framework, Dufwenberg & Kirchsteiger (2004) extend the model to sequential games. In both models, players form beliefs about the intentions of others and evaluate their kindness accordingly. An action is viewed as kind (or unkind) if it yields an intended material payoff that is greater (or smaller) than a specific reference point. This reference point is simply defined as the average of the highest and lowest material payoffs that the decision maker could potentially receive.

The model developed by Dufwenberg & Kirchsteiger (2004) provides an intuitive and influential framework for understanding kindness in strategic interactions. However, some existing experimental studies (Falk et al., 2003, Orhun, 2018) suggest that the model may face limitations in fully explaining the observed experimental findings.

The issues raised in Dufwenberg & Kirchsteiger (2004) can be effectively illustrated by the four ultimatum games shown in Figure 1.1, originally from Falk et al. (2003). They investigated the behavior of the responder (R) in response to the proposer's (P) O_1 offer. Consider two games in Figures 1.1a and 1.1b. According to the model proposed by Dufwenberg & Kirchsteiger (2004), the O_1 offer in Figures 1.1b should be perceived as less kind than the O_1 offer in Figures 1.1a. Therefore, we would expect a higher proportion of responders to reject (choose n) the O_1 offer in Figure 1.1b than in Figure 1.1a. However, the experimental findings contradict this prediction: 44.4% of responders rejected the O_1 offer in Figure 1.1a, whereas only 26.7% did so in Figure 1.1b.

Moreover, consider Figures 1.1c and 1.1d. Dufwenberg & Kirchsteiger (2004) predicts that the O_1 offer in Figures 1.1d should be perceived as more kind than the O_1 offer in Figures 1.1c. Therefore, if we observe some responders rejecting the O_1 offer, we would expect fewer responders to do so in Figure 1.1d than in Figure 1.1c. However, the experimental results indicate that there is no statistically significant difference between the two games. Moreover, 18% of responders rejected the O_1 offer in Figure 1.1c, where the proposer has no alternative options—i.e., intentions are not present.



(a) Ultimatum game – (5,5)

(b) Ultimatum game – (2,8)

(c) Ultimatum game – (8,2)

(d) Ultimatum game – (10,0)

Figure 1.1: The mini-ultimatum games from Falk et al. (2003)

To address the issues raised in the existing literature, in this paper, we first investigate the efficient strategy before considering the kindness of other players. As stated in Rabin (1993) and Dufwenberg & Kirchsteiger (2004), "wasteful play" should not be included in the evaluation of kindness. Our new definition successfully resolves the paradox that arises in their definitions of efficient strategy (a more detailed discussion is provided in Section 1.5.1). For instance, our definition considers the O_2 offer to be inefficient in Figure 1.1d, and thus it should be excluded from kindness evaluations. Consequently, we should observe consistent behavior by the responders in their replies to the O_1 offer in both Figure 1.1c and Figure 1.1d.

Next, given the limited explanatory power of existing models based on experimental evidence, we revisit the central issue of when one's behaviour can be perceived as kind in our model from two perspectives: intentional kindness and consequential kindness. Our definition of kindness allows us to explain a wide range of experimental games—such as the ultimatum game (Falk et al., 2003) and the sequential prisoner's dilemma (Orhun, 2018)—which cannot be explained by existing behavioural models.

To capture other players' intentions, Dufwenberg & Kirchsteiger (2004) define the intentional kindness of others based on what those players could give to the decision maker. In other words, the definition remains limited to the payoffs of the decision maker alone. The definition provided by Dufwenberg & Kirchsteiger (2004) is undoubtedly crucial, but we argue that it is one-sided and incomplete. Building on their framework, in our model, we propose a new definition of intentional kindness that further incorporates the status of the other players—that is, the material payoffs of other players are also taken into account when assessing intentional kindness. To explain: it is clear that the responder would receive more if the proposer chose the O_2 offer in Figure 1.1b than in Figure 1.1a. In this sense, the proposer's choice of the O_1 offer appears less kind in Figure 1.1b than in Figure 1.1a. However, one must also consider the proposer's potential payoffs. Choosing the O_2 offer results in a much worse outcome for the proposer in Figure 1.1b (a material payoff of 2) than in Figure 1.1a (a material payoff of 5). Thus, the proposer has an excuse for not choosing the O_2 offer because "one cannot unambiguously infer from his unwillingness to propose an unfair offer to himself that he wanted to be unfair to the responder" (Falk et al., 2003).

To achieve this, we introduce a new *reference point* (more details in Section 1.3.3). In this reference point, two elements of intentions are included:

1. What the decision maker can get: this depends on the decision maker's material payoffs and reflects whether other players are being (un)kind.

2. What the decision maker should get: this depends on the material payoffs of the other players and reflects the extent to which they are being (un)kind.

Apart from the intentions of other players, the consequences of an action constitute another central component of our model. These consequences refer to the final payoff distributions resulting from the decision maker's action and help explain why people may still respond negatively even in the absence of intentions: people care about what they could have obtained relative to others. They experience disutility from receiving less than others. That is why some responders still reject the O_1 offer even when it is the default option (Figure 1.1c). Our model also includes consequential kindness to make the model complete.

The rest of the paper is organized as follows: Section 1.2 reviews the literature. In Section 3.4, we present our model, which incorporates consequential kindness and intentional kindness into the decision maker's utilities. We also develop the concept of expected reciprocity equilibrium (ERE) and prove its existence. Section 1.4 applies our model to several experimental games: the ultimatum game (Falk et al., 2003), the sequential prisoner's dilemma and the sequential prisoner's dilemma with punishment (Orhun, 2018). These games are selected because existing behavioural models fail to explain the corresponding experimental findings. We show that our model is consistent with the experimental results. Section 1.5 discusses the differences between our model and those of Rabin (1993) and Dufwenberg & Kirchsteiger (2004), such as the efficient strategies and the implications for equilibrium. Section 1.6 concludes.

1.2 Literature Review

In order to explain behavior that deviates from pure self-interest and strict rationality, two main classes of models can be distinguished: consequence-based models and intention-based models. Consequence-based models (Fehr & Schmidt, 1999, Bolton & Ockenfels, 2000, Charness & Rabin, 2002) claim that fairness refers to the final distribution of material payoffs. A decision maker's behaviour is driven not only by their own material payoffs, but also by how much others gain relative to them. For example, Fehr & Schmidt (1999) assume that an agent feels envy if other players' material payoffs exceed their own, and feels guilt or discomfort when other players receive less. Moreover, the agent experiences greater disutility when another player gains more than when they themselves gain more than another player. The model of Bolton & Ockenfels (2000) assumes that the decision maker cares about their relative status, and that their utility depends on their own material payoff relative to the average payoff of all players. This class of models captures the primary determinants of other-regarding behaviour. A similar model is proposed by Falk & Fischbacher (2006). Although their model includes beliefs and intentions, the perception of kindness is determined by expected material payoffs: if "player i believes that player j aims to let them get more out of the exchange than player j wants for themselves," then player i perceives player j as kind. The model also incorporates the intention factor, but it uses a set of predefined values to determine how a player seeks to behave kindly or unkindly.

Another class is intention-based reciprocity models, built on the framework of psychological games (Geanakoplos et al., 1989, Battigalli & Dufwenberg, 2009), focuses on underlying intentions as a key influence on preferences (Rabin, 1993, Dufwenberg & Kirchsteiger, 2004, Falk & Fischbacher, 2006). In a normal-form setting, Rabin (1993) uses the decision maker's beliefs about other players' actions, as well as their beliefs about the other players' beliefs regarding their own actions, to assess kindness. Empirical studies have revealed surprising effects of move order (Cooper et al., 1993, Weber et al., 2004, Camerer, 1997, Dhaene & Bouckaert, 2010), where outcomes differ substantially from those in simultaneous-move games. This highlights the importance of sequential moves in the study of reciprocity. Dufwenberg & Kirchsteiger (2004) address this issue in their sequential reciprocity model, which extends Rabin's model to sequential games. They introduce three key changes compared to Rabin (1993), thereby proposing a different structure of preferences for the decision maker. One controversial change is their definition of an efficient strategy, which is independent of players' beliefs—whereas Rabin's definition is belief-dependent. The limitations of Rabin's definition are discussed in

Dufwenberg & Kirchsteiger (2004). Regarding the belief-independent definition, Isoni & Sugden (2019) argue that it leads to a paradox in trust games. Although Dufwenberg & Kirchsteiger (2019) responded to this critique by proposing a new definition, the paradox remains unresolved. Another debated change involves belief-updating rules, whereby a player's evaluation of their opponents' kindness depends on their most updated beliefs at each decision node. Jiang & Wu (2019) argue that the belief-updating rule in Dufwenberg & Kirchsteiger (2004) is not appropriate for games with more than two players. They propose an alternative rule that categorizes players' beliefs based on whether perceived kindness is evaluated using their most updated forms.

The experimental literature provides extensive evidence on the effects of reciprocity (Dawes & Thaler, 1988, Falk, 2007). One typical experiment is the ultimatum game, in which the proposer makes an offer and the responder decides whether to accept or reject it (Güth et al., 1982, Thaler, 1988, Blount, 1995). Contrary to predictions based on pure self-interest, experimental results suggest that proposers often make generous offers, and responders frequently reject positive but unequal offers. As a responder might put it: "I would rather give up some material payoffs than accept an unfair offer." Falk et al. (2003) explore the nature of fairness through four mini-ultimatum games. They find that people evaluate fairness based not only on the consequences of actions, but also on the perceived intentions behind them. A similar result is observed in the moonlighting game (Falk et al., 2008), in which player A first chooses a number a, denoting the transfer. If $a \geq 0$, A gives B the amount a; if $a < 0$, A takes a from B. In the case where $a \geq 0$, the experimenter triples the amount, so B receives $3a$. After observing A's choice, player B can respond with a reward or punishment. They find that 40% subjects exhibit both positively and negatively reciprocal responses. Another widely studied experimental setting is the prisoner's dilemma. For example, Clark & Sefton (2001) and Dhaene & Bouckaert (2010) show that reciprocity influences individual behaviour. Ahn et al. (2007) find that players in advantageous positions are less likely to cooperate to reward their opponent. Baader et al. (2024) find that variation in cooperative behaviour with payoffs aligns with the predictions of consequence-based models. However, Orhun (2018) show that existing reciprocity models fail to explain subjects' behaviour when the second mover has the opportunity to punish uncooperative behaviour.

When we discuss reciprocity, the central question often concerns how kindness is conceptualized. In addition to the models mentioned above, Çelen et al. (2017) propose a new definition of kindness based on the notion of blame: suppose I were in the other player's position and consider whether I would choose an action that is more or less kind than the one actually chosen. If I would choose a kinder action, I blame the opponent; otherwise, I blame myself. Dufwenberg et al. (2013) incorporate the concept of vengeance and develop the notion of vengeance equilibrium to reflect negative reciprocity. Sohn & Wu (2022) extend the Dufwenberg & Kirchsteiger (2004) model by introducing uncertainty, exploring the threshold of cooperation, and proposing an extended sequential reciprocity equilibrium. Finally, Battigalli & Dufwenberg (2022) review the literature on belief-dependent motivations within the framework of psychological game theory.

1.3 The Model

Model Overview — our model introduces three main components that distinguish it from existing models (Rabin, 1993, Dufwenberg & Kirchsteiger, 2004). The first component is the efficient strategy, which serves as the model's starting point. Before evaluating kindness, we identify all efficient strategies—a step whose importance is discussed in Section 1.5.1. The second and third components are intentional kindness and consequential kindness, respectively. Intentional kindness is the core of our model and plays a crucial role in explaining observed experimental findings. We propose a new definition of intentional kindness and introduce a novel reference point standard for its evaluation. The third component, consequential kindness, incorporates the envy element from Fehr & Schmidt (1999), thereby completing the model.

1.3.1 Baseline framework

Our discussion in this paper will be confined to two-player, multi-stage, extensive-form games with finite actions at each stage and complete and perfect information. Therefore, the player's choice appears sequentially and can be fully observed.

Focusing on multi-stage games with observable actions helps the formulation of strategies and beliefs, while preserving the model's general relevance, as such games are the primary focus of most applied and experimental research.

Formally, let $N = \{1, 2\}$ be the set of players, H be the set of choice profiles, or histories. $A_{i,h}$ be the set of actions for player $i \in N$ at $h \in H$. Player i's behavioural strategies is denoted by $\sigma_i \in \times_{h \in H} \Delta(A_{i,h}) =: \Delta_i$. It assigns at each history $h \in H$ a probability distribution over a set of pure actions of player $i \in N$. Define $\Delta = \prod_{i \in N} \Delta_i$. Furthermore, player i's pure strategy is denoted by $s_i \in S_i$.

With $\sigma_i \in \Delta_i$, $h \in H$, $\sigma_{i,h}$ denotes the strategy that prescribes the same choice as σ_i, except for the choice that decides history h that is made with probability 1. The material payoff of player i is given by $\pi_i : \Delta \to \mathbb{R}$. The material payoff means cash or some other measurable quantity (e.g. the number of vouchers), which denotes the selfish payoffs that we generally use in the classical game theory.

Moreover, our discussion in this paper includes the utility from intentions which reflect a player's psychological consideration. Like other intention-based reciprocity models (Rabin, 1993, Dufwenberg & Kirchsteiger, 2004), therefore, we apply the framework of psychological game theory (Geanakoplos et al., 1989, Battigalli & Dufwenberg, 2009). That is, when playing the game, player i's beliefs about others' strategies (first-order belief) and about others' beliefs about their own strategy (second-order belief) are important as they can influence the player's inference about others' intentions. Furthermore, in sequential games, the choice that a player has made can be fully observed by their opponents at each stage. Hence, the updating rule is also necessary (more explanations can be found in Dufwenberg & Kirchsteiger (2004)). With this objective in mind, we define two types of beliefs (first-order belief and second-order belief) with updating rules[2].

In this paper, as we mainly consider a two-player game, for notational convenience, we use i and j to refer to the two different players.

[2]Some scholars, such as Lianjie Jiang et al. (2018), argue that the Dufwenberg & Kirchsteiger (2004) definition of updating rules causes a series of problems, but these drawbacks are of no relevance to the two-stage games studied in this work.

Definition 1 (Beliefs and updating rules). *Let $b_i \in B_i = \Delta_j$ be player i's first-order belief and $b_{i,h}$ be the updated first-order belief that specifies player j's behavioural strategy that leads to history h. $c_i \in C_i = \Delta_i$ denotes player i's second-order belief and $c_{i,h}$ denotes the updated second-order belief that specifies player i's behavioural strategy that leads to history h.*

Example. Ultimatum game-(5,5) in Figure 1.1a. Definition 1 describes that after observing some actions, each player update their first-order belief and second-order belief to match the past actions. Assume the responder initially forms the first-order belief b_R with $b_R(O_1) = 0.3$ and $b_R(O_2) = 0.7$. After observing the O_1 offer, the responder updates their belief to $b_{R,O_1}(O_1) = 1$ and $b_{R,O_1}(O_2) = 0$. In the same fashion, suppose the responder forms the initial second-order belief c_R with $c_R(y|O_1) = 0.4$ and $c_R(n|O_1) = 0.6$. Once the responder has made their choice, assume y after the O_1 offer, then they update their second-order belief with $c_{R,y|O_1}(y|O_1) = 1$ and $c_{R,y|O_1}(n|O_1) = 0$.

Notice that Definition 1 implies that players give up their past probabilistic beliefs when pure actions are realized. As a result, the actions of others are always interpreted as intentional and deliberate choices, rather than as mistakes or random deviations.

1.3.2 Efficient strategy

The idea of reciprocity suggests that we would like to reward those who give us more (interpreted as kind) and punish those who give us less (interpreted as unkind). However, what if the only reason that other people give us more is that they can also benefit from this action? How do we identify the purpose of their action and define their kindness? both Rabin (1993) and Dufwenberg & Kirchsteiger (2004) emphasize that before evaluating one's kindness, we should first rule out all wasteful strategies that no one is motivated to play. They argue that an appropriate definition of an *efficient strategy* can help. Nonetheless, as discussed in Section 1.1 and further explored in Section 1.5, existing definitions of efficient strategy cause a range of problems. Especially for so-called *punishment without cost*:

Punishment without cost. *Assume that the material payoff of player i is $\pi_i(a_{i,h}, a_{j,h})$ and that of player j is $\pi_j(a_{i,h}, a_{j,h})$. If, for some $a'_{i,h} \neq a_{i,h}$, it holds that $\pi_i(a_{i,h}, a_{j,h}) = \pi_i(a'_{i,h}, a_{j,h})$ and $\pi_j(a_{i,h}, a_{j,h}) < \pi_j(a'_{i,h}, a_{j,h})$, then the action $a_{i,h}$ is referred to as punishment without cost relative to $a'_{i,h}$.*

For the ultimatum game in Figure 1.1d, after proposer's choice of the O_2 offer, responder's choice of n (reject the O_2 offer) can be viewed as punishment without cost compared to y (accept the O_2 offer).

As we have mentioned in Section 1.1, the O_1 offer in Figure 1.1d is indeed the same as the O_1 offer in Figure 1.1c from the perspective of the responder. So what is the implication? In Figure 1.1c, the O_1 offer and the O_2 offer are the same for the proposer. Clearly, we are not able to read any intention from the proposer's action. In Figure 1.1d, although the proposer has two different options, the experimental results reported by Falk et al. (2003) implies that that the O_2 offer in Figure 1.1d does not influence the responder's inference about the proposer's intentions. It suggests that having the O_2 offer in Figure 1.1d cannot make the O_1 offer more kind/unkind from the perspective of the responder. Why does the responder behave this way?

To understand this phenomenon, let us try to infer the responder's consideration in Figure 1.1d. On the one hand, the responder will receive zero material payoff regardless of whether they accept or reject if the proposer chooses the O_2 offer. On the other hand, the responder has the chance to receive a material payoff of 2 if they accept the O_1 offer. Therefore, the O_2 offer can never be a kind behaviour. Now, given the chance to punish this unkind behaviour without any cost (the material payoffs of rejecting or accepting the O_2 offer are both zero), the responder should choose n since no one is motivated to reward an unkind behaviour[3].

Correspondingly, if the responder believes that the proposer believes the responder never rewards an unkind behaviour (means the O_2 offer must lead to n), then the proposer should never select the O_2 offer from the perspective of the responder since this would lead both players to the worst material payoff pair (0,0). Hence, the O_1 offer in Figure 1.1d will be the only choice for the proposer from the perspective of the responder. In other words, the O_2 offer should be considered a

[3]In Falk et al. (2003) experiment, around 90% chose n after O_2.

"wasteful play" that should not be taken into consideration in Figure 1.1d when the responder considers the underlying intentions of the proposer. That is why the reponders behave the same in Figure 1.1c and Figure 1.1d after the O_1 offer.

Similar situations frequently arise in other games and settings. It is essential to rule out such wasteful strategies before evaluating intentional kindness—a goal also pursued by Rabin (1993) and Dufwenberg & Kirchsteiger (2004). To address this issue, we introduce the concept of the potential worst outcome (PWO).

PWO as a sequential rationality refinement. To rule out all wasteful strategies, the idea of sequential rationality seems to be feasible. We can define a special second-order belief that assigns the probability 1 to a strategy that satisfies sequential rationality. But we noticed that it sometimes does not work as expected, e.g., punishment without cost. Based on our inference and discussion, we propose a refinement of sequential rationality by adding the idea of "potential worst outcome" to define a special second-order belief to rule out all wasteful strategies. To this end, we adopt three steps to meet our purpose: in step (i), we find the most advantageous strategy that should be unique for player i (by sequential rationality); in step (ii), if σ_i does not satisfy (i) because σ_i might be not unique, then player i may have the chance to punish their opponents without cost. Here we suppose that the player i would punish their opponent to satisfy our definition of "worst outcome"; and in step (iii), if σ_i does not satisfy (ii) because σ_i is still not unique, then there exist multiple strategies that bring both players the same material payoffs. The payoffs of players are indifferent between these strategies, thus i chooses randomly.

Definition 2 (Special second-order belief). *For all $h \in H$, $\sigma_i \in \Delta_i$ and $\sigma_j \in \Delta_j$, let $\hat{\Delta}_{i,h} \equiv \arg\max_{\sigma_{i,h} \in \Delta_{i,h}} \pi_i(\sigma_{i,h}, \sigma_{j,h})$ and define $c_i^{pwo} \in C_i^{pwo} \subseteq \hat{\Delta}_{i,h}$ as follows:*

$$\sigma_{i,h} \in C_i^{pwo} \begin{cases} \textit{if either (i) } \pi_i(\sigma_{i,h}, \sigma_{j,h}) > \pi_i(\sigma'_{i,h}, \sigma_{j,h}) \ \forall \ \sigma'_{i,h} \in \Delta_{i,h} - \{\sigma_{i,h}\} \\ \textit{or if (ii) } \pi_j(\sigma_{i,h}, \sigma_{j,h}) < \pi_j(\sigma'_{i,h}, \sigma_{j,h}) \ \forall \sigma'_{i,h} \in \hat{\Delta}_{i,h} - \{\sigma_{i,h}\} \\ \textit{or if (iii) } \pi_k(\sigma_{i,h}, \sigma_{j,h}) = \pi_k(\sigma'_{i,h}, \sigma_{j,h}) \ \forall \ k \in \{i,j\} \ \forall \sigma'_{i,h} \in \hat{\Delta}_{i,h}. \end{cases}$$

Example. Ultimatum game-(10,0) in Figure 1.1d. To find c_R^{pwo}, notice that $\pi_R(y|O_1) > \pi_R(n|O_1)$ and thus $c_R^{pwo}(y|O_1)$= 1, However, if we consider the history of play is the O_2 offer, we find that $\pi_R(y|O_2) = \pi_R(n|O_2)$. Then we need to move to Definition 2(ii)[4]. Since $\pi_P(n|O_2) < \pi_P(y|O_2)$, then we get $c_R^{pwo}(n|O_2)$=1.

Definition 2 provides us with a way to rule out wasteful strategies. Furthermore, we apply this special second-order belief C_i^{pwo} for player i to define the efficient strategy for player j.

Definition 3 (Efficient strategy). *Define an efficient strategy set for $j \in \{1,2\}$ as follows:*

$$E_j^{pwo} = \left\{ \sigma_j \in \Delta_j \;\middle|\; \begin{array}{l} \textit{if } \nexists\, \sigma'_j \in \Delta_j \textit{ such that for all } h \in H \textit{ and } c_i^{pwo} \in C_i^{pwo}\textit{:} \\ (i)\ \pi_k(\sigma'_{j,h}, c_i^{pwo}) \geq \pi_k(\sigma_{j,h}, c_i^{pwo})\ \forall k \in \{i,j\} \textit{ and} \\ (ii)\ \pi_k(\sigma'_{j,h}, c_i^{pwo}) > \pi_k(\sigma_{j,h}, c_i^{pwo})\ \textit{ for some } k \in \{i,j\} \end{array} \right\}.$$

Definition 3 excludes a strategy σ_j such that if there exists at least one σ'_j which describes the choice that leads to Pareto-superior outcomes given the special second-order belief C_i^{pwo}.

Example. To illustrate this definition, we still use ultimatum game-(10,0) in Figure 1.1d. Recall that we have obtained $c_R^{pwo}(y|O_1)$=1 and $c_R^{pwo}(n|O_2)$=1 by Definition 2. From the perspective of the responder, according to the Definition 3, playing the O_2 offer is not efficient now since $(0,0) < (8,2)$.

Thus only the O_1 offer will be taken into consideration in Figure 1.1d, recall that the O_1 offer and the O_2 offer are indifferent in Figure 1.1c. The behaviour for the responder now should be the same between two games. This result is consistent with our inference and the experimental results.

In addition to the games discussed above, our definition successfully addresses some other potential problems encountered with existing definitions. We discuss this in detail in Section 1.5.

[4]This is the difference compared with the sequential rationality. If we apply the idea of the sequential rationality, then the responder has no preference between y and n when the proposer plays the O_2 offer. However, we want to evaluate the player's intention, so our definition 2(ii) serves the purpose.

1.3.3 Kindness

Kindness consideration is important to understand decision maker's behaviour. In our model, we consider the kindness by two elements: intentions and consequences. According to our model, the utility consists of three parts: the decision maker's material payoffs, **intentional kindness** Ψ_i and **consequential kindness** Φ_i.

1.3.3.1 The intentional kindness

Having defined the efficient strategy, we can move to one important part of kindness - intentions behind the behaviour. We are not the first one to propose that intentions matter as discussed in Section 1.1. But we have also argued that existing ideas of underlying intentions retains some potential drawbacks and can not explain some experimental findings. So we interpret the intentional kindness again and propose our view of the underlying intentions.

What is the intentional kindness? *We do not expect others to sacrifice their own material payoffs to help (or hurt) us, but once they do, we perceive them as intentionally kind (or unkind). In response, we are willing to bear a cost to reward (or punish) them in return.*

As aforementioned in Section 1.1, in two ultimatum games shown in Figure 1.1a and Figure 1.1b, the responder may reject the the O_1 offer if they perceive the proposer as acting unkindly. This raises two questions: what factors determine the responder's perception of being treated kindly or unkindly, and to what extent?

It is easy to answer the first question: apart from the possibility that they can receive 2 or 0 (if the proposer chooses the O_1 offer), the responder can potentially get 5 in Figure 1.1a and 8 in Figure 1.1b (if the proposer chooses the O_2 offer). Such consideration makes the O_1 offer in both games to be unkind.

In terms of to what extent that the proposer is unkind, from the responder's perspective, the proposer would receive 8 if they choose the O_1 offer, but only 5 if they choose the O_2 offer in Figure 1.1a, and just 2 if they choose the O_2 offer in Figure 1.1b. Given this, the proposer's decision to choose the O_1 offer in Figure 1.1b may appear more acceptable than in Figure 1.1a, as no one is expected to help others at a significant cost on their own payoff.

Our view of the intentional kindness captures two questions outlined above. Following Rabin (1993) and Dufwenberg & Kirchsteiger (2004), we continue to use the idea of a reference point to capture intentional kindness. However, instead of simply using the average of the lowest and highest possible payoffs, we adopt a different standard to define the reference point to evaluate intentional kindness.

Definition 4 (Reference point). *Let the reference point of player i be*

$$\pi_i^r(c_i) = \sum_{s_j \in E_j^{pwo}} \vartheta(c_i, s_j) \cdot \pi_i(c_i, s_j).$$

Intention function $\vartheta(c_i, s_j)$. Generally, $\vartheta(c_i, s_j)$ has the following four properties: (i) $\vartheta(c_i, s_j)$ is non-decreasing in $\pi_j(c_i, s_j)$, $\frac{\partial \vartheta(c_i,s_j)}{\partial \pi_j(c_i,s_j)} \geq 0$ where $s_j \in E_j^{pwo}$, and non-increasing in $\pi_j(c_i, \tilde{s}_j)$, $\frac{\partial \vartheta(c_i,s_j)}{\partial \pi_j(c_i,\tilde{s}_j)} \leq 0$ where $\tilde{s}_j \in E_j^{pwo} - \{s_j\}$; (ii) if we have $\pi_j(c_i, s_j) \geq \pi_j(c_i, \tilde{s}_j)$, then we must have $\vartheta(c_i, s_j) \geq \vartheta(c_i, \tilde{s}_j)$; (iii) we must have $\vartheta(c_i, s_j) > 0$ $\forall s_j \in E_j^{pwo}$; and (iv) we have $\sum_{s_j \in E_j^{pwo}} \vartheta(c_i, s_j) = 1$. The first two properties guarantee that others would like to choose the action that brings them a higher material payoff; the last two properties ensure that the reference point is located between the lowest and highest material payoff that player i might receive. For our purpose, the logistic quantal response function (McKelvey & Palfrey, 1995) can be an appropriate one[5]: $\vartheta(c_i, s_j) = \frac{\exp[\lambda \cdot \pi_j(c_i,s_j)]}{\sum_{\hat{s}_j \in E_j^{pwo}} \exp[\lambda \cdot \pi_j(c_i,\hat{s}_j)]}$, as it satisfies all four of our properties; for simplicity, this specific function will be used with $\lambda = 1$ in the rest of the paper.

Reference point, as a crucial part in the kindness evaluation, should reflect two things: what decision maker i can get (depends on the decision maker's material payoffs) and what decision maker i should get (depends on the material payoffs of other player j). Our definition of reference point suggests such considerations where $\pi_i(c_i, s_j)$ measures what player i can get and $\vartheta(c_i, s_j)$ measures what player i should get and to what extent player j sacrifices their own material payoff in

[5] Other functions can also be applied as the intention function as long as they satisfy the four properties.

helping player i. It is convincing that player j is more likely to choose the action that can bring themselves a higher material payoff from the perspective of player i. The intention function $\vartheta(c_i, s_j)$ serves the purpose.

We introduce the new reference point for two main reasons. (1). The drawback of the existing definition of the reference point is that using "equitable payoff" as a simple principle to determine kindness means that people do not consider their decisions deeply and analytically (Messick, 1995). They simply take a quick read on a situation and then make their decision. However, In most experimental games and real-world observations, this heuristic processing produces incoherent results, especially when there is an option for costly punishment (e.g. prisoner's dilemma with punishment, ultimatum games). Moreover, if we have more than two actions, "equitable payoff" might be pointless as it is very easy to reject kind behaviour when the highest material payoff is too large and easy to accept behaviour that is not quite kind when the lowest material payoff is very small. (2). our reference point takes into consideration a player's material payoff as well as that of their opponent. It is convincing in explaining the player's psychological concerns. Besides, applying our definition in Section 1.4, the efficiency is approved by the experimental results where the "equitable payoff" fails to predict such empirical results.

Having defined the reference point, we now turn to the intentional kindness term.

Definition 5 (Intention part). *Player i's belief about how intentionally kind player $j \neq i$ is to i at history $h \in H$ is given by the following function:*

$$k_j(b_{i,h}, c_{i,h}) = \pi_i(b_{i,h}, c_{i,h}) - \pi_i^r(c_{i,h}),$$

Having $\pi_i^r(c_{i,h})$ as a reference standard, $k_j(b_{i,h}, c_{i,h}) > 0$ suggests that player i perceives player j as intentionally kind, $k_j(b_{i,h}, c_{i,h}) < 0$ suggests that player i perceives player j as intentionally unkind, and $k_j(b_{i,h}, c_{i,h}) = 0$ suggests that player i perceives player j as neither intentionally kind nor intentionally unkind.

Having introduced Definitions 4 and 5, we can specify player i's utility from the intentional kindness intention term. We use Ψ_i to denote the intentional kindness.

Definition 6 (Intentional kindness). *Player i's utility from the intentional kindness at history $h \in H$ is defined by*:

$$\Psi_i(\sigma_{i,h}, b_{i,h}, c_{i,h}) = \beta_i \cdot k_j(b_{i,h}, c_{i,h}) \cdot \pi_j(\sigma_{i,h}, b_{i,h}),$$

where β_i is an exogenously given non-negative number, which measures how sensitive player i is to the intention concerns with respect to player j.

A value of β_i=0 indicates that player i does not care about whether player j intends to help or hurt them, while β_i>0 means that player i cares about the underlying intentions of player j and prefers to give player j more material payoff for kind behaviour and less material payoff for unkind behaviour. The larger β_i is, the more player i cares about the underlying intentions.

1.3.3.2 The consequential kindness

With the intentional kindness term Ψ_i, we find that for most experimental games, it provides us with a reasonable explanation of the player's behaviour. However, there still exists some shortcomings. For example, the experimental results in Figure 1.1c (Falk et al., 2003) suggest that if we only consider the intention term, then the responder should always accept the offer since there does not exist any intentions for the proposer as the proposer is forced to propose the (8,2) offer. In reality, this is not the case: some responders still reject the offer in the experiment. Therefore, the intentional kindness term Ψ_i alone fails to explain players' reciprocal behaviour.

A large amount of experimental and theoretical evidence demonstrates the importance of relative gains between players (Fehr & Schmidt, 1999, Bolton & Ockenfels, 2000, Charness & Rabin, 2002, Falk et al., 2003), especially for those who are inequity-averse. Fehr & Schmidt (1999) argue that individual behaviour is driven not only by selfishness but also by concerns for others' well-being. In their model, the utility of one player comprises three parts: their own material payoff, the disutility for gaining less than others, and the disutility for gaining more than others. From the experiment of (Falk et al., 2003), the authors do find that non-negligible portions of responders reject the (8,2) offer even it is the only offer that the proposer can provide, however, almost all responders accept the offer that takes responders higher material payoffs than the proposer. It is very intuitive that if the (2,8) offer is the only offer for the proposer, the responder have no incentive to reject the offer. This is especially evident in sequential games, where no player is motivated to choose an action that reduces their own payoff in order to reduce inequity.

Therefore, in our model, we have the following assumption. In addition to the purely selfish players, there exist players who dislike unequal outcomes. Specifically, they think they are experiencing consequential unkindness if they are worse off in material payoffs than their opponents. To illustrate our idea more directly, we introduce the following notation. We set $L_i(\sigma_{i,h}, b_{i,h}) = \min\{\pi_i(\sigma_{i,h}, b_{i,h}) - \pi_j(\sigma_{i,h}, b_{i,h}), 0\}$, which describes that player i might suffer disutility if and only if they gain less than player j (a negative difference). This is exactly the envy component of Fehr & Schmidt (1999) model. We employ the term Φ_i to denote the consequential kindness.

Definition 7 (Consequential kindness). *Player i's utility from the consequential kindness at history $h \in H$ is defined by*

$$\Phi_i(\sigma_{i,h}, b_{i,h}) = \alpha_i \cdot L_i(\sigma_{i,h}, b_{i,h}),$$

where α_i is an exogenously given non-negative number, which measures how sensitive player i is to the consequence concerns with respect to player j. Different individuals and different opponents might have different values of α_i.

A value of α_i=0 indicates that player i does not care about how much player j might receive compared to what they receive, while α_i >0 indicates that player i suffers disutility when obtaining less than others.

1.3.4 The utility function and the equilibrium

Having defined two important kindness elements, the consequence part Φ_i and the intention part Ψ_i, we can move to the utility of player i in sequential games.

Definition 8 (The utility function). *The utility of player i at history $h \in H$ is a function $U_i : \Delta_i \times B_i \times C_i \to \mathbb{R}$ defined by*

$$U_i(\sigma_{i,h}, b_{i,h}, c_{i,h}) = \pi_i(\sigma_{i,h}, b_{i,h}, c_{i,h}) + \Psi_i(\sigma_{i,h}, b_{i,h}, c_{i,h}) + \Phi_i(\sigma_{i,h}, b_{i,h}),$$

where Ψ_i represents player i's utility from the intentional kindness and Φ_i represents player i's utility from the consequential kindness.

The value of α_i and β_i are large (small) for these who care (do not care) about reciprocity. The values $\alpha_i = \beta_i = 0$ suggest that player i does not care about kindness, in which case the problem is reduced to classic game theory.

We have by now fully incorporated the reciprocity concerns into our model. We then look for equilibrium in which player i chooses optimal σ_i that maximizes their utility at the given history h. The players' initial first and second order beliefs are required to be correct, and will be updated based on the updating rules as explained in definition 1.

Definition 9 (Expected reciprocity equilibrium). *The profile $\sigma^* = (\sigma_i^*)_{i \in N}$ is an expected reciprocity equilibrium (ERE) if for all $i \in N$ and for each history $h \in H$ it holds that*

(i) $\sigma_{i,h}^* \in \underset{\sigma_i \in \Delta_{i,h}(\sigma^*)}{\arg\max} \quad U_i(\sigma_i, b_{i,h}, c_{i,h})$

(ii) $b_i = \sigma_j^*$ for all $j \neq i$

(iii) $c_i = \sigma_i^*$ for all $j \neq i$

The equilibrium indicates that at history h each player makes the optimal decisions given equilibrium strategy and beliefs at other histories. Moreover, first and second order beliefs are correct and are updated as the game progresses.

Theorem. *An expected reciprocity equilibrium always exists.*

The proof follows the strategy in Dufwenberg & Kirchsteiger (2004). The key point is that that the perceived intentional kindness at some history h depend on the beliefs and second order beliefs about the actions following all histories. In other words, the behaviour in unreached histories has effects on the preferences. So, the backward induction that are usually used for proofs in standard game theory fails. As in the Dufwenberg & Kirchsteiger (2004), the existence proof can be addressed by analyzing all histories simultaneously. The detailed proof can be found in Appendix A.1.

1.4 Applications

In this section we apply our model to two well known and experimentally tested games: the ultimatum game and the sequential prisoner's dilemma game. We discuss the predictions of our model in these games and compare them with those of Dufwenberg & Kirchsteiger (2004). All games we will analyze are extensive games, and we mainly focus on the second mover's behaviour based on the corresponding experimental settings.

We start with the four mini-ultimatum games introduced as examples in Sections 1.1 and 3.4, depicted in Figures 1.1a–1.1d. These games were originally proposed by Falk et al. (2003), who observed that the rejection rate of the O_1 offer decreases progressively from Figure 1.1a to Figure 1.1c. These games illustrate not only the role of negative reciprocity motives in shaping responder behavior, but also how contextual variations influence the strength of these motives.

Next, we review the sequential prisoner's dilemma games with and without punishment, in which the material payoff structures and original form are taken from the experimental study of Orhun (2018). These games can help us to understand the positive reciprocity and why decision makers bear a cost to help others. The experimental results show that the chance of punishment for the second player decreases their perception of how kind the first player is, which is in agreement with our predictions (the detailed predictions of Dufwenberg & Kirchsteiger (2004) can be found in Orhun (2018) paper).

For each game in the following analysis, we begin by presenting the game structure and the corresponding experimental findings. We then briefly summarize the predictions derived from Dufwenberg & Kirchsteiger (2004) and from our own model. Detailed calculations and extensive proofs are provided in Appendix A.2.

1.4.1 Negative reciprocity: four mini-ultimatum games

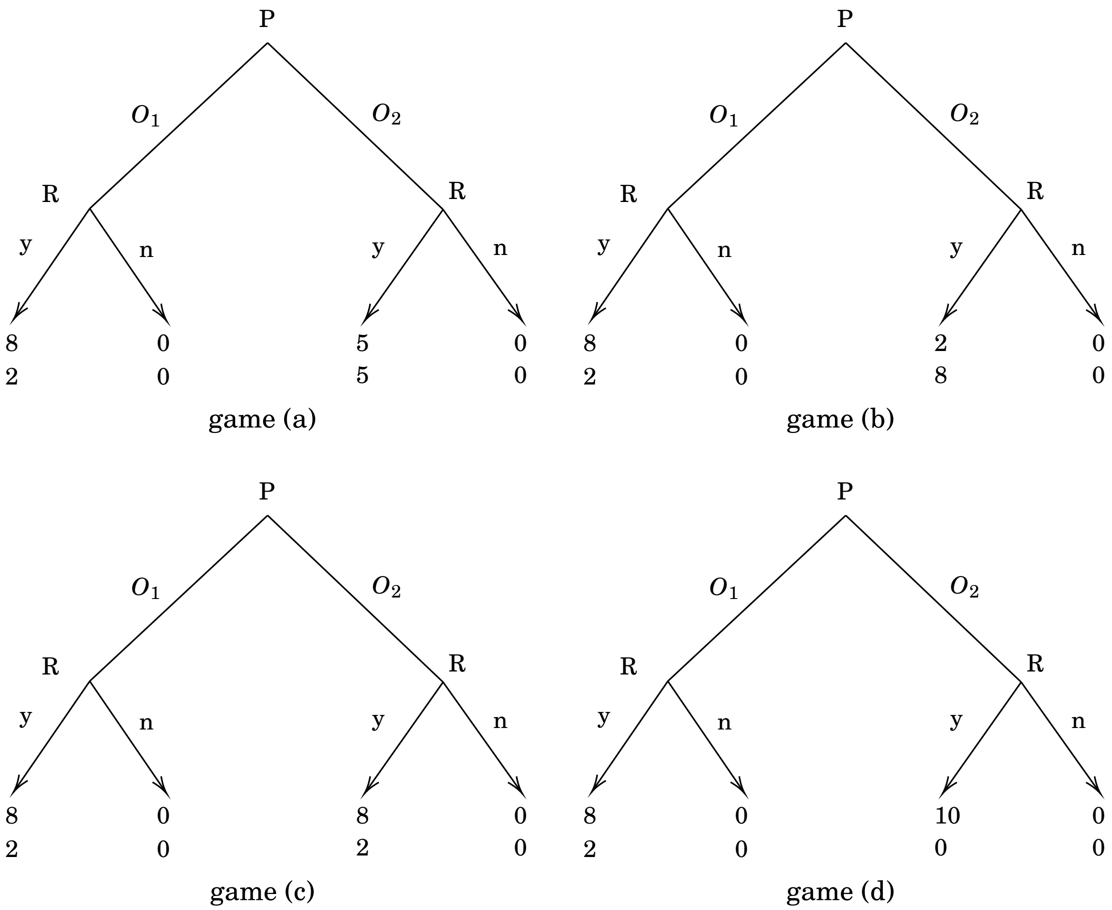


Figure 1.2: Four mini-ultimatum games from Falk et al. (2003)

The ultimatum game is one of the most well-known games that reflects negative reciprocity. As discussed in previous sections, in the ultimatum game, the proposer as the first mover allocates a fixed amount of money between them and the responder. The responder as the second mover either accepts or rejects the offer. If they accept, the resulting payoffs follow the allocation made by the proposer. In case of rejection, the payoffs are zero for both the proposer and the responder. The standard economic theory (rational material payoff maximisers) predicts that the responder should accept any non-zero offer. While researchers have experimentally observed that there is a large share of participants reject the non-zero offer (Falk et al., 2003). Rejection always implies that the responder would like to sacrifice their own material payoff to punish the proposer (negative reciprocity). Therefore, when the responder decides to accept or reject the allocation is crucial.

The experimental ultimatum games analyzed in this section are the same as those previously introduced in Section 1.1. For ease of reference, we reproduce these games in Figure 1.2.

Table 1.1: Rejection rate of the O_1 offer across games in Figure 1.2

games	Rejection Rate (%)
(a)	44.4
(b)	26.7
(c)	18.0
(d)	8.9

The games in Figure 1.2 are proposed by Falk et al. (2003). Experimental results from Table 1.1 indicate that the rejection rate (by choosing n) after the O_1 offer decreases from game (a) to game (d). Falk et al. (2003) find that the differences in rejection rates between any two games are statistically significant, except for the difference between game (c) and game (d), which is not significant ($p = 0.369$, two-sided). Therefore, the rejection rates across the four games follow this order: game (a) > game (b) > game (c) = game (d).

Moreover, the rejection rates of the O_2 offer are as follows. Nobody rejected the O_2 offer in game (a), and only one subject rejected the O_2 offer in game (b). Almost 90% rejected the O_2 offer in game (d).

By adopting our model and Dufwenberg & Kirchsteiger (2004) model, predictions can be summarized as follows:

Comparison 1. Efficient Strategy:

Dufwenberg & Kirchsteiger (2004): in games (a) - (d), all strategies are efficient.

Our model: in games (a) - (c), all strategies are efficient; in game (d), for those strategies of proposer that assign positive probability to the O_2 are not efficient.

Dufwenberg & Kirchsteiger (2004) definition of efficient strategy (see Section 1.5.1) implies that all available strategies are efficient. Therefore, choosing the O_1 offer in game (d) can be viewed as a kind action, as accepting the O_1 offer provides the responder with higher material payoffs compared to any response following the O_2 offer. Therefore, if we observe some responders rejecting the O_1 offer (by choosing y), we would expect fewer responders to do so in game (d) than in game (c).

By adopting our model, Definition 2 and Definition 3 tell us that the O_2 offer is not efficient in game (d). If the O_2 offer is not efficient, it will not be taken into account when responder evaluates the kindness of the O_1 offer. That is, game (c) and game (d) are essentially the same for the responder when facing the O_1 offer. Therefore, the rejection rate between game (c) and game (d) should be indifferent.

The prediction from our model is consistent with the experimental findings. More detailed comparisons about the different definitions of efficient strategies will be discussed in Section 1.5.1.

Comparison 2. game (a) vs. game (b):

Dufwenberg & Kirchsteiger (2004): the responder is more likely to accept (by choosing y) the O_1 offer in game (a) than in game (b).

Our model: the responder is more likely to accept (by choosing y) the O_1 offer in game (b) than in game (a).

From the perspective of accepting the O_1 offer in game (a) and game (b), our model and that of Dufwenberg & Kirchsteiger (2004) yield completely opposite predictions.

In their model, the kindness of the proposer depends entirely on the responder's own payoff. Specifically, the maximum payoff for the responder is 5 (y after the O_2 offer) in game (a) and 8 (y after the O_2 offer) in game (b). Choosing the O_1 offer in game (b) yields a payoff that is further from this maximum than in game (a). As a result, the O_1 offer in game (b) is perceived as less kind than the O_1 offer in game (a), making the responder less likely to accept it. Therefore, their model predicts that the responder is more likely to accept the O_1 offer in game (a) than in game (b). Detailed mathematical calculations are provided in Appendix A.2.

In our model, by contrast, the perceived kindness of the proposer depends on both the responder's payoffs and the proposer's payoffs. Specifically, in addition to considering what the responder could receive—as in Dufwenberg & Kirchsteiger (2004)—our model also accounts for what the responder should receive, by assigning different weights to the proposer's possible choices. Intuitively, the O_1 offer should be more likely to be chosen in game (b) than in game (a), because the O_2 offer is significantly worse for the proposer in game (b) than in game (a). It is therefore more reasonable to expect the proposer to choose the O_1 offer in game (b). As a result, the responder should be more likely to accept the O_1 offer in game (b) than in game (a). Detailed mathematical calculations are provided in Appendix A.2.

Moreover, both our model and that of Dufwenberg & Kirchsteiger (2004) predict that the responder is more likely to accept the O_1 offer in game (c) and game (d) than in game (a) and game (b). In games (c) and (d), neither model attributes negative intentions to the proposer. In contrast, choosing the O_1 offer in games (a) and (b) is perceived as reflecting negative intentions. As a result, the O_1 offer is more likely to be accepted in games (c) and (d) than in games (a) and (b).

The prediction from our model is totally consistent with the experimental findings – the rejection rates across the four games: game (a) > game (b) > game (c) = game (d).

Comparison 3. game (c) vs. game (d):

Dufwenberg & Kirchsteiger (2004): the responder will always accept the O_1 offer (by choosing y) in game (c) and game (d).

Our model: the responder will reject the O_1 offer (by choosing n) in game (c) and game (d) only if $\alpha_R > 1/3$.

Dufwenberg & Kirchsteiger (2004) suggest that in the absence of any intentions, the responder will behave like a rational player. This is why their model predict choice y following the O_1 offer in game (c). In the case of game (d), as previously mentioned, the O_1 offer is considered a kind action in their model, and thus, no one would be expected to reject a kind offer.

In our model, we make different predictions. First note that based on definition of efficient strategy, the O_1 offer is the only reasonable offer for proposer, so the intentional kindness part k_P is zero for the responder after the O_1 offer in both game (c) and game (d). Furthermore, the O_1 offer is an unequal offer as accepting it takes responder less than the proposer. The utility of playing y after the O_1 offer: $U_R(y|O_1) = 2+(2-8)\alpha_R$ and of playing n after the O_1 offer: $U_R(y|O_1) = 0+(0-0)\alpha_R$. Therefore, if $\alpha_R > 1/3$, $U_R(y|O_1) < U_R(n|O_1)$ must hold. This implies that the responder will reject the O_1 offer when $\alpha_R > 1/3$. The result indicates that the aversion against inequitable outcomes plays a role. This is the same as the experimental findings where 18% of responders reject the O_1 offer when proposer has no options.

This is also why our model incorporates consequential kindness: even without intentions, people's behavior may still deviate from the predictions of purely rational choice.

1.4.2 Positive reciprocity: the sequential prisoner's dilemma

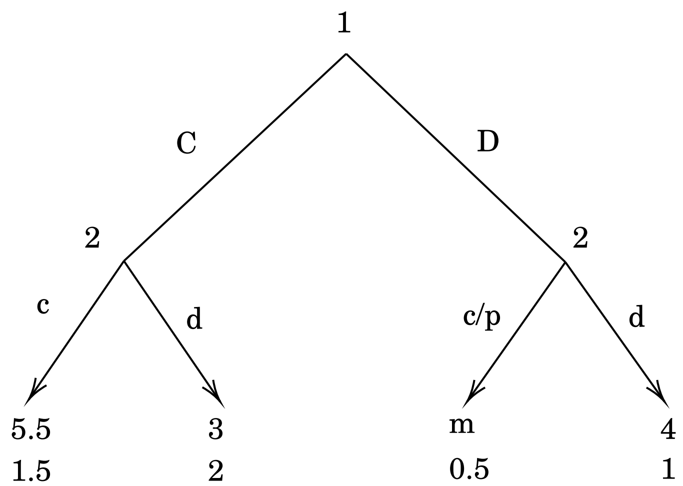


Figure 1.3: The sequential prisoner's dilemma with/without punishment

In the sequential prisoner's dilemma, the first mover can either cooperate or defect. After observing the first mover's choice, the second mover faces the same choice. The standard subgame-perfect solution is that both parties defect. However, many experimental studies reveal that mutual cooperation might be another possible solution (Ahn et al., 2001, Dhaene & Bouckaert, 2010, Charness et al., 2016, Engel

& Zhurakhovska, 2016, Gächter et al., 2021, Baader et al., 2024, Schneider & Shields, 2022).

In this section we analyse the sequential prisoner's dilemma with and without punishment, as shown in Figure 1.3, the settings are proposed by Orhun (2018). Their experimental results reflect the issues from the existing models[6]. In Figure 1.3, $m = 1.5$ means that player 2 has the option to punish player 1 (with cost) if player 1 treats them unkindly by choosing D. With $m = 6.5$, punishment is not available, while player 2 has a chance to reward player 1's unkind behaviour D at a cost.

Table 1.2: Results of the game shown in Figure 1.3

Version	2 Choice $(c/p\|D)$ (%)	2 Choice $(c\|C)$ (%)
$m = 1.5$	25.00	34.55
$m = 6.5$	04.17	56.52

Table 2 lists the players' behaviour in experiments on the game from Figure 1.3 with different values of m. First, we notice that almost no subject (4.17%) would like to reward player 1's unkind behaviour D at a cost (choice $(c|D)$ and $m = 6.5$), while one quarter subjects would like to punish player 1's unkind behaviour D at a cost (choice $(p|D)$ and $m = 1.5$). More importantly, the experimental results suggest that more player 2s choose to cooperate following player1's cooperation when punishment for player 1's defection is absent than when it is available.

Comparison 4. $m = 1.5$ vs. $m = 6.5$:

Dufwenberg & Kirchsteiger (2004): Player 2 is more likely to cooperate (c) given player 1's cooperation (C) when $m = 1.5$ than when $m = 6.5$.

Our model: Player 2 is more likely to cooperate (c) given player 1's cooperation (C) when $m = 6.5$ than when $m = 1.5$.

Orhun (2018) remarks the predictions of Dufwenberg & Kirchsteiger (2004) under different treatments (see Appendix A.2). The prediction from Dufwenberg &

[6]The Dufwenberg & Kirchsteiger (2004) model predicts a more positive reciprocity environment in the case with $m = 1.5$ than when $m = 6.5$. Hence, player 1 is more kind when $m = 1.5$ than when $m = 6.5$.

Kirchsteiger (2004) model suggests that player 2 is more likely to cooperate (by choosing c) given that player 1's cooperation (player 1 chose C) when $m = 1.5$ than when $m = 6.5$. The reason is that the chance of punishment potentially reduces the minimum payoff (is 1 when $m = 6.5$, is smaller than 1 when $m = 1.5$ as player 2 may choose to punish player 1's defection) of player 2. This further implies the kindness of player 1 in $m = 1.5$ is larger than $m = 6.5$ from the perspective of player 2. Therefore, player 2 will be more likely to cooperate after cooperation when $m = 1.5$ than $m = 6.5$.

Unfortunately, the experimental results tell a different story from the predictions of Dufwenberg & Kirchsteiger (2004). To understand why punishment decreases player 2's propensity to cooperate after player 1's cooperation, let us try to infer player 1's intentions. In the treatment with $m = 6.5$, player 2 may interpret player 1's cooperation as a willingness to sacrifice their own material payoff to benefit player 2—that is, cooperation signals kindness. However, such intentions are less apparent when $m = 1.5$, as player 2 cannot clearly infer player 1's motives. There are two possible reasons for player 1 to cooperate. One is the same as in the $m = 6.5$ treatment. The other is more strategic: to avoid punishment. Consequently, player 2 is more likely to cooperate after player 1 cooperates in the $m = 6.5$ treatment (56.52%) than in the $m = 1.5$ treatment (34.55%).

Our model fully captures this idea. To see this, our model suggests a higher reference point when $m = 1.5$ than when $m = 6.5$. As noted in Definition 5, a higher reference point implies a lower value of perceived kindness from player 1, which in turn leads to a weaker reciprocal response. Therefore, Player 2 is more likely to cooperate after cooperation when $m = 6.5$ than when $m = 1.5$. Our prediction is consistent with the experimental findings. Detailed mathematical calculations are provided in Appendix A.2.

There are more experimental sequential prisoner's dilemma games can be explained by our model. For example, one can apply the same method to check Ahn et al. (2007) sequential prisoner's dilemma games with asymmetric payoffs. Our model also get the same predictions as their experimental findings suggest.

1.5 Discussion

1.5.1 Comparison of efficient strategy

1.5.1.1 Three definitions of efficient strategy

The definition of efficient strategy in Rabin (1993) is a set that depends on player i's beliefs. It can be expressed as:

$$E_i^{Rabin}(b_i) = \left\{ \sigma_i \in \Delta_i \;\middle|\; \begin{array}{l} \text{if } \nexists\, \sigma_i' \in \Delta_i \text{ such that:} \\ (i)\pi_k(\sigma_i', b_i) \geq \pi_k(\sigma_i, b_i) \text{ for all } k \in \{i,j\} \\ (ii)\pi_k(\sigma_i', b_i) > \pi_k(\sigma_i, b_i) \text{ for some } k \in \{i,j\} \end{array} \right\}$$

This definition indicates that player i's action is efficient if and only if it is Pareto efficient given the first-order belief b_i. Consider Figure 1.4 for $a = 2.5$ as an example (similar example also provided in Dufwenberg & Kirchsteiger (2019)). Assume that player 1 believes player 2 will choose d following D. Assume furthermore that player 1 assigns probability p to the prospect that player 2 will choose c following C. Now ask: is player 1 kind? According to the $E_i^{Rabin}(b_i)$, the answer is yes if and only if $p \leq 1/2$; if $p > 1/2$ then choice D no longer sits in $E_i^{Rabin}(b_i)$. Since Rabin (1993) cares about normal-form games, thus they do not have belief updating rules like in Dufwenberg & Kirchsteiger (2004) and our model, it retains some limitations when we study the extensive-form games (see discussion in Dufwenberg & Kirchsteiger (2004) paper as well).

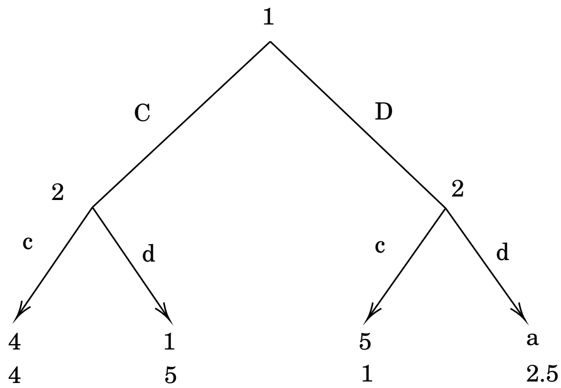


Figure 1.4: The sequential prisoner's dilemma

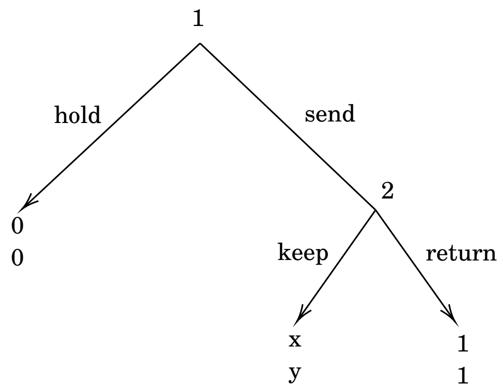


Figure 1.5: The trust game

In order to extend the study to a more general analysis, Dufwenberg & Kirchsteiger (2004) have proposed another definition of efficient strategy that does not depend on player's beliefs; they use the following definition:

$$E_i^{DK} = \left\{ \sigma_i \in \Delta_i \;\middle|\; \begin{array}{l} \text{if } \nexists\, \sigma_i' \in \Delta_i \text{ such that:} \\ (i)\pi_k(\sigma_{i,h}', \sigma_{j,h}) \geq \pi_k(\sigma_{i,h}, \sigma_{j,h}) \text{ for all } h, \sigma_j, k \in \{i,j\} \\ (ii)\pi_k(\sigma_{i,h}', \sigma_{j,h}) > \pi_k(\sigma_{i,h}, \sigma_{j,h}) \text{ for some } h, \sigma_j, k \in \{i,j\} \end{array} \right\}$$

In this definition, they point out that player i's strategy should be efficient if it is Pareto efficient for at least one strategy for player j. That is, a strategy is not efficient if there is another strategy that leads to a higher material payoff for any player in the game. This definition performs better than Rabin (1993) definition in many situations, but we will see that it still retains a series of limitations and paradoxes.

In our definition, to understand the truly intentional kindness of the player (if they aim to be kind or avoid punishment), we propose a special second-order belief C_i^{pwo} through Definition 2, which is based on the intuition of the potential worst outcome. The definition can help us to select the efficient strategies:

$$E_j^{pwo} = \left\{ \sigma_j \in \Delta_j \;\middle|\; \begin{array}{l} \textit{if } \nexists\, \sigma_j' \in \Delta_j \textit{ such that for all } c_i^{pwo} \in C_i^{pwo} \textit{ and } h \in H\textit{:} \\ (i)\ \pi_k(\sigma_{j,h}', c_i^{pwo}) \geq \pi_k(\sigma_{j,h}, c_i^{pwo})\ \forall k \in \{i,j\} \textit{ and} \\ (ii)\ \pi_k(\sigma_{j,h}', c_i^{pwo}) > \pi_k(\sigma_{j,h}, c_i^{pwo})\ \textit{ for some } k \in \{i,j\} \end{array} \right\}$$

1.5.1.2 Paradox with the definition of efficient strategy

When considering players' intentions, some strategies are inherently wasteful. Before evaluating the kindness of other players, it is essential to rule out such strategies. To address this, three definitions are proposed as above. However, existing definitions also raise certain issues.

Let us take the game in Figure 1.4, with $a = 0$ and $a = 2.5$, as one example. Note that player 1's C can always benefit player 2 compared with player 1's D since player 2 can receive more material payoffs no matter what their response is $(4, 5 > 1, 2.5)$, but with different intentions under different a. In the case of $a = 2.5$, player 1 can receive at least 2.5 (if player 2 plays d) when player 1 chooses D. On the other hand, if player 1 plays C, they might receive 1 (if player 2 plays d) although they might get a positive payoff of 4 (if player 2 plays c). Here we might infer that since player 1 puts themselves in a fragile position to help player 2 obtain a larger payoff, player 1 is kind. When $a = 2.5$, we can see the limitation of $E_i^{Rabin}(b_i)$ as discussed before. Our definition and Dufwenberg & Kirchsteiger (2004)'s definition both indicate that C and D are efficient. Under Rabin's definition, however, the action D is efficient only when player 1's first-order belief $b_1(c|C)$ is greater than 1/2, otherwise only C is efficient. Therefore, $E_i^{Rabin}(b_i)$ rules out some strategies that are efficient. Moreover, $E_i^{Rabin}(b_i)$ excessively depends on the player's beliefs, so is not suitable for the study of sequential games as discussed in Dufwenberg & Kirchsteiger (2004).

On the other hand, in the case of $a = 0$, the worst outcome of playing D is 0 (when player 2 plays d)[7], which is strictly worse than playing C regardless of player 2's response. Therefore, we cannot infer any intentional kindness of player 1 even though they choose C. Under this scenario, we can see drawbacks of Dufwenberg & Kirchsteiger (2004)'s definition of efficient strategy. Our definition suggests that D is inefficient, which is consistent with our inference. In Dufwenberg & Kirchsteiger (2004), however, both C and D are efficient. Dufwenberg & Kirchsteiger (2004)'s definition predicts the same value of kindness for player 1 no matter what the value of a is. This is a contradiction.

Isoni & Sugden (2019) also propose a paradox of trust when studying reciprocity with existing models. They argue that although Dufwenberg & Kirchsteiger (2004)'s model is compatible with the properties of the trust world, it does not provide a psychologically convincing explanation for why reciprocal kindness can clarify the trust world[8]. In Figure 1.5, for example, having G_1: $(x, y) = (1/2, -1/2)$ and G_2: $(x, y) = (1/2, 1/2)$. The paradox appears once we apply their definition. Intuitively, if *send* is perceived as a kind behaviour in G_1, then *send* should also be perceived as kind in G_2, as the only distinction between the two games is that material payoff for *keep* after *send* for player 2 is smaller in G_1 than in G_2. But in Dufwenberg &

[7]This is in fact the only realistic result, since no one is willing to hurt themselves to help an unkind person.

[8]They further argue that Dufwenberg & Kirchsteiger (2004)'s new definition in Dufwenberg & Kirchsteiger (2019) still cannot explain the trust world.

Kirchsteiger (2004), *hold* is not efficient in G_2 (suggesting that *send* should result in 0 kindness) and *hold* is efficient in G_1 (suggesting that *send* should result in positive kindness). Again, this contradicts intuition.

This evidence encourages us to propose a more appropriate methodology to avoid the contradiction, especially when one is able to punish others. Definitions 2 and 3 serve our purpose and provide us with a plausible explanation. If we apply our definition of efficient strategy, in the game in Figure 1.4, D is efficient when $a = 2.5$ but is not efficient when $a = 0$. In Figure 1.5, for both G_1: $(x, y) = (1/2, -1/2)$ and G_2: $(x, y) = (1/2, 1/2)$, only *send* is efficient. Thus the paradox is resolved.

1.5.1.3 Connections between the three definitions

As we have mentioned, Rabin (1993) definition depends on the players' beliefs[9]. It might reject some actions that truly matter, and might cause contradictions in sequential games. Dufwenberg & Kirchsteiger (2004)'s definition does not indicate too much psychological concerns and it leads to paradoxes in many games as indicated in Isoni & Sugden (2019).

Comparison 5. Consider the efficient minimum material payoff of player $i \in N$. Then we must have:

$$E_j^{pwo} \subseteq E_j^{DK} \text{ and } \min_{\sigma_j \in E_j^{PWO}} \pi_i(\sigma_j, \sigma_i) \geq \min_{\sigma_j \in E_j^{DK}} \pi_i(\sigma_j, \sigma_i).$$

Our definition and that of Dufwenberg & Kirchsteiger (2004) are both independent of the players' initial beliefs. However, our definition of an efficient strategy depends on a specific second-order belief. To prove Comparison 1, first note that the Dufwenberg & Kirchsteiger (2004) model initially assumes all strategies are possible. They then exclude a strategy σ'_j if there exists another strategy σ_j that yields Pareto-superior outcomes for all possible strategies (Δ_i) of the other player.

In our model, we first define C_i^{pwo}, which is a subset of Δ_i, i.e., $C_i^{\text{pwo}} \subseteq \Delta_i$. Therefore, when comparing whether strategy σ'_j yields Pareto-superior outcomes relative to σ_j, any strategy deemed efficient under our definition must also be

[9] In our study, we mainly discuss extensive-form games, thus in this section, we compare different definitions of efficient strategy in the sequential environment.

efficient under Dufwenberg & Kirchsteiger (2004)'s definition—but vice versa. Therefore, $E_j^{pwo} \subseteq E_j^{DK}$.

Furthermore, because our model excludes more (or equal) strategies than Dufwenberg & Kirchsteiger (2004) model, the minimum material payoff under efficient strategy in our definition should be less than or equal to Dufwenberg & Kirchsteiger (2004)'s definition. This Comparison also suggests that a player's behaviour would be perceived as less kind and predicts less positive reciprocity in our model than in Dufwenberg & Kirchsteiger (2004) if we use the same reference point standard.

Comparison 6. If there is a game such that $E_i^{Rabin} = E_i^{pwo} = E_i^{DK}$ after ruling out a set of strategies, then these strategies must be strictly worse than all other strategies for both players.

To see this, according to three definitions of efficient strategy. E_i^{Rabin} depends on the player's beliefs, so when one strategy is not strictly better than another strategy for both players, each strategy might be efficient or even both strategies might be efficient strategies (because it depends on the player's beliefs). On the other hand, for E_i^{pwo} and E_i^{DK}, the efficient strategy is fixed because it is independent of the player's initial beliefs. Therefore, if there is a game such that $E_i^{Rabin} = E_i^{pwo} = E_i^{DK}$ after ruling out a set of strategies, then these strategies must lead both players to strictly worse payoffs. In Figure 1.5, for example, with $G_2 : (x, y) = (1/2, 1/2)$, $hold$ must be a wasteful strategy. Therefore, under any of E_i^{Rabin}, E_i^{pwo} or E_i^{DK}, only $send$ is efficient.

1.5.2 Revisiting the sequential prisoner's dilemma

In the last subsection, we have discussed the differences between the three definitions of efficient strategies. In this section, we also want to discuss the intentional kindness in our model and in Dufwenberg & Kirchsteiger (2004).

In Dufwenberg & Kirchsteiger (2004), players derive direct utility from their own material payoffs and psychological utility from perceived kindness. In the most basic formulation of kindness, a player's kindness is calculated relative to a reference point. In their model, this reference point is defined by a specific version of the equitable payoff rule—namely, the average of the player's highest and lowest possible material payoffs. If a player chooses an action that results in a final material payoff for the decision maker that exceeds this reference point, they are perceived as kind. Otherwise, they are not. Notably, in their framework, the decision maker considers only their own material payoffs. In other words, a player's kindness or unkindness is assessed solely based on how their actions affect the decision maker's outcome, without accounting for how much this player gives up their own material payoff to help or hurt the decision maker.

To more directly illustrate how our model differs from that of Dufwenberg & Kirchsteiger (2004), we use a simple sequential prisoner's dilemma as a demonstration. To be the standard sequential prisoner's dilemma, we assume that $4 > n > 1$ and $4 > m > 1$

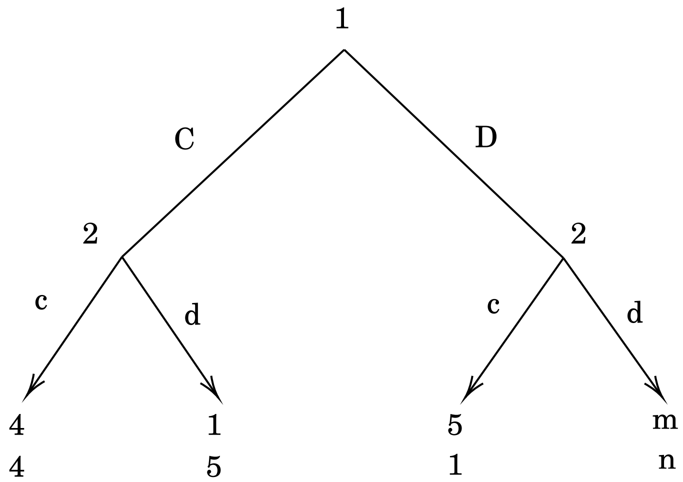


Figure 1.6: The standard sequential prisoner's dilemma

Prediction 1. Dufwenberg & Kirchsteiger (2004)

(1) Player 2 is more likely to cooperate (c) after player 1's cooperation (C) when n decreases.

(2) Player 2's behavior after player1's cooperation (c) remains unchanged when m varies.

Prediction 2. (our model)

Player 2 is more likely to cooperate (c) after player 1's cooperation (C) when

(1) n decreases, and

(2) m increases.

See proof in Appendix A.3.

First, when the value of n varies, our model and Dufwenberg & Kirchsteiger (2004) predict the same result. A smaller value of n suggests a larger kindness from the player 1 (suppose player 1 chooses C) as player 1's cooperation helps player 2 avoid a worse situation of getting n. Thus player 1 deserves a more generous response.

The second aspect concerns the value of m. Dufwenberg & Kirchsteiger (2004) suggests that no matter how the value of m changes, player 2's behavior following player 1's cooperation remains unchanged. This contradicts both our intuition and the experimental results (also the findings presented in Chapter 2). When m is larger, choosing D should be a safer option for player 1. Therefore, when player 1 still chooses C, they appear more kind, which in turn prompts a more cooperative response from player 2. Our model makes such a prediction.

Our prediction also highlights the different impacts of n and m. This may help explain why some studies (e.g., Baader et al. (2024)) do not find evidence of reciprocity, as they typically employ symmetric sequential prisoner's dilemma games where $m = n$. Our result also points to a new experimental direction for investigating the existence of reciprocity and, more importantly, what constitutes reciprocity.

1.6 Conclusion

In this paper, we propose a model of reciprocity that aims to explain a decision maker's reciprocal behaviour by introducing new definitions of efficient strategy, intentional kindness, and consequential kindness.

Our definition of efficient strategy successfully solves the paradox in the trust game (Isoni & Sugden, 2019) and successfully explains the results of a range of experimental studies (Falk et al., 2003). We also compare our definition with two well-known definitions of efficient strategy from Rabin (1993) and Dufwenberg & Kirchsteiger (2004). Then, we split kindness into two parts: intentional kindness and consequential kindness. We argue that when a decision-maker evaluates the intentional kindness of others, they consider not only their own payoffs but also the extent to which others sacrifice their own payoffs to help or harm them. This is also what experimental studies suggest (Falk et al., 2003, 2008, Orhun, 2018, Ahn et al., 2007). We incorporate this idea with a new definition of reference point. Our model also incorporates consequential kindness, assuming that players care about the distribution of outcomes as well. Then we finish our model and develop the concept of ERE and prove its existence.

We apply our model to some famous experimental games such as the ultimatum game, the sequential prisoner's dilemma with/without punishment. Our model is in line with these experimental findings.

According to our theoretical framework, there are several possible further directions can be studied. First, we could focus on a more general case, with more players and more stages in the game. It must be more complicated if players need to interact with more people and play more stages. For example, we could consider whether the updating rules still work in this case (Jiang & Wu, 2019). Moreover, reciprocity under uncertainty is also important since players often have limited information about their opponents (Sohn & Wu, 2022). Finally, we could test whether our model produces the correct predictions in additional experimental settings; for example, most of experimental work on sequential prisoner's dilemma games always starts with symmetric games (Baader et al., 2024, Mengel, 2018). As we have previously discussed, a bidirectional impact may shape the decision maker's choices.

CHAPTER 2

On the Nature of Conditional Cooperation

2.1 Introduction

Conditional cooperation has been a phenomenon documented in both economic literature (Fischbacher et al., 2001, Frey & Meier, 2004, Cubitt et al., 2017) and outside economics (Axelrod & Hamilton, 1981, Rand & Nowak, 2013). Conditional cooperation implies that a player is more prone to cooperate (in a social dilemma) if they believe that that their counterpart would be cooperating. Given it's definition conditional cooperation has been associated with *reciprocity* and should be context dependent. While conditional cooperation has been indirectly documented in various social dilemmas if we consider its context-dependent character (or reciprocity), there is somewhat a lack of clean evidence for it that is not confounded by pro-social preferences and other motives. This paper provides this evidence using a novel experimental design. Moreover, we aim at further studying the link between reciprocity and conditional cooperation.

The prisoners dilemma is the standard setting for studying conditional cooperation (Dal Bó & Fréchette, 2011). Figure 2.1 presents the standard prisoners dilemma (PD) as used for studies of repeated games. However, an important issue when studying conditional cooperation in repeated context using the prisoners dilemma is that path dependence might have an overwhelming effect (Cooper et al., 1996, Dal Bó & Fréchette, 2019). Thus, more recent studies introduced a sequential PD (SPD) as depicted on Figure 2.2 to study conditional cooperation (Baader et al., 2024). In this setting the action of the first-mover is known to the second-mover before she is taking her choice. Thus, second-mover choosing to cooperate after the first-mover has chosen to cooperate, despite it being less profitable, constitutes conditional cooperation.

More importantly, it is crucial to recognize that the traditional experimental setting of symmetric SPDs may cause a non-negligible confound when studying the nature of conditional cooperation, as different payoff parameters may influence conditional cooperation in totally different directions. Therefore, one key distinction between our experimental design and the existing experimental literature on SPDs is that we do not require the game to be symmetric (e.g., $x_1^{CC} = x_2^{CC}$ is not required). Our experimental design allows us to identify the effects of all payoff parameters separately, thereby avoiding any confound and enabling a cleaner test of conditional cooperation.

		Player 2	
		Cooperate	Defect
Player 1	Cooperate	x_1^{CC}, x_2^{CC}	x_1^{CD}, x_2^{CD}
	Defect	x_1^{DC}, x_2^{DC}	x_1^{DD}, x_2^{DD}

Figure 2.1: The prisoner's dilemma

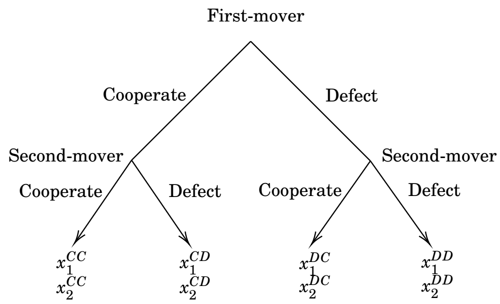


Figure 2.2: The sequential PD

Conditional Cooperation In order to detect the evidence for the presence of conditional cooperation we ask the subjects to make decisions in various modified dictator games and SPDs. The modified dictator games (simple money allocation task between them and another subject in the room) imitate both cooperation path (i.e., after first-mover's cooperation) and defection path (i.e., after first-mover's defection) of the SPD. Hence, we can perform direct within-subject comparisons of conditional cooperation controlled for other motives by contrasting their decisions in cooperation path or defection path of SPD to their decision in the corresponding modified dictator game (DG). We find that, on average, subjects are 10 percentage points more likely to cooperate in SPD than in the corresponding modified dictator games in the cooperation path. Moreover, contrasting the subjects' decisions on defection path in SPD to the corresponding modified dictator games we find no evidence of significant difference. The observation on the defection path is reasonable as these who chose (x_1^{DC}, x_2^{DC}) indicates that they are extremely pro-social given that $x_1^{DC} >> x_2^{DC}$. Consequently, no much difference observed between the two games, suggesting that the second-mover's behavior following defection is relatively stable. Therefore, when analyzing conditional cooperation, it is sufficient to focus on the second-mover's response to the first-mover's cooperation. Taken together, these observations provide clear evidence of conditional cooperation in our analysis.

Reciprocity Reciprocity can be linked to conditional cooperation in multiple ways. The most straight-forward is the idea that if a first-mover chooses to cooperate, then they are performing a generous action, and thus deserve positive payback. However, depending on the extent to which this action – cooperation by the first-mover – is perceived as generous, some indirect effects of reciprocity might be present.

In particular, when contrasting two games a second-mover might be more prone to conditionally cooperate in the game where they would face a much worse outcome, x_2^{DD} if both players defected (Figure 2.1 and Figure 2.2), as the perceived generosity of an action – the first-mover cooperation – should increase with the magnitude of the favor it does to that individual (the second-mover). This is also widely documented in existing reciprocity literature (see Dufwenberg & Kirchsteiger, 2004). However, little discussed in the literature is that the perceived generosity of an action should also depend on how much one has to abandon to do the favor. In the PD / SPD context this could be measured by x_1^{DD} (Figure 2.1 and Figure 2.2), which is the payoff a first-mover would receive if both players defected. The intuition is that a large x_1^{DD} should imply that defection is actually a relatively safe option for first-mover since the second-mover is likely to respond to cooperation by defecting. Hence if the first-mover performs a more trusting action by cooperating, they are more deserving of a positive response.

Note that x_1^{DD}, x_2^{DD} is, to some extent, a relevant outcome payoff, as we observe second-mover defecting in 79.37% of cases after the first-mover defected. Although the effects of x_1^{DD}, x_2^{DD} on conditional cooperation have been studied by Baader et al. (2024), their findings provide limited evidence supporting x_1^{DD}, x_2^{DD} as an explanation for conditional cooperation. This limitation may come from their use of a symmetric SPD, where $x_1^{DD} = x_2^{DD}$, potentially leading to a confound.

An even more interesting effect is the effect of (x_1^{DC}, x_2^{DC}) payoff (Figure 2.1 and Figure 2.2). While it is likely to be rather irrelevant in the case of an SPD, it is instrumental in standard repeated PD since first-mover defecting and second-mover cooperating would have positive probability. Hence, demonstrating that this payoff affects the rate of conditional cooperation in SPD would be strong indicator also for PD. Note that effect of this payoff can be measured in isolation only using the asymmetric SPD, as in the symmetric case it would also affect the (x_1^{CD}, x_2^{CD}) payoff (Figure 2.1 and Figure 2.2) which arises when the first-mover cooperates and the second-mover defects.

Hence, in order to measure the effects of these payoffs we use a series of asymmetric SPDs, changing each payoff separately. In particular, we expect the second-mover to be more reciprocal, if first-mover has chosen to cooperate, when the payoffs after the first-mover's defection are (i) more attractive to first-mover (first-mover gets more), and (ii) less attractive to second-mover (second-mover gets less). We find evidence supporting the reciprocal patterns in our data. That is, the second-mover is more reciprocal for corresponding changes in x_1^{DD} and x_2^{DD} and x_2^{DC}, but we find little support of the effect of x_1^{DC}.

Literature Initially the idea of conditional cooperation has been introduced by Fischbacher et al. (2001). This manner of behavior has been documented in various social dilemmas, including PDs (static one-shot, repeated and sequential) (Schmidt et al., 2001, Engel & Zhurakhovska, 2016, Gächter et al., 2024) as well as linear public good games (Thöni & Volk, 2018, Kirchkamp & Mill, 2020, Bilancini et al., 2022, Katuščák & Miklánek, 2023). Note that PD presents a better opportunity to manipulate one's beliefs about another person cooperation because there is less strategic uncertainty and rather clear meaning behind each of the payoffs. Hence, various studies have focused on different payoff manipulations of the payoff matrix in the PD (see Mengel (2018) for the overview of the literature). Moreover, there are several theories about indexes that predict well the cooperation rates (see e.g. Rapoport (1967), Ahn et al. (2001), Mengel (2018), Gächter et al. (2021)).

However, for the studies of conditional cooperation SPD presents a better design, because it fixes the beliefs of second-mover by the fact that she takes her decision after observing the action of first-mover. Thus, several studies have provided evidence in support of conditional cooperation using the SPDs. In particular, increasing the gains from both players' cooperation leads to the higher cooperation by both first-mover and second-mover (Schneider & Shields, 2022). The rate of conditional cooperation is higher when free-riding results in greater losses on the first-mover and smaller gains for the second-mover (see Baader et al., 2024). Moreover, if the defection is made more attractive for both first-mover and second-mover it results in lower rate of conditional cooperation (see Clark & Sefton, 2001). However, most of the previous studies used symmetric SPDs. This restriction implies that when changing some of the payoffs on the cooperation path, the corresponding payoffs on defection path would also change. Therefore, we resort to the study of asymmetric SPDs, which have been relatively little used previously (see Ahn et al., 2007).

Structure The remainder of the paper is organized as follows. Section 2 provides the details of the experimental design, procedures and establishes the hypotheses Section 3 presents the experimental results. Section 4 discusses the existing theories. Section 5 concludes. Additional empirical results and further analysis will be provided in the Appendix B.

2.2 Experimental Design, Hypotheses and Procedures

2.2.1 Sequential prisoner's dilemma

2.2.1.1 Design

Our experiment uses a sequential version of the Prisoner's Dilemma (see Figure 2.3) where the first-mover chooses to *Cooperate* or *Defect*, and *after observing this* *choice* the second-mover responds with either *Cooperate* or *Defect*.

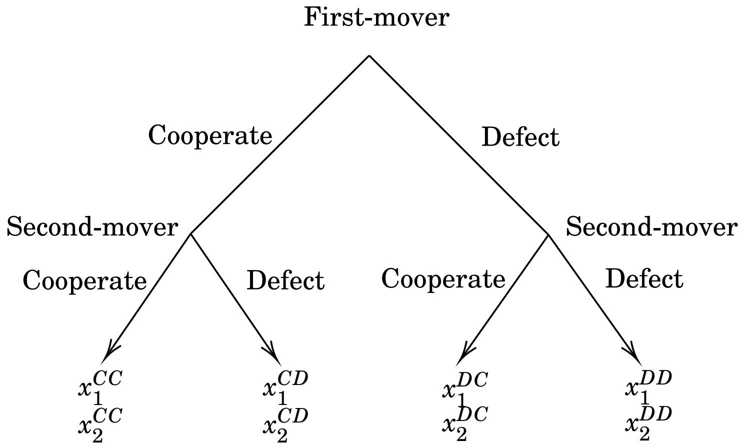
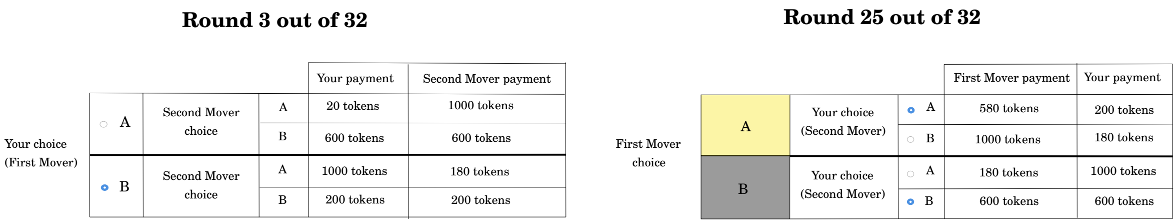


Figure 2.3: Sequential prisoner's dilemma

We argue that the SPD is better suited to studying other-regarding preferences and reciprocity than the more familiar simultaneous version of the game (see Figure 2.1). In the simultaneous version the presence of cooperation may be due to different motives, such as inequity aversion or altruism or reciprocity. While reciprocity requires a subject to be responding to a belief about their opponent's choice, so that they cooperate if they believe their opponent will also cooperate, and defect if they believe their opponent will also defect (Rabin, 1993). Accurate beliefs are hard to obtain in the lab even though there are some methods that are theoretically perfect (Hossain & Okui, 2013, Charness et al., 2021). So it is problematic to interpret cooperation in the simultaneous version. In the SPD, second-movers respond to observed choices, thus there is no concern about unobserved beliefs, enabling us to test how their choice is conditional on first-mover's choice.

The key component of SPD is depicted in Figure 2.3. To make this game tree into a prisoner's dilemma the payoffs should satisfy the following properties: $x_2^{CD} > x_2^{CC} > x_2^{DD} > x_2^{DC}$, $x_1^{DC} > x_1^{CC} > x_1^{DD} > x_1^{CD}$ and $x_1^{CC} + x_2^{CC} > \{x_1^{CD} + x_2^{CD}, x_1^{DC} + x_2^{DC}\}$. Note that we are using the asymmetric (sequential) prisoners dilemma to make sure that we can change payoffs one-by-one thus providing a cleaner test.

In each SPD, mutual cooperation maximizes the players' joint earnings, yielding payoffs of x_1^{CC} to the first mover and x_2^{CC} to the second mover. However, once the first mover cooperates, the second mover can increase her own earnings by defecting, which leaves the first mover with x_1^{CD} and gives the second mover x_2^{CD}. If the first mover instead defects, the second mover's best reply is likewise to defect, producing payoffs of x_1^{DD} and x_2^{DD} for the first and second movers, respectively. Because each player is assumed to maximize only her own payoff—and this is common knowledge—the game has a single equilibrium: the first mover defects, and the second mover defects regardless of the first mover's action.



(a) first-mover **(b)** second-mover

Figure 2.4: Interface of the experiment: SPD

In the experiment, each subject had to make decisions in 16 such SPD games with varying payoffs. Every subject takes decisions for in both the first- and second-mover roles. Moreover, we use the strategy method to elicit the second-movers choices in order to ensure that we collect complete data and minimize path dependence. An example of the interface is provided in Figure 2.4. The left panel shows the interface for the first-mover decisions while the right panel shows the interface for the second-mover decisions. The order of the games is randomized during the experiment.

Table 2.1 presents the parametrization of the 16 SPDs. We note two important features of this parametrization. First, we ensure that payoffs change one-by-one thus allowing for the cleaner direct evidence. Second, we can proceed with direct tests for several hypotheses. For example, the difference between G1 and G2 is only in x_2^{DD}, thus allowing a direct of conditional cooperation depending on on this payoff parameter. For example, existing reciprocity theories (Dufwenberg & Kirchsteiger, 2004) would imply that the second-mover is more likely to conditional cooperate in G1 compared to G2.

Table 2.1: Payoff parameters in SPDs

Game	x_1^{CC}	x_2^{CC}	x_1^{CD}	x_2^{CD}	x_1^{DC}	x_2^{DC}	x_1^{DD}	x_2^{DD}
G1	600	600	180	1000	1000	180	200	200
G2	600	600	180	1000	1000	180	200	**580**
G3	600	600	180	1000	1000	180	**580**	200
G4	600	600	180	1000	1000	180	**580**	**580**
G5	600	600	180	1000	**700**	180	200	200
G6	600	600	180	1000	1000	**20**	200	200
G7	600	600	180	1000	**700**	**20**	200	200
G8	600	600	180	**700**	1000	180	200	200
G9	600	600	**20**	1000	1000	180	200	200
G10	600	600	**20**	**700**	1000	180	200	200
G11	600	**850**	180	1000	1000	180	200	200
G12	**850**	600	180	1000	1000	180	200	200
G13	**850**	**850**	180	1000	1000	180	200	200
G14	600	600	180	**700**	**700**	180	200	200
G15	600	600	**20**	1000	1000	**20**	200	200
G16	600	600	**20**	**700**	**700**	**20**	200	200

2.2.1.2 Hypotheses

We aim to explore *why second-mover chooses to cooperate after the first-mover has cooperated* by systematically varying the payoffs one-by-one. To formulate our hypotheses, we classify the payoffs into two dimensions based on the properties of the SPD. The first dimension covers payoffs in the *cooperation path* (first-mover chose to cooperate), that is, x_1^{CC}, x_2^{CC}, x_1^{CD}, and x_2^{CD}. The second dimension covers payoffs in the *defection path* (first-mover chose to defect), that is, x_1^{DC}, x_2^{DC}, x_1^{DD} and x_2^{DD}.

We start with a simple case—the cooperation path—where the associated payoffs are directly related to the final outcomes of both first- and second-movers. If we consider only payoff changes in the cooperation path while holding the payoffs in the defection path fixed, then, even though reciprocity exists, the level of reciprocity in the two games will remain the same. In behavioral economics, there are fruitful discussions on how these payoffs influence people's decisions (Fehr & Schmidt, 1999, Becker, 1976). Further discussions on this topic will be provided in Section 4.

First, we propose the following hypotheses.

Hypothesis 1. In any two SPDs a and b, if first-mover cooperates,

(i) *if* $x_2^{CC}(a) > x_2^{CC}(b)$*, the second-mover will be more likely to cooperate in SPD* a *than SPD* b*;*

(ii) *if* $x_1^{CC}(a) > x_1^{CC}(b)$ *and* $x_1^{CC}(a) \leq x_2^{CC}(a)$*, the second-mover will be more likely to cooperate in SPD* a *than SPD* b*;*

(iii) *if* $x_1^{CC}(a) > x_1^{CC}(b)$ *and* $x_1^{CC}(a) > x_2^{CC}(a)$*, the second-mover will be more likely to defect in SPD* a *than SPD* b*;*

(iv) *if* $x_2^{CD}(a) > x_2^{CD}(b)$*, the second-mover will be more likely to defect in SPD* a *than SPD* b*;*

(v) *if* $x_1^{CD}(a) > x_1^{CD}(b)$*, the second-mover will be more likely to defect in SPD* a *than SPD* b*;*

These hypotheses are intuitive. Hypothesis (1.i) suggests that second-mover will be more likely to cooperate when her payoff from her cooperation increases. Hypothesis (1.iv) suggests that second-mover will be less cooperative when her payoff from her defection increases. Hypotheses (1.i) and (1.iii) imply that second-mover prefers an outcome that can increase her payoff. This is consistent with most existing utility models (for example, Fehr & Schmidt, 1999, Becker, 1976, Dufwenberg & Kirchsteiger, 2004)

Hypotheses (1.ii) and (1.iii) posit that second-mover will be more likely to cooperate when the first-mover's payoff from second-mover's cooperation increases, but only if first-mover's payoff is smaller than the payoff of second-mover. Otherwise, the second-mover will be less cooperative. This implies that people are willing to help others but may resist situations where others gain more than they do. This is captured by the idea that people is inequity averse (Fehr & Schmidt, 1999).

Similarly, hypothesis (1.v) posits that the second-mover will be more likely to defect when the first-mover's payoff from the second-mover's defection increases. This can be explained in two ways. First, the second-mover experiences less inequity by defecting when x_1^{CD} increases (recall that $x_2^{CD} > x_1^{CD}$ always holds in our experiment). Second, the second-mover can excuse her decision to defect and feel less guilty by defecting as now first-mover's payoff from her defection is not that bad. But part (v) of the hypothesis is relatively strong given the fact that $x_2^{CD} \gg x_1^{CD}$ in our experiment even after increasing x_1^{CD}.

Then we can start with a more interesting case — the defection path — where the associated payoffs are not directly related to the final outcomes of both first- and second-movers if the first-mover cooperates. In this case, we would be considering whether "off path of play" payoffs have an effect on conditional cooperation. We use the same method as before and consider only payoff changes in the defection path while holding the payoffs in the cooperation path fixed. In this case even though other-regarding preferences may be present, their effect would remain the same in the two games. In behavioral economics, there are discussions focusing on reciprocity that aim to explain how it works. Further discussions will be provided in Section 4. We propose the following hypotheses.

Hypothesis 2. In any two SPDs a and b, conditional on first-mover's cooperation,

(i) *if* $x_2^{DD}(a) > x_2^{DD}(b)$*, the second-mover will be less likely to cooperate in SPD a than SPD b;*

(ii) *if* $x_1^{DD}(a) > x_1^{DD}(b)$*, the second-mover will be more likely to cooperate in SPD a than SPD b;*

(iii) *if* $x_2^{DC}(a) > x_2^{DC}(b)$*, the second-mover will be less likely to cooperate in SPD a than SPD b;*

(iv) *if* $x_1^{DC}(a) > x_1^{DC}(b)$*, the second-mover will be more likely to cooperate in SPD a than SPD b;*

Hypothesis (2.i) can be interpreted through the existing literature on reciprocity (Dufwenberg & Kirchsteiger, 2004). A common explanation is that the perceived generosity of an action should increase with the magnitude of the favor one does for others. The second-mover's payoff after defection is x_2^{DD}. If this value increases, then perceived generosity will be decreasing as first-mover's cooperation could not significantly increase second mover's payoff. Therefore, second-mover will be more likely to defect as she is likely to consider the first-mover's cooperation as a generous action.

When evaluating first-mover's generosity, second-mover's associated payoff has captured most researchers' attention, while surprisingly ignoring the effect of the first-mover's payoff. A recent important exception is He & Wu (2023). However, the perceived generosity of an action should also depend on how much one has to sacrifice to do the favor. In other words, when defection is a safer choice for first-mover, first-mover's cooperation could be considered to demonstrate significant generosity, as they expose themselves to the risk of being defected against. Thus, second-mover should be more cooperative to reciprocate first-mover's generosity. This suggests that the concept of reciprocity should not only consider the magnitude of the favor one does for others but also the extent to which one sacrifices to perform the favor. He & Wu (2023) focus on the maximum payoff, so their model yields hypothesis (2.iv).

However, one should expect that x_1^{DD} is more salient, given the fact that defection following defection is a more likely occurrence (for example, 79.37% choices in our experiment are defection after defection). So we also present hypothesis (2.ii).

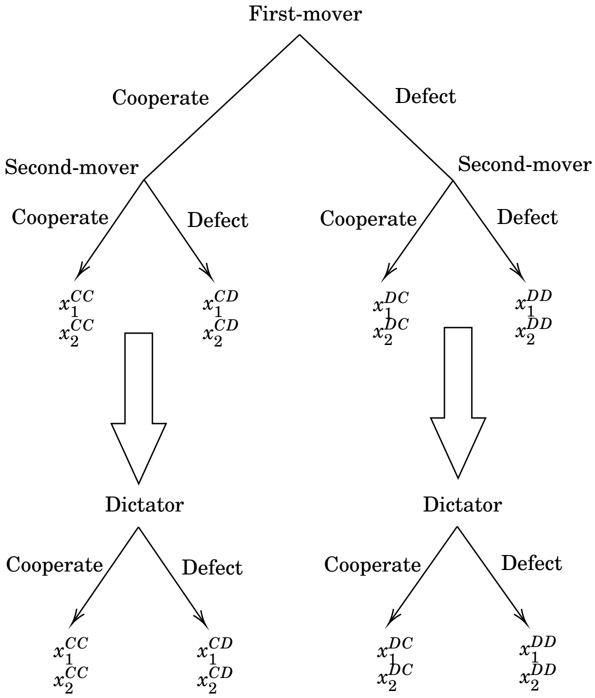
Hypothesis (2.iii) has very similar property to hypothesis (2.i) but has not yet been studied to our knowledge. One reason is that, theoretically (see for example Dufwenberg & Kirchsteiger, 2004), cooperation after defection is unlikely, as first-mover defection would most likely lead the second-mover to also defect (negatively reciprocate). Thus, defection after defection should be the most likely outcome to be expected. If this is the case, then x_2^{DC} should have no effect on the second-mover's behavior. In our experiment, we still begin by hypothesizing that there are some effects, as we argue that people's behavior could be more complex. They may still want to reciprocate to others if others help them avoid a worse outcome.

2.2.2 Modified dictator game (DG)

2.2.2.1 Design

Widely disseminated conclusions about observations of cooperation in laboratory experiments have motivated the development of utility theories intended to improve the empirical validity of game theory. For example, some models incorporate perceptions of others' intentions into the utilities and claim that kindness matters (Rabin, 1993, Dufwenberg & Kirchsteiger, 2004, Falk & Fischbacher, 2006), while other models incorporate fairness into the utilities (Fehr & Schmidt, 1999, Becker,

1976) (see Section 4 for more details). However, even though all models provide seemingly reasonable explanations for conditional cooperation, it is still unclear where these decisions are originally from.



(a) C-path DG (b) D-path DG

Figure 2.5: Modified dictator games based on SPD game payoffs

As a motivating example, in our SPD experiment, if we observe that a second-mover cooperates after cooperation and defects after defection, can we directly conclude that their decisions are actually conditional on the first-mover's behavior? The answer is no, as we have already mentioned that, according to different utility models, second-mover's actions could be motivated by reciprocity that is conditional on the behavior of others or by general other-regarding preferences characterized by altruism or inequity aversion that are not conditional on the behavior of others. If we want to state that people's behavior is also context-dependent and that conditional cooperation exists, we should implement other experimental designs to help us discriminate between these two motives.

Therefore, in this section, we employ a simple binary modified dictator game to control for other-regarding preferences. In a dictator game, there are two players:

the dictator and the silent receiver. The silent receiver is an inactive player who can not make any decisions. The dictator can choose between two options, *Cooperate* or *Defect*, thereby determining the payoffs for both players (see the bottom half of figure 2.5). (In the experiment, these choices are labeled neutrally in as A and B, see Figure 2.6)

		Second Mover Payment	First Mover payment
Second Mover choice	○ A	200 tokens	580 tokens
	● B	180 tokens	1000 tokens

Figure 2.6: Interface of the experiment: DG

We include 14 modified dictator games with different payoff combinations based on the 16 SPD games as depicted in Figure 2.5 and Table 2.2. The parametrization of the modified dictator games mirrors the scenarios the second-mover would encounter if first-mover chose to cooperate or defect. Each SPD can generate two modified dictator games: C-path DG that has the same payoff structure as in the SPD after first-mover's cooperation and D-path DG that has the same payoff structure as in the SPD after first-mover's defection. In the experiment, each subject is asked to make decisions in the role of the dictator. However, the computer randomly assigns their actual role (either the dictator or the silent receiver) at the end of the experiment.

We do not ask subjects to make two decisions per round in the modified dictator games, unlike in the SPD tasks (see Figure 2.4(b)). There are two main reasons for this. First, although we mirror the payoff structures of the SPDs, the modified dictator games are designed to be context-free. Including both decisions in one round would introduce potentially additional information and irrelevant context, which goes against the property of dictator games and will confuse subjects. Second, reducing the number of decisions helps streamline the experiment. Recall that there are 16 SPDs—if we preserved the two-decision structure, the modified dictator games would require 32 decisions. Many of these would share the same payoff structures, leading to unnecessary repetition and inefficient use of the experimental budget.

Table 2.2: Payoff parameters in DGs

Game	x_1^{CC}	x_2^{CC}	x_1^{CD}	x_2^{CD}	x_1^{DC}	x_2^{DC}	x_1^{DD}	x_2^{DD}
D1	600	600	180	1000	-	-	-	-
D2	600	600	180	**700**	-	-	-	-
D3	600	600	**20**	1000	-	-	-	-
D4	600	600	**20**	**700**	-	-	-	-
D5	600	**850**	180	1000	-	-	-	-
D6	**850**	600	180	1000	-	-	-	-
D7	**850**	**850**	180	1000	-	-	-	
D8	-	-	-	-	1000	180	200	200
D9	-	-	-	-	1000	180	200	**580**
D10	-	-	-	-	1000	180	**580**	200
D11	-	-	-	-	1000	180	**580**	**580**
D12	-	-	-	-	**700**	180	200	200
D13	-	-	-	-	1000	**20**	200	200
D14	-	-	-	-	**700**	**20**	200	200

2.2.2.2 Hypotheses

We hypothesize that conditional cooperation exists. The idea is that in SPD games, the source of cooperation can be from either conditional cooperation (associated with reciprocity) or unconditional other-regarding preferences (such as altruism and inequality aversion). In contrast, modified dictator games lack the context of the other player's (first-mover's) behavior, resulting in the absence of conditional cooperation or reciprocity as a source of cooperation. Therefore, in modified dictator games, cooperation can only arise from unconditional other-regarding preferences. In other words, a difference in the cooperation rates in modified dictator game versus the corresponding SPD (i.e., with the same feasible payoffs for each player) indicated context-dependence or conditionality of the (second-mover's) decision making. Thus, a higher rate of (second-mover) cooperation on the cooperation path in the SPD compared to the corresponding C-path DG would indicate the presence of conditional cooperation in the SPD due to reciprocity. This leads to the following hypothesis.

Hypothesis 3. When facing the same feasible choices in SPD and DG,

(i) *the second-mover will be more likely to cooperate in the cooperation path of the SPD than in the corresponding C-path DG;*

(ii) *the second-mover will be less likely to cooperate in the defection path of the SPD than in the corresponding D-path DG.*

As we have mentioned before, the only difference between SPD and associated modified dictator game is the context dependence. It can be explained by reciprocity. Reciprocity comprises two directions. The first is 'positive reciprocity', which suggests that "if someone is generous to me, I will be generous as well and reciprocate by cooperating". Applying it to our context of SPDs and modified dictator games, there is positive reciprocity in the cooperation path of the SPD. So we should observe behavior indicated in hypothesis (3.i). The second direction is negative reciprocity, which means that "if someone treats me poorly, I will respond by being less generous to them, i.e., defect". In the context of SPD and DG, there is negative reciprocity in the defection path of the SPD, as the first-mover's defection always results in the second-mover receiving the lowest payoff in SPD. So we should observe behavior indicated in hypthesis (3.ii).

2.2.3 Belief elicitation

We also ask subjects to provide their beliefs about the first-mover's decisions and second-mover's decisions. Belief elicitation is secondary research question in this paper, but it is also useful for us to evaluate subject's behavior. Therefore, we choose 7 SPDs[1] to elicit their beliefs (see Appendix B for more details). This part of the experiment is designed in a simple and straightforward manner, using a non-incentivized, interval-based approach (Manski, 2004). We elicit beliefs to account for the fact that they tend to be noisier than preferences, especially when it comes to beliefs about conditional cooperation. Figure 2.7 presents one case that subjects will face in the experiment.

[1]We do not elicit beliefs for all SPDs in the experiment for two main reasons. First, the belief elicitation is not incentivized and is implemented in a simple questionnaire. Second, the 7 SPDs we selected are sufficient to understand how subjects form their beliefs.

				First Mover payment	Second Mover payment
First Mover choice	A	Second Mover choice	A	600 tokens	600 tokens
			B	180 tokens	700 tokens
	B	Second Mover choice	A	1000 tokens	180 tokens
			B	200 tokens	200 tokens

1. Assume Second Mover knows First Mover chose A, what do you think is the percent chance that Second Mover would choose A?

○ 0%-20% ○ 21%-40% ○ 41%-60% ○ 61%-80% ○ 81%-100%

2. Assume Second Mover knows First Mover chose B, what do you think is the percent chance that Second Mover would choose A?

○ 0%-20% ○ 21%-40% ○ 41%-60% ○ 61%-80% ○ 81%-100%

Figure 2.7: Interface of the experiment: Beliefs

2.2.4 Procedures

The experiment is arranged in three consecutive blocks. First, subjects are faced with 14 modified dictator games. Next, they take the decisions in 16 SPDs. Finally, subjects were presented with belief elicitation and a short post-experimental survey. The experiment lasted on average 60 minutes. The order of blocks were fixed to allow participants to gradually transition from simple individual decisions to more complex strategic tasks. All tasks within blocks were randomized.

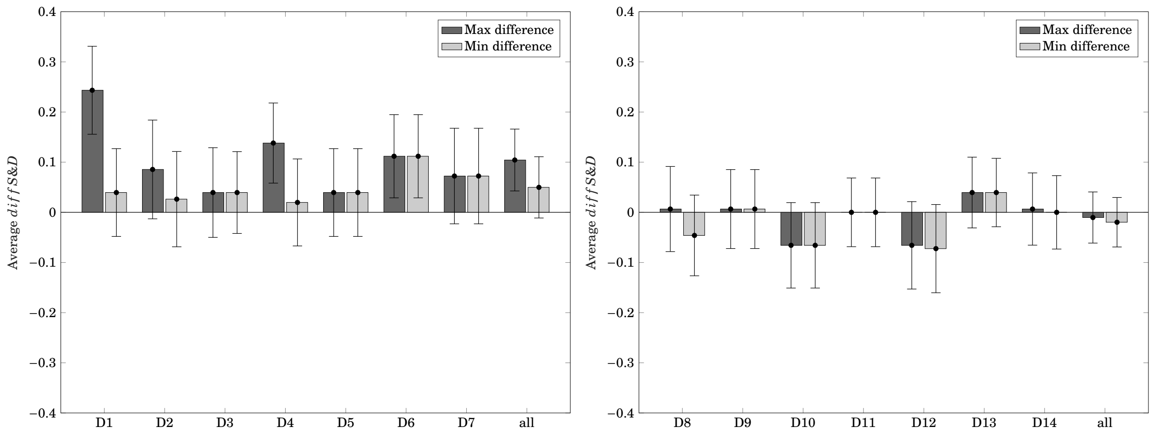
To compute their payments, one game from block 1 and one game from block 2 would be chosen at random for payment. The roles in each block would also be randomized. The belief elicitation was not incentivized. The average payment subjects received was £14.15 (including £5 of show up fee).

The experimental interface is implemented using the oTree software (Chen et al., 2016). The sessions were conducted May to July 2023 in the University of Essex using the general sample of the undergraduate students. 152 subjects participated in the experiment, among them 15.13% were economics students, and 50.66% were female.

2.3 Results

The analysis in this section is structured as follows. We start by presenting clean evidence about conditional cooperation. Next, we proceed by testing second-mover's cooperation after (first-mover) cooperation with varied payoffs in cooperation path and second-mover's cooperation after (first-mover) cooperation with varied payoffs in defection path. Finally, we also examine first-mover's behavior and test whether they consider reciprocity in their decisions. All other descriptive statistics can be found in Appendix B.

2.3.1 Detecting conditional cooperation



(a) In the cooperation path **(b)** In the defection path

Figure 2.8: Difference between DG and corresponding SPDs

Notes: Each bar in the graphs represents the average $diffS\&D$ (the sum of $diffS\&D$ divided by the number of participants). If the bar value is above zero, it suggests that subjects are, on average, more cooperative in SPD than in DG. If the bar value is below zero, it suggests that subjects are, on average, more cooperative in DG than in SPD. The whiskers identify the 95% confidence interval.

Recall that the experiment contains within-subject treatment in which a subject had to make the decisions in the DGs that correspond to every potential cooperation and defection path of in SPD. Contrasting each subject's decisions across these games allows us to present the direct evidence on conditional cooperation. To do so we create a subject-level variable $diffS\&D$ that equals 1 if subject cooperated in

SPD and did not in the DG, −1 if subject cooperated in DG and did not in SPD, and 0 if subject made a same decision in both SPD and DG.

Figure 2.8 presents the results of the analysis of this variable corresponding to the cooperation path (Figure 2.8a) and defection path (Figure 2.8b). One may notice that in our design for one DG we may have more than one corresponding SPD, so we include the maximum difference and minimum difference between the DG and corresponding SPDs.

In the cooperation path (Figure 2.8a) we find that subjects are in aggregate more likely to cooperate in SPD than in the corresponding DG (p=0.010, Wilcoxon signed-rank test).

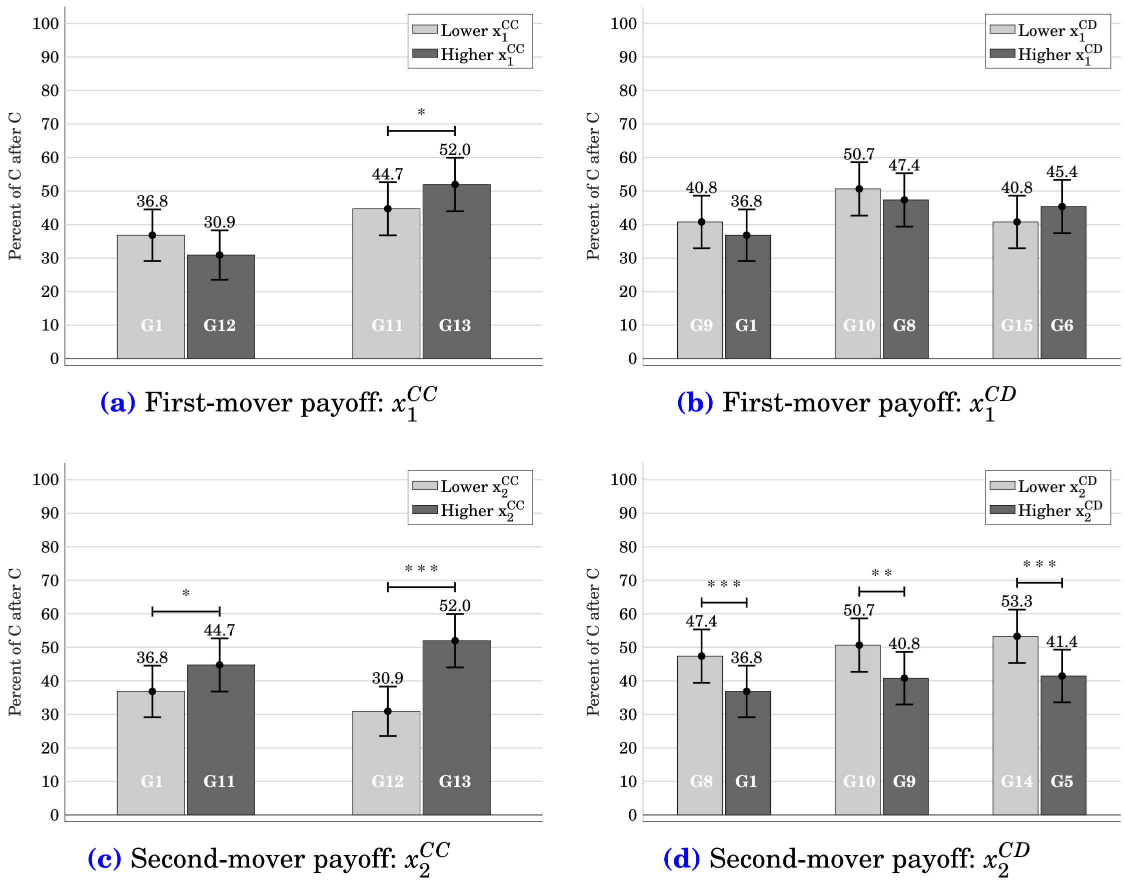
In contrast, when looking at the difference in cooperation in defection path (Figure 2.8b), we do not see any significant difference (p=0.534, Wilcoxon signed-rank test). Moreover, there is no consistent effect being present as the variable goes both ways. This direct evidence shows that there is context dependence of the decisions but this context dependence is only present in the cooperation path. That is rather clear evidence in favor of us observing the conditional cooperation and not just choice driven by unconditional pro-social preferences.

Experimental Result 1. When facing the same feasible choices in SPD and DG, second-mover is more likely to cooperate in the cooperation path in the SPD than in the C-path DG, while there is no consistent effect present in the defection path.

2.3.2 Second-mover's cooperation with varied payoffs in the cooperation path

In this section, we will discuss Hypothesis 1, which concerns the second-mover's cooperation level conditional on first-mover's cooperation if we change payoffs in the cooperation path. We use the same idea as in the last section, recall that our experiment contains 16 SPD games with payoff changes one by one. We use the within subject design and directly compare each subjects' choices across the relevant different games.

We begin by considering the differences among all relevant games in this section. We found that a Cochrane's Qtest rejects the null hypothesis that the rate of conditional cooperation is the same across all relevant games (Q= 112.22, p<0.001). A detailed analysis reveals that the rate changes systematically with payoffs. Figure 2.9 presents the results of the analysis of this variable corresponding to the cooperation path. The Figure compares the proportions of cooperation after cooperation if we change the payoffs in the the cooperation path in low payoff values (light bars) and high payoff values (dark bars). Four sub figures denote four different payoff parameters in the SPD games.



(a) First-mover payoff: x_1^{CC}

(b) First-mover payoff: x_1^{CD}

(c) Second-mover payoff: x_2^{CC}

(d) Second-mover payoff: x_2^{CD}

Figure 2.9: Second-mover's cooperation: in the cooperation path

Notes: The Figure compares the proportions of second-mover's cooperation after first-mover's cooperation if we change the payoffs in the the cooperation path with low payoff values (light bars) and with high payoff values (dark bars). The whiskers identify the 95% confidence interval. $*p < 0.1; **p < 0.05; ***p < 0.01$ (McNemar's test)

In all subsequent analyses, we first conduct an aggregate test of each hypothesis.

For example, when examining the effect of x_2^{CC}, we pool G1 and G12 and compare them with G11 and G13 to test whether increasing x_2^{CC} raises the second mover's cooperation. We then report the all pairwise (binary) comparisons, G1 vs. G11 and G12 vs. G13.

Figure 2.9a presents the case in which x_1^{CC} changes. Here we do not run the aggregate test as G1 to G12 and G11 to G13 have different properties. From G1 to G12, second-mover's payoff is becoming smaller than first-mover, while second-mover's payoff is always greater or equal to first-mover from G1 to G12. We further find that increasing x_1^{CC} weakly increases the rate of cooperation only when $x_2^{CC} \geq x_1^{CC}$ (McNemar tests: G11 vs. G13: p=0.082 and G1 vs. G12: p=0.164). A plausible explanation is inequity aversion (Fehr & Schmidt, 1999): from G1 to G12, the second-mover's payoff becomes lower than that of the first-mover, which may discourage cooperation.

Only x_1^{CD} disconfirms Hypothesis 1. We find that in aggregate there is no significant difference on second-mover's cooperation after (first-mover) cooperation when changing x_1^{CD} (p=0.7976, Wilcoxon signed-rank test). All binary comparisons likewise show no significant differences (McNemar tests: all $p > 0.327$). One explanation for why second-mover did not cooperate differently with respect to change in x_1^{CD} could be that there is a large payoff difference in defection after cooperation. The fact that $x_2^{CD} \gg x_1^{CD}$ in SPD suggests that if the second-mover is selfish, a small change in x_1^{CD} is unlikely to affect her chances of cooperating after cooperating. Thus we do not observe a significant change in their behavior.

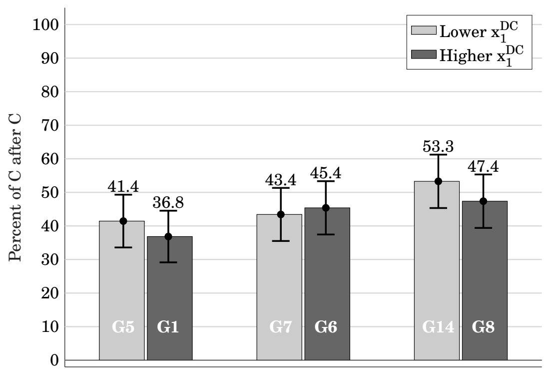
Figures 2.9c suggest that in aggregate increases in x_2^{CC} make the second-mover more likely to cooperate after cooperation (p<0.01, Wilcoxon signed-rank test). All binary comparisons also confirm our Hypothesis 1 (McNemar tests: G1 vs. G11: p=0.052 and G12 vs. G13: p<0.01).

Figures 2.9d suggest that in aggregate increases in x_2^{CD} make the second-mover more likely to cooperate after cooperation (p<0.01, Wilcoxon signed-rank test). All binary comparisons also confirm our Hypothesis 1 (McNemar tests: all $p < 0.018$).

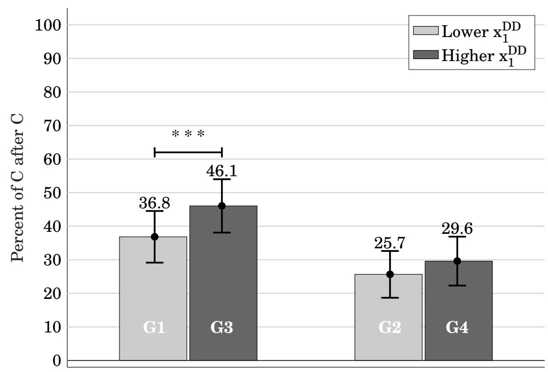
These results confirm the hypothesis and are also quite intuitive—the second-mover always has an incentive to choose the action that yields a higher payoff for themselves.

Experimental Result 2. The second-mover is more likely to cooperate after first-mover's cooperation if their payoff from cooperation x_2^{CC} increases or from defection x_2^{CD} decreases. Additionally, they are more likely to cooperate if first-mover's payoff x_1^{CC} increases, but only when first-mover's payoff does not exceed their own after the increase. However, no consistent effect is observed when x_1^{CD} increases.

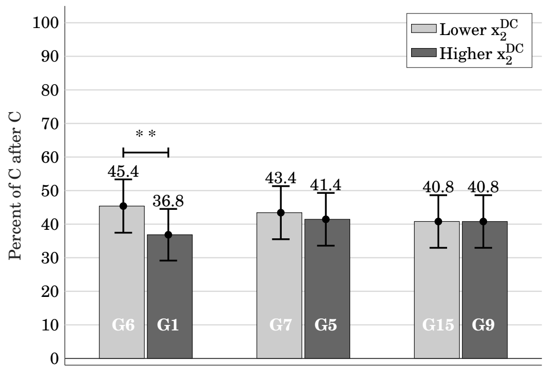
2.3.3 Second-mover's conditional cooperation with varied payoffs in the defection path



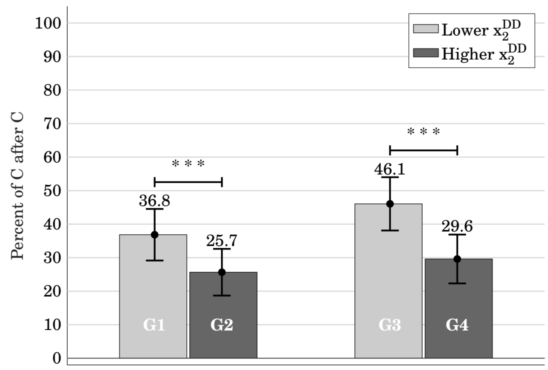
(a) First-mover payoff: x_1^{DC}



(b) First-mover payoff: x_1^{DD}



(c) Second-mover payoff: x_2^{DC}



(d) Second-mover payoff: x_2^{DD}

Figure 2.10: Second-mover's conditional cooperation: in the defection path

Notes: The Figure compares the proportions of cooperation after cooperation if we change the payoffs in the the defection path with low payoff values (light bars) and with high payoff values (dark bars). The whiskers identify the 95% confidence interval. $*p < 0.1; **p < 0.05; ***p < 0.01$ (McNemar's test)

We now consider Hypothesis 2, which relates to the effect on conditional cooperation from changes in the payoffs on the "off-path of play" defection path (where first-mover defects). We use the same analysis method as in the previous section. Figure 2.10 presents direct evidence of changes to conditional cooperation when the payoffs in the defection path are varied. Four sub figures denote four different payoff parameters in the defection path in the SPD games.

First, a Cochrane's Qtest rejects the null hypothesis that the rate of cooperation is the same across all relevant games (Q= 111.395, p < 0.001). This result suggests that "off-path of play" plays an important role. In other words, cooperation is not solely driven by unconditional pro-social preferences, but also by context-dependent motivations such as reciprocity.

With the exception of payoff x_1^{DC}, the results are in line with those indicated by Hypothesis 2. As shown in Figure 2.10a, we find that in aggregate there is no significant difference in conditional cooperation when x_1^{DC} is changed (p<0.151, Wilcoxon signed-rank test). Moreover, all binary comparisons are also not statistically significant (McNemar tests: all p>0.164). This may be attributed to the fact that cooperation after defection is very unlikely (less than 20% cases in our experimental results) and second-mover does not take the effect of x_1^{DC} into much consideration. While if we look at Figure 2.10b, x_1^{DD}, we do find the same effect as we stated in Hypothesis (2.ii). We find that in aggregate increasing x_1^{DD} will decrease conditional cooperation (p<0.011, Wilcoxon signed-rank test). Moreover, a binary comparison also confirms Hypothesis (2.ii)(G1 vs. G3: McNemar test: p=0.010). Here the binary comparison of G2 vs. G4 is not that significant is reasonable as the value of x_2^{DD} is already large enough in these two games, so first's mover's cooperation will become not that generous. It is worth noting that no theoretical model currently predicts this effect of changes in x_1^{DD} as existing works (Rabin, 1993, Dufwenberg & Kirchsteiger, 2004, He & Wu, 2023) focus more on second-mover's payoffs when talking about the reciprocity. For further discussion, see Section 2.4.

The result of a change in x_2^{DD} is not surprising, we find both that in aggregate (p<0.01, Wilcoxon signed-rank test) and binary comparison (McNemar tests: all p<0.001) suggest that increasing x_2^{DD} would decrease conditional cooperation. This is in line with what intention-based reciprocity models (Dufwenberg & Kirchsteiger, 2004) predict. An increase in x_2^{DD} can promote second-mover's conditional cooperation because x_2^{DD} essentially highlights how generous that first-mover is.

More interestingly, we also find similar effect when we change x_2^{DC}. We find a trend that in aggregate increasing x_2^{DC} will decrease conditional cooperation (p=0.091, Wilcoxon signed-rank test). Moreover, one binary comparison also confirms Hypothesis (2.iii) (G6 vs. G1: McNemar test: p=0.031). Overall, we do observe that the increasing x_2^{DC} can also increase conditional cooperation. This effect is not provided as a predictions from any of the existing theoretical models.

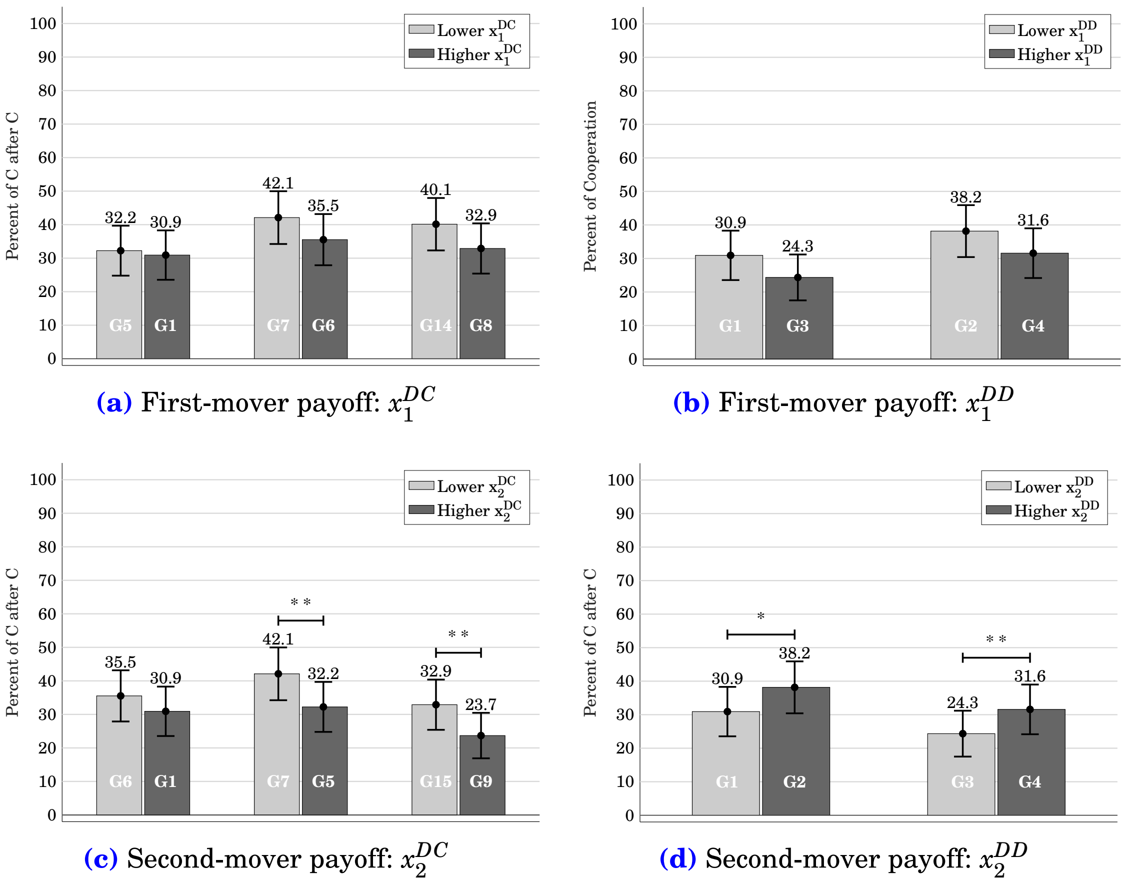
Experimental Result 3. The second-mover is less likely to cooperate conditional on first-mover's cooperation when x_2^{DD} or x_2^{DC} increase. They will be more likely to cooperate when x_1^{DD} increases, while there is no consistent effect from changing x_1^{DC}.

2.3.4 First-mover's cooperation with varied payoffs in the defection path

Although our main focus is on second-mover's response to cooperation, first-mover's cooperation rates also vary substantially across the 16 SPD games, ranging from 23.7% up to 42.1%[2].

Here, we find a strong effect associated with x_2^{DC}. We find that in aggregate increasing x_2^{DC} will decrease first-mover's cooperation (p<0.01, Wilcoxon signed-rank test). Moreover, two out of three binary comparison also confirms this finding (G7 vs. G5 and G15 vs. G9: McNemar test: all p<0.033). It is direct to infer first-mover's considerations: first-mover may believe that second-mover is less likely to cooperate after cooperation if x_2^{DC} increases (suppose reciprocity is common knowledge), and the first-mover may also develop a higher belief in second-mover's likelihood of cooperation after defection when x_2^{DC} goes to large even though cooperation after defection is theoretically unlikely. So first-mover is more likely to defect to pursue the highest payoff for themselves in the game (recall that x_1^{DC} is larger than any other first-mover's possible payoffs).

[2] a Cochrane's Qtest rejects the null hypothesis that the rate of cooperation is the same across all relevant games (Q= 293.559, p<0.001)



(a) First-mover payoff: x_1^{DC}

(b) First-mover payoff: x_1^{DD}

(c) Second-mover payoff: x_2^{DC}

(d) Second-mover payoff: x_2^{DD}

Figure 2.11: First-mover's cooperation: in the defection path

Notes: The Figure compares the proportions of unconditional cooperation if we change the payoffs in the the defection path with low payoff values (light bars) and with high payoff values (dark bars). The whiskers identify the 95% confidence interval. $*p < 0.1; **p < 0.05; ***p < 0.01$ (McNemar's test)

In Figure 2.11d We find that in aggregate increasing x_2^{DD} will increase first-mover's cooperation (p<0.01, Wilcoxon signed-rank test). Moreover, all binary comparison also confirms this finding (McNemar tests: all p<0.081). This is in contrast with our experimental results. As we argue second-mover will be more reciprocal if x_2^{DD} decreases, we may except first-mover to be more cooperative. However, one can not ignore the fact that the first-mover may tend to be optimistic in holding a higher belief in second-mover's likelihood of cooperation when they choose to defect, especially when x_2^{DD} is not too large. As a result, first-mover is more likely to choose defection if x_2^{DD} decreases.

Moreover, although we find little evidence in separate binary comparisons (McNemar tests: all p>0.164), we do find evidence that in aggregate a higher x_1^{DC} leads to a lower first-mover cooperation rate (p=0.013, Wilcoxon signed-rank test). This may be because an increase in x_1^{DC} provides the first-mover with a potential higher payoff after defection. We also find a similar pattern with x_1^{DD} variation (in aggregate: p=0.045, Wilcoxon signed-rank test; binary comparisons: McNemar tests: all p>0.175).

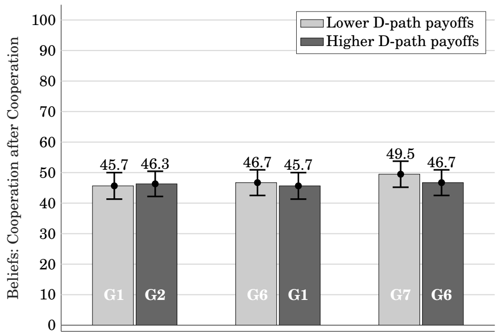


Figure 2.12: Reciprocity in Beliefs

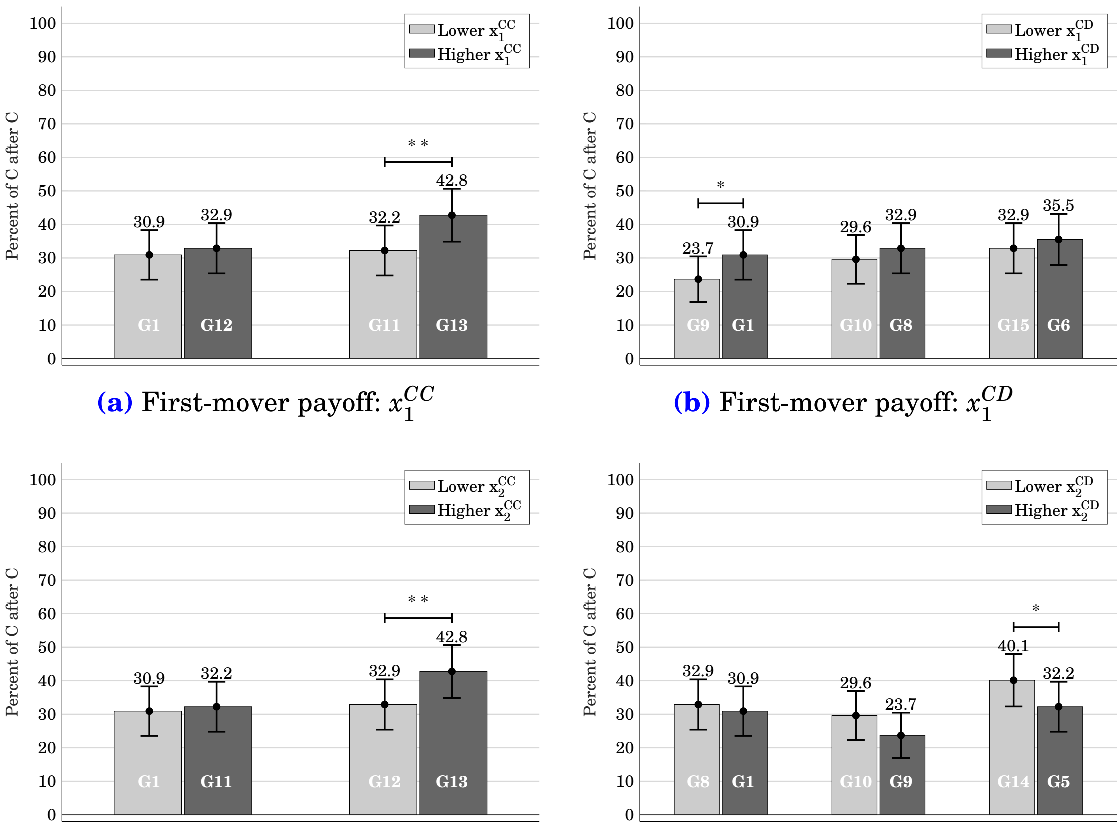
Notes: The first pair of bars, the second pair of bars, and the third pair of bars show the cases if we change x_2^{DD}, x_2^{DC} and x_1^{DC}, respectively. The whiskers identify the 95% confidence interval.

Our experiment also contains a brief belief elicitation part, where we can obtain first-mover beliefs about the second-mover's behavior. Figure 2.12 denotes the (first-mover) subject's beliefs about the second-mover's cooperation after cooperation when changing the payoffs after first-mover's defection. The first bar, the second bar, and the third bar show the cases if we change x_2^{DD}, x_2^{DC} and x_1^{DC}, respectively.

We do not find a significant difference in how x_2^{DD}, x_2^{DC} and x_1^{DC} influence first-mover beliefs about reciprocity (all $p > 0.12$, Wilcoxon signed-rank test). Note here that our beliefs measures are expected to be noisier than the subject's choices, given that we did not incentivize belief elicitation.

Experimental Result 4. The first-mover is more likely to cooperate if x_2^{DC}, x_1^{DC} and x_1^{DD} decrease, while they are more likely to cooperate if x_2^{DD} increases.

2.3.5 First-mover's cooperation with varied payoffs in the cooperation path



(a) First-mover payoff: x_1^{CC}

(b) First-mover payoff: x_1^{CD}

(c) Second-mover payoff: x_2^{CC}

(d) Second-mover payoff: x_2^{CD}

Figure 2.13: First-mover's cooperation: in the cooperation path

Notes: The Figure compares the proportions of unconditional cooperation if we change the payoffs in the the cooperation path with low payoff values (light bars) and with high payoff values (dark bars). The whiskers identify the 95% confidence interval. $*p < 0.1; **p < 0.05; ***p < 0.01$ (McNemar's test)

In this subsection, we examine first-mover's behavior while considering the effect of varying payoffs on the cooperation path (first-mover cooperates). The results are very intuitive, when first-mover's payoff after their cooperation, x_1^{CC}, increases, we find that in aggregate increasing it will increase first-mover's cooperation (p<0.042, Wilcoxon signed-rank test). Moreover, one binary comparison also confirms this finding (G11 vs. G13: McNemar test: p=0.024). The plausible reason that the difference between G1 and G12 is not significant is that increasing from G1 to G12 will make the first mover's payoff to be higher than the second-mover and this may discourage second-mover to cooperate after cooperation. Therefore, there is a potential confound that may decrease the difference.

Similarly, when first-mover's payoff after their cooperation, x_1^{CD}, increases, we find that in aggregate increasing it will increase first-mover's cooperation (p<0.028, Wilcoxon signed-rank test). Moreover, one out of three binary comparisons also confirms this finding (G1 vs. G9: McNemar test: p=0.082).

When second-mover's payoff after first mover's cooperation, x_2^{CC}, increases, we find that in aggregate increasing it will increase first-mover's cooperation (p<0.068, Wilcoxon signed-rank test). Moreover, one out of two binary comparisons also confirms this finding (G12 vs. G13: McNemar test: p=0.021). This might because increasing x_2^{CC} from G12 to G13 will decrease the difference between two players and thus first-mover believes that the second-mover will be more likely to cooperate after cooperation.

When second-mover's payoff after first mover's cooperation, x_2^{CD}, increases, we find that in aggregate increasing it will decrease first-mover's cooperation (p<0.041, Wilcoxon signed-rank test). Moreover, one out of three binary comparisons also confirms this finding (G14 vs. G5: McNemar test: p=0.067). This might because first-mover may form the belief that increasing x_2^{CD} will decrease the second-mover's cooperative probability. Therefore, first-mover will be more likely to defect if x_2^{CD} increases.

These findings would suggest that first-mover's belief about second-mover's decision is formed correctly on the cooperation path.

We can also look at first-mover's beliefs about second-mover's behavior. Figure 2.14 denotes the subject's beliefs about second-mover's behavior after cooperation when changing the payoffs on the cooperation path. The first bar, the second bar, and the third bar state the cases if we change x_2^{CD}, x_2^{CC}, and x_1^{CC} respectively (all p<0.01, Wilcoxon signed-rank test). These result align with the results on decisions that we noted above.

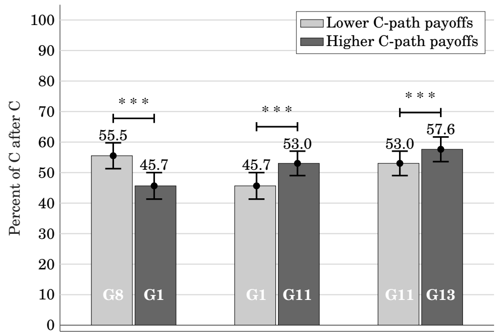


Figure 2.14: Beliefs when varying C-path payoffs

Notes: The first pair of bars, the second pair of bars, and the third pair of bars show the cases if we change x_2^{CD}, x_2^{CC}, and x_1^{CC} respectively. The whiskers identify the 95% confidence interval.
$*p < 0.1; **p < 0.05; ***p < 0.01$ (Wilcoxon signed-rank test)

Experimental Result 5. The first-mover is more likely to cooperate if x_1^{CC}, x_1^{CD}, or x_2^{CC} increase or if x_2^{CD} decreases.

2.4 Discussion

To explain the observed cooperation in our experiment, researchers have suggested that people exhibit (unconditional) prosocial preferences (outcome-based models) and reciprocal preferences (intention-based models), and have incorporated these concerns into game-theoretic models.

Outcome-based models capture concerns over the distribution of final payoffs. A well-known example is the altruism model proposed by Becker (1976), which suggests that the decision maker cares about others' outcomes. The utility function is expressed as $U_i = x_i + \theta \cdot x_j$ where $\theta \in (0,1)$. This model reflects two key features: first, individuals prefer choices that increase the payoffs of any player; second, decisions are context-free—meaning the second mover's behavior is not influenced by the first mover's action. The second feature is common for all outcome-based models. While the first feature cannot account for our experimental findings—for instance, increasing x_1^{CC} may actually make the second mover less likely to cooperate. A similar finding is also reported by Charness & Rabin (2002). We find that the inequity aversion model proposed by Fehr & Schmidt (1999) provides a good fit for explaining the variability of payoffs along the cooperation path. The model can be simply expressed as $U_i(x) = x_i - \alpha_i max\{x_j - x_i, 0\} - \beta_i max\{x_i - x_j, 0\}$ where $i = 1$, 2 and $j \neq i$; $\beta_i \leq \alpha_i$. This utility function suggests that subjects will experience the disutility when inequitable distribution occurs. They experience inequity if they are worse off in material payoffs than others, and they also feel inequity if they are better off. Consequently, the second mover may become less willing to cooperate as x_1^{CC} increases, provided that $x_2^{CC} < x_1^{CC}$ after the change.

Outcome-based models do not account for the defection path; instead, they only capture the second mover's baseline preferences, which should be identical to those observed in modified dictator games. Conditional cooperation, however, should not be considered part of these baseline preferences, as it depends on the first mover's behavior and differs fundamentally from the modified dictator game setup. Intention-based models provide a more suitable explanation. In his seminal paper, Rabin (1993) suggests that individuals are willing to bear a cost to reward those they perceive as kind. This model was later extended to sequential games by Dufwenberg & Kirchsteiger (2004). Their model suggest that the variability of payoffs along the defection path can affect the conditional cooperation. However, their model exclusively care x_2^{DD} while ignore the effect of the first mover's payoffs following first mover's defection. A current study by He & Wu (2023) extends the work of Cox et al. (2008) and incorporates the role of sacrifice in reciprocity. Their model suggests that the first mover following defection can efficiently influence the conditional cooperation. However, the model still does not fully account for all payoff changes in our experiment, as it focuses solely on the maximum values from opportunity sets. Thus the model overlooks the effect of x_1^{DD}. The model emphasizes maximum payoffs while neglecting the fact that some of these outcomes are less likely to occur. Even though the prediction is not perfectly consistent with our experimental results, it provides insight into the role of sacrifice in reciprocity. In other words, the first-mover's payoff should also be taken into consideration when considering reciprocity.

2.5 Conclusion

This paper experimentally examines the presence of conditional cooperation, and provide the link between conditional cooperation and reciprocity. By comparing the sequential prisoner's dilemma with the corresponding dictator game, we present a clean evidence of the presence of conditional cooperation.

We further examine why people (conditionally) cooperate. We address this question experimentally from two perspectives. First, we consider the effect of direct payoff changes where the associated payoffs are directly related to the final outcomes of both first- and second-movers. Not surprisingly, our results are consistent with the inequity aversion model (Fehr & Schmidt, 1999). Second, we explore the effects of indirect payoff changes where the associated payoffs are not directly related to the final outcomes of both first- and second-movers. This can be explained by reciprocity. However, we find that existing models cannot fully account for our findings. The existing models (Cox et al., 2008, He & Wu, 2023, Dufwenberg & Kirchsteiger, 2004) either inaccurately estimate or completely overlook the influence of the first-mover's payoff on perceptions of generosity.

The theory of reciprocity has been extensively used to understand various applied economic problems in the last two decades, for example, public good investment (Dufwenberg & Patel, 2017, Fischbacher & Gächter, 2010), and charitable giving (Bekkers & Wiepking, 2011, Karlan & List, 2007). Our findings suggest a need for richer frameworks of reciprocity than that are currently used.

CHAPTER 3

Revealed Preference Analysis of Conditional Cooperation in Sequential Prisoner's Dilemma Games

3.1 Introduction

A large body of evidence shows that decision-makers often deviate from maximizing their own monetary payoffs; they are willing to forgo their selfish interests to help others. This behavior can be well illustrated by a sequential prisoner's dilemma (see Figure 3.1), in which one player (the first-mover) moves first, and the other player (the second-mover) observes this action before making their own choice. Each player must choose between $cooperation$ and $defection$. In such games, if both players aim to maximize their own payoffs, defection is the best response for each. However, experimental studies find that a large proportion of second-movers choose to cooperate after observing first-mover cooperation—even in one-shot, anonymous, and controlled environments.[1] To explain this, the concept of

[1] This suggests that factors such as reputation, repeated interaction, and tit-for-tat strategies are not necessary for cooperative behavior. See, for example, Rapoport & Chammah (1965), Ahn et al. (2001), Clark & Sefton (2001), Ahn et al. (2007), Dhaene & Bouckaert (2010), Charness et al. (2016), Engel & Zhurakhovska (2016), Miettinen et al. (2020), and Gächter et al. (2021).

conditional cooperation is widely used (see Thöni & Volk (2018) for a review). It suggests people are willing to cooperate if others do so as well. However, more recent studies point out that conditional cooperation does not necessarily reflect stable personality traits: decision-makers may not always conditional cooperate, and such behavior may depend heavily on the specific experimental setting and parameters (Baader et al., 2024). In other words, conditional cooperation is still a reduced-form and abstract motive that may not fully capture the diversity of motivations behind non-selfish behavior.

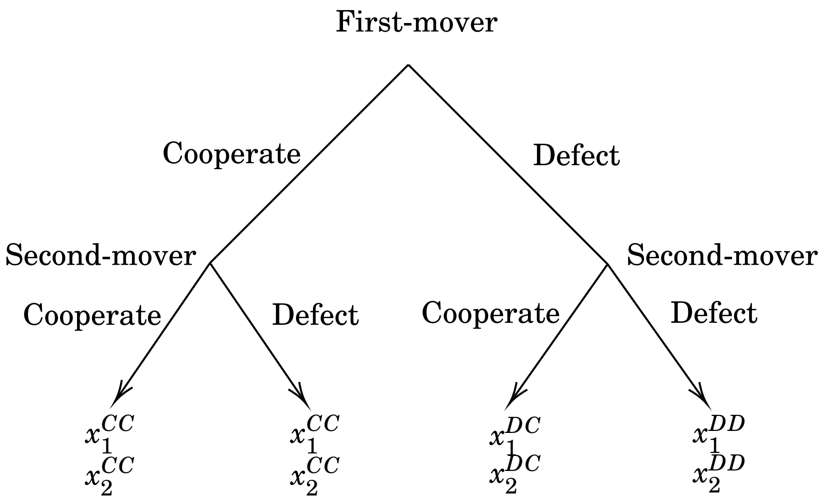


Figure 3.1: The sequential prisoner's dilemma

The definition of conditional cooperation suggests that decision maker's behavior is dependent on others' behaviour, thus it should be context dependent. While if we observe a second-mover decides to cooperate after first mover's cooperation, can we claim that this second-mover's cooperation is truly because of the first-mover's cooperation? The answer is obviously negative. There are numerous studies suggest that people do not maximize selfish interest may also come from unconditional social preferences, such as inequity aversion, efficiency concerns, reputation concerns (Fehr & Schmidt, 1999, Bolton & Ockenfels, 2000, Andreoni & Bernheim, 2009), even when there is no strategic interactions with others (e.g., dictator games Engel (2011)). Therefore, to understand the conditional cooperation, one must carefully disentangle it from unconditional social preferences.

As aforementioned, conditional cooperation can not be identified as a preference itself as it is still an abstract concept. To explore the real motive for people to conditionally cooperate, reciprocity, as a conditional preference, can be linked to conditional cooperation. The most straight-forward is the idea that first-mover's cooperation already performs a generous enough action, and thus deserve positive payback.

The idea of reciprocity has been extensively studied by economists for decades since Güth et al. (1982). Many reciprocity-related experimental works (Fehr et al., 1993, Clark & Sefton, 2001, Falk et al., 2003, Güth & Kocher, 2014) spark the development of theoretical models (Rabin, 1993, Dufwenberg & Kirchsteiger, 2004, Cox et al., 2008). Roughly speaking, all of them posit that first-mover's generosity depends on to which extent that second-mover can receive (only second-mover related payoffs) while ignore the first-mover's real intentions. That is, first-mover's potential payoffs should also play a role. For example, a large x_1^{DD} should imply that defection is actually a relatively safe option for first-mover since the second-mover is likely to respond to cooperation by defecting. Hence if the first-mover performs a more trusting action by cooperating, they are more deserving of a positive response.

To explain how reciprocity shapes conditional cooperation—and to disentangle conditional cooperation from unconditional social preferences—we employ a revealed preference approach to theoretically clarify the nature of conditional cooperation. To this end, in our model, we use quasi-monotone preferences to represent baseline motivations in an unconditional decision-making environment. Second—and this constitutes our main contribution—we define reciprocal preferences to capture the perceived generosity of the first-mover, which in turn influences the second-mover to act more or less cooperatively in response to the first-mover's cooperation.

In Chapter 1 of this thesis, we developed a theoretical model of reciprocity, where the consequential component is linked to quasi-monotone preferences, and the intentional component is connected to the concept of reciprocal preferences, which we explore further in this chapter. Here, we offer a more general definition of reciprocal preferences. In Chapter 1 section 1.5.2, we presented predictions for the sequential prisoner's dilemma, where x_1^{DC} and x_2^{DC} were found to have no effect on conditional cooperation. However, in Chapter 2, we observe some effects. The reciprocal preferences proposed in this chapter account for these findings.

The rest of the paper is organized as follows: Section 2 reviews the literature. Section 3 presents our revealed preference analysis. Section 4 discusses more existing theoretical models, and Section 5 concludes.

3.2 Literature Review

We provide a brief literature review. The concept of conditional cooperation was first introduced by Fischbacher et al. (2001). Since then, this behavior has been documented across various experimental contexts to explain subjects' decisions, particularly in public goods games (Muller et al., 2008, Thöni & Volk, 2018, Kirchkamp & Mill, 2020, Bilancini et al., 2022, Katuščák & Miklánek, 2023) and sequential prisoner's dilemmas (Clark & Sefton, 2001, Ahn et al., 2007, Miettinen et al., 2020). In a more recent study, Baader et al. (2024) experimentally show that conditional cooperation does not reflect stable personality traits; individuals may exhibit different behavioral patterns even in similar settings. For example, varying payoff parameters can shift behavior from defection to cooperation or vice versa. Therefore, understanding the nature of conditional cooperation is crucial.

Reciprocity is central to many social interaction environments. A large body of evidence shows that people routinely deviate from payoff maximization in ways that can be explained by reciprocity. For instance, Falk et al. (2003) experimentally found that, in ultimatum games, an unequal offer is much more likely to be rejected if the proposer could have made a more equitable offer, compared to cases where only more unequal offers were available. Orhun (2018) showed that greater defection rate following cooperation was observed in sequential prisoner's dilemmas when the second mover had the ability to punish the first mover's defection. Game theory based approaches have been used to explore the foundations of reciprocity (e.g., Rabin (1993), Dufwenberg & Kirchsteiger (2004), Falk & Fischbacher (2006)). However, He & Wu (2023), using sender–receiver games, argued that existing models of reciprocity overemphasize the role of the second mover (receiver) while neglecting the role of the first mover (sender). These findings suggest the need for a more generalized model of reciprocity.

Moreover, in the discussion of cooperation, or more generally, non-selfish behaviour, it does not necessarily stem from reciprocity alone. There is a growing body of research suggesting that people also exhibit unconditional social preferences, such as inequity aversion (Fehr & Schmidt, 1999), altruism (Becker, 1976), and concern for others' welfare (Charness & Rabin, 2002). Importantly, reciprocity must coexists with such unconditional prosocial preferences.

We consider cooperation to consist of both unconditional cooperation driven by prosocial preferences (Fehr & Schmidt, 1999) and conditional cooperation based on reciprocity. We apply this framework to sequential prisoner's dilemma games.

3.3 Theory

We focus our analysis on the sequential prisoners dilemma. This game has two players $\{1,2\} = N$, each of whom has two actions *cooperate* or *defect*. The extensive form game is presented in Figure 3.1. The payoffs are determined by both players' decisions and follow the standard sequential prisoners dilemma but not necessary symmetric[2]. Each outcome is specified by payoffs for both players $x = (x_1, x_2)$, where x_1 represents the monetary payoff for the first-mover, and x_2 one for the second-mover. For simplicity, the subscript 2 is intentionally assigned to the second-mover and subscript 1 to the first-mover for consistency. Denote by $X \subseteq \mathbb{R}^2_+$ the feasible space of payoffs. Given the sequential nature of the game we proceed by defining the games for the first- and second-movers separately. All proofs omitted from this section are provided in the Appendix C.1.

Before we proceed with defining formally the notions of consistency for the first- and second-mover. Each players $i \in \{1,2\}$ is endowed with the preference relation $\succeq_i$, that is a binary relation that is **complete** and **transitive**.[3] Denote by $\succ_i$ the strict (asymmetric) part of this relation and by $\sim_i$ the indifference part.

Another supplementary construct we need is the **quasi-monotonicity** (Castillo et al., 2019). That is the relaxation of standard monotonicity that accounts for possible split motives. Denote the partial order of quasi-monotonicity by Q. Then, for $x, y \in X$ we have $xQ_i y$ if $x \geq y$ and $x_i - y_i \geq x_j - y_j$. That is, it is not sufficient

[2] Payoff structures: $x_2^{CD} > x_2^{CC} > x_2^{DD} > x_2^{DC}$, $x_1^{DC} > x_1^{CC} > x_1^{DD} > x_1^{CD}$ and $x_1^{CC} + x_2^{CC} > \{x_1^{CD} + x_2^{CD}, x_1^{DC} + x_2^{DC}\}$. We are not requiring $x_1^{CC} = x_2^{CC}$, $x_1^{DD} = x_2^{DD}$, $x_1^{CD} = x_2^{DC}$, and $x_2^{CD} = x_1^{DC}$

[3] A binary relation is **complete** if every pair is comparable. A binary relation is **transitive** if for every three alternatives x, y, z such that $x \succeq_i y$ and $y \succeq_i z$ there also is $x \succeq_i z$.

that both players got higher payoffs but also that player i got an increase that is at least as large as that of the player j got. Figure 3.2 provides a visual depiction of quasi-monotonicity order. The shaded area presents the set of points that are better than the point x.

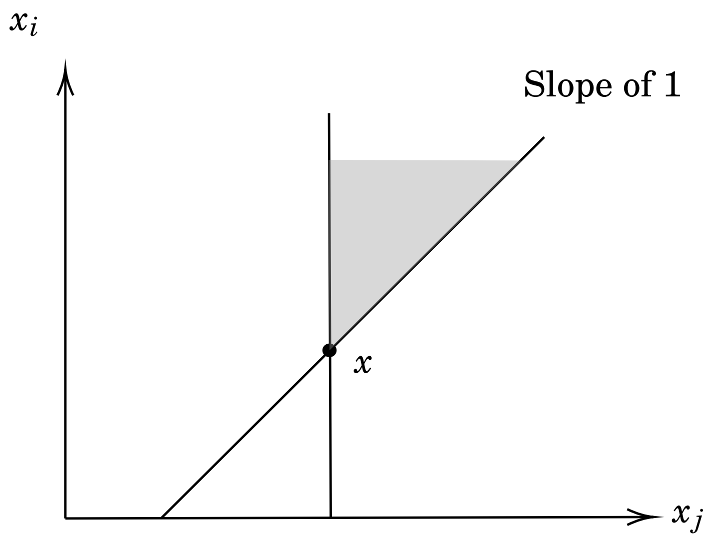


Figure 3.2: Quasi-monotonicity

3.3.1 Second-mover consistency

In any two-stage extensive-form game, the first-mover faces a menu of possible final payoff allocations and must choose among them. In the sequential prisoner's dilemma, this environment is even simpler: the first-mover decides whether to cooperate or defect. Such menu is the *context* in which the first-mover's action takes place.

Given the game form on the Figure 3.1, the second-mover is faced with a simple decision. We also focus only on preferences over the outcomes on the cooperation path, i.e. if the first-mover chosen to cooperate. We make this simplifying assumption in order not to further abuse the notation and also in light of the fact that if the first-mover has chosen to defect then there is no scope for conditional cooperation.[4]

[4]Moreover, in experimental work on sequential prisoner's dilemma, there are very few second-movers would like to choose cooperation after defection, defection after defection makes up the bulk of elicited choices (87% in aggregate), see Gächter et al. (2021) and Baader et al. (2024). Baader et al. (2024) even proposed a modified sequential prisoner's dilemma game that exclude cooperation

However, in order to encompass reciprocity as the motive we need to define the preferences to be *context dependent*. In the standard case, if the first-mover chooses to cooperate and the second-mover chooses to cooperate (defect), they receive the payoffs of x^{CC} (x^{CD}). We represent this outcome as a tuple to reflect the relevant features,

$$\mathbf{x} = (x^{Ca}, x^{Db}, a, b), \text{ where } x^{Ca}, x^{Db} \in X \text{ and } a, b \in \{C, D\}.$$

In this representation the first element stays for the realized outcome, while the second element represent the relevant context. The second element (x^{Db}) shows the the counterfactual/context-dependent payoffs, note that this payoff can serve as the benchmark for how "tempting" it was for the first-mover to choose defection and how "kind" it was in terms of helping the second-mover. Note that in our game x^{Db} may correspond to either x^{DC} or x^{DD}, we do not impose a strict constraint on this term. However, if one wishes to focus on only part of the context, one can restrict attention to the relevant component [5]. Finally, a represents the action second-mover has taken in order to come to the outcome. This part of the vector is important because the reciprocity can only be seen as the motive when talking about the second-mover choosing to cooperate.

This representation helps us thinking second-mover's preferences as two parts. First, we maintain the first assumption that the preference relation

> is **quasi-monotone**, if $\mathbf{x} = (x^{Ca}, x^{Db}, a, b)$ and $\tilde{\mathbf{x}} = (\tilde{x}^{Ca}, x^{Db}, a, b)$ such that $x^{Ca} Q_2 \tilde{x}^{Ca}$ we have $\mathbf{x} \succeq_2 \tilde{\mathbf{x}}$.

This assumption is important for us to capture subjects' unconditional baseline preferences even there is no context (i.e., $x^{Db} = \emptyset$). In other words, if x^{Db} does not play a role in second-mover's decisions (or context does not matter), we should observe that $(x^{Ca}, x^{Db}, a, b) \sim_2 (x^{Ca}, \emptyset, a, b)$. This would suggest a standard experimenter's strategy to exclude the the unconditional preferences that can be used to test the nature of conditional cooperation (conditional preferences). With more details, $(x^{Ca}, \emptyset, a, b)$ suggests an environment that the first-mover is actually a

after defection. Therefore, we deem this decision as trivial.

[5]For example, following the implications of Dufwenberg & Kirchsteiger (2004), we know that the authors care only about the second-mover's payoff in the case of mutual defection; therefore, one can replace x^{Db} with x_2^{DD}.

silent player, second-mover can solely determine the final payoffs allocations (i.e., modified dictator games).

Some existing studies have shown that $(x^{CC}, x^{Db}, C, b) \not\sim_2 (x^{CC}, \emptyset, C, b)$, suggesting that context matters and reciprocity plays a key role in explaining such context. For example, Cox et al. (2008) Axiom R and Axiom S implies (x^{CC}, x^{Db}, C, b) should be more altruistic than $(x^{CC}, \emptyset, C, b)$, suggesting second-mover will be more likely to cooperate in sequential prisoner's dilemma than modified dictator games.[6] More details about Cox et al. (2008) and other models can be found in Section 3.4.

To keep the structure and assumptions as minimal and tractable as possible, we do not introduce additional axioms and instead take $(x^{CC}, x^{Db}, C, b) \succeq_2 (x^{CC}, \emptyset, C, b)$ from Cox et al. (2008). This can be easily explained by the fact that the first-mover's cooperation is always perceived as a kind action in the sequential prisoner's dilemma; therefore, there is no reason for the second-mover to cooperate in the modified dictator game but defect in the sequential prisoner's dilemma.

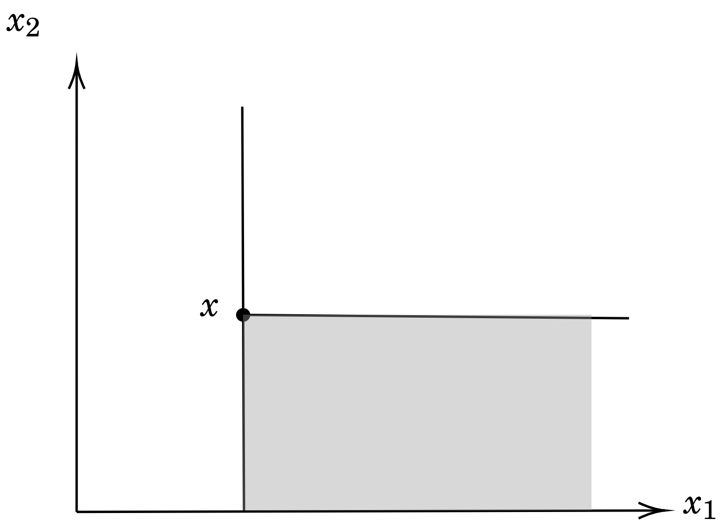


Figure 3.3: Reciprocity

We now understand that context plays a role, but how it operates remains ambiguous. As pointed out in He & Wu (2023), the model in Cox et al. (2008) lacks a measure of the intensity of reciprocity.

[6] This is also what we found in Chapter 2

To define the reciprocal preference relation we need another supplementary relation we denote by R_2. This relation is defined as xR_2y for $x, y \in X$ if $x_2 \leq y_2$ and $x_1 \geq y_1$. Figure 3.3 illustrates the relation presented by R_2.

Here, we maintain our second assumption that the preference relation

> is **reciprocal** if for every $\mathbf{x} = (x^{CC}, x^{Db}, C, b)$ and $\tilde{\mathbf{x}} = (x^{CC}, \tilde{x}^{Db}, C, b)$ such that $x^{Db} R_2 \tilde{x}^{Db}$ we have $\mathbf{x} \succeq_2 \tilde{\mathbf{x}}$.

The idea behind reciprocity is two-fold. First, a lower second-mover's payoff following the first-mover's defection implies that the first-mover's cooperation is particularly generous, as it helps the second-mover avoid a potentially low enough payoff. As a result, the second-mover is more likely to reciprocate with cooperation. This perspective is well documented in existing reciprocity models (Dufwenberg & Kirchsteiger, 2004). Second, a higher first-mover's payoff after defection suggests that defection is actually a relatively safe option for the first-mover. Therefore, when the first-mover chooses to cooperate instead, first-mover's cooperation is perceived as especially generous, thus the return action should also be more cooperative. Figure 3.3 presents the visual depiction of the reciprocity. Shaded areas present the points deemed more generous than point x.

Definition 1. ***Second-mover is consistent*** *if she is endowed with reciprocal and quasi-monotone preference relation.*

3.3.2 First-mover consistency

Although our main focus is on second-mover's response to cooperation, the preferences of first-mover are also very interesting. Preferences for the first-mover are defined over slightly more complex space. When taking action the first-mover effectively chooses a *binary lottery*.

$$L_a = (x^{aC}, x^{aD}, q) \in X \times X \times [0, 1],$$

where $x^{aC} \in X$ is the outcome if the second-mover decides to cooperate, $x^{aD} \in X$ is the outcome if the second-mover decides to defect, $q \in [0, 1]$ is the *subjective belief* that second-mover would cooperate and $a \in \{C, D\}$. Denote by $\mathscr{L}$ the space of all such binary lotteries. Thus the preferences of the first-mover ($\succeq_1$) are defined over all such binary lotteries. Hence, in order to define *first-mover consistency* we need to define both *preference* and *belief* components.

Preferences. We require the first-mover's preferences to respect quasi-monotonicity and stochastic dominance. A preference relation **respects quasi-motonicity** if for every $L_a = (x^{aC}, x^{aD}, q)$ and $\tilde{L}_a = (\tilde{x}^{aC}, \tilde{x}^{aD}, q)$ such that $x^{aC} Q_1 \tilde{x}^{aC}$ and $x^{aD} Q_1 \tilde{x}^{aD}$ we have $L_a \succeq_1 \tilde{L}_a$. A preference relation **respects stoschastic dominance** if for every $L_a = (x^{aC}, x^{aD}, q)$ and $\tilde{L}_a = (\tilde{x}^{aC}, \tilde{x}^{aD}, \tilde{q})$ such that $(x^{aC}, \emptyset, 1) \succeq_1 (\tilde{x}^{aC}, \emptyset, 1)$, and $(\emptyset, x^{aD}, 0) \succeq_1 (\emptyset, \tilde{x}^{aD}, 0)$, and $q \geq \tilde{q}$ we have $L_a \succeq_1 \tilde{L}_a$.

Beliefs. Recall that belief is represented by $q : X \times X \times \{C, D\} \to [0,1]$. That is, the second-mover determines the probability of cooperation, depending on the action taken by the first-mover. Note that this belief function is not directly observable to the researcher, thus we are required to impose some discipline over it. We start by making the **known preference restrictions** assumption, that is first-mover believes that second-mover has consistent (quasi-monotone and reciprocal) preference relation. We also require the belief function to be **consistent**, that is if $\mathbf{x} \succeq_2 \tilde{\mathbf{x}}$, then $q(\mathbf{x}) \geq q(\tilde{\mathbf{x}})$, where $\succeq_2$ is the believed preference relation of the second-mover.

Consistency. As we mentioned above the first-mover consistency requires imposing conditions on both preferences and belief components.

Definition 2. ***First-mover is consistent*** *if she is endowed with preference relation that respects quasi-monotonicity and stochastic dominance as well as a consistent belief function.*

3.3.3 Testing the Theory

To provide the formal tests for the theories we need to start with defining the set of data available. As per usual the revealed preference data set consists of budgets and choice. In this case the budget

$$B^t = \{x^{CC,t}, x^{CD,t}, x^{DC,t}, x^{DD,t}\}, \text{ where } x^{aa'} \in X \text{ and } t \in T$$

consists of the four outcomes that specify the game, where T is a finite set of observations. The choice

$$a^t = \{a_1^t, a_2^t\} \in \{C, D\}^2$$

are the actions taken by the first- and second-movers denoted by a_1^t and a_2^t correspondingly. Recall that for the sake of simplicity we only consider the action taken by second-mover conditionally by the first-mover choosing to cooperate. Then, a **data set** is a finite collection of such observations

$$\mathscr{D} = \{a^t, B^t\}_{t \in T}.$$

Denote by $\hat{\succsim} \in Y \times Y$ the **revealed preference relation**[7] over an abstract set Y, where $\hat{\succ}$ and $\hat{\sim}$ denote the strict and indifferent parts of $\hat{\succsim}$. A revealed preference relation is **acyclic** if for every sequence $y_1, \ldots, y_n \in Y$ such that $y_j \hat{\succsim} y_{j+1}$ for every $j \leq n-1$ with at least one comparison being strict, there is no $y_n \hat{\succsim} y_1$. This definition of acyclicity is equivalent to the standard definition of Generalized Axiom of Revealed Preference from Varian (1982) and Suzumura (1976) consistency. Thus to define the tests for the theory we are going to simply define the corresponding revealed preference relation and impose the acyclicity condition over it.

Second-mover consistency. In order to define the revealed preference relation we need to construct to supplementary sets. We refer to them as *cooperation* and *defection* sets. The **cooperation set** defines the collection of outcomes in which second-mover would be more prone to cooperate than in observation $t \in T$, that is

$$C^t = \{\mathbf{x} \in X : x^{CC} Q_2 x^{CC,t} \text{ and } x^{Db} R_2 x^{Db,t}\}.$$

The **defection set** is the collection of points in which subject is more prone to defect, that is

$$D^t = \{\mathbf{x} \in X : x^{CD} Q_2 x^{CD,t}\}$$

Finally based on the total data set we can derive the data set for the second-mover,

$$\mathscr{D}_2 = \{a_2^t, \{\mathbf{x}_C^t, \mathbf{x}_D^t\}\}_{t \in T}.$$

Based on the total set of payoffs in the game we derive the outcomes that correspond to the second-mover choosing to cooperate or defect in a particular instance.

[7]Recall that preference relation is a reflexive binary relation.

Definition 3. *Let $\hat{\succeq}_2$ be the* ***second-mover's revealed preference relation****, then* $\mathbf{x}\hat{\succeq}\tilde{\mathbf{x}}$ *if at least one of the conditions satisfies:*

(i) $\exists t \in T : \mathbf{x} = \mathbf{x}^t_a$ *and* $\tilde{\mathbf{x}} = \mathbf{x}^t_{\tilde{a}}$ *such that* $a^t = a$*, or*

(ii) $\exists t, s \in T : \mathbf{x} = \mathbf{x}^s_C$ *and* $\tilde{\mathbf{x}} = \mathbf{x}^t_C$ *such that* $\mathbf{x} \in C^t$*, or*

(iii) $\exists t, s \in T : \mathbf{x} = \mathbf{x}^s_D$ *and* $\tilde{\mathbf{x}} = \mathbf{x}^t_D$ *such that* $\mathbf{x} \in D^t$*,*

for every $\mathbf{x}, \tilde{\mathbf{x}} \in X$*.*

The complication in defining the revealed preference relation comes from the necessity to define the downward closure of the budget. This construct is relatively straightforward and commonly used in the revealed preference literature (see Forges & Minelli, 2009 and Nishimura et al., 2017). However, since the outcomes in our cases are context dependent and the partial orders governing the downward closures depend on the type of action taken, we have to define them separately. To finalize this part we need to define the notion of *rationalizability*. A data set $\mathscr{D}_2$ is **rationalizable** if there is a second-mover consistent preference relation $\succeq_2$ such that $\mathbf{x}^t_{a^t} \succeq_2 \mathbf{x}^t_a$ for every $t \in T$

Proposition 3.1. *A data set $\mathscr{D}_2$ is rationalizable if and only if second-mover's revealed preference relation is acyclic.*

First-mover consistency. We start by defining the data set. Note that data set can only include the parts observable to the researcher, thus we cannot include q that is a subjective belief function. Hence, a **first-mover's data set** is

$$\mathscr{D}_1 = \{a^t_1, \{(x^{CC,t}, x^{CD,t}), (x^{DC,t}, x^{DD,t})\}\}_{t \in T}.$$

Next stage is to define the revealed preference relation, that also has to be defined solely over the observables. For the brevity of notation let

$$\mathbb{x}_C = (x^{CC}, x^{CD}) \text{ and } \mathbb{x}_D = (\mathbb{x}^{DC}, \mathbb{x}^{DD}).$$

Let us also note that based on the data set the first-mover can also define the corresponding $\mathbf{x}_C$ and $\mathbf{x}_D$ for the second-mover. Recall that these are important because we need to take care about consistency of the belief function as well.

Definition 4. *Let* $\hat{\succeq}_1$ *be the* ***first-mover's revealed preference relation****, then* $\mathbb{x}\hat{\succeq}\tilde{\mathbb{x}}$ *if at least one of the conditions satisfies:*

(i) $\exists t \in T : \mathbb{x} = \mathbb{x}_a^t$ *and* $\tilde{\mathbb{x}} = \mathbb{x}_{\tilde{a}}^t$ *such that* $a^t = a$*, or*

(ii) $\exists t, s \in T : \mathbb{x} = \mathbb{x}_C^s$ *and* $\tilde{\mathbb{x}} = \mathbb{x}_C^t$ *such that* $\mathbb{x} Q_1 \tilde{\mathbb{x}}$*,* $\mathbf{x}_C^s \in C^t$*, and* $\mathbf{x}_D^t \in D^s$*, or*

(iii) $\exists t, s \in T : \mathbb{x} = \mathbb{x}_D^s$ *and* $\tilde{\mathbb{x}} = \mathbb{x}_D^t$ *such that* $\mathbb{x} Q_1 \tilde{\mathbb{x}}$*.*

for every $\mathbb{x}, \tilde{\mathbb{x}} \in X$*.*

To finalize the statement we need to define the what does it mean for the data set to be rationalizable. A data set $\mathscr{D}_1$ is **rationalizable** if there is a first-mover consistent preference relation and first-mover consistent belief function such that for every $(\mathbb{x}_{a^t}^t, q_{a^t}^t) \succeq_1 (\mathbb{x}_a^t, q_a^t)$ for every $t \in T$.

Proposition 3.2. *If a data set* $\mathscr{D}_1$ *is rationalizable then first-mover's revealed preference relation is acyclic.*

3.3.4 Reduced form implications

Prediction 1 (Reduced-form implications from the revealed-preference model).

1. Suppose the first-mover has both cooperation and defection available, then the second-mover will be more likely to cooperate after observing cooperation, compared to a variant where the first-mover could only cooperate (passive player).

2. Consider two sequential prisoner's-dilemma games. The second-mover is more likely to cooperate after the first-mover's cooperation in game A than in game B if one of the following holds:

   a) the increase of x_2^{CC} from game B to game A is at least as much as the increase of x_1^{CC};
   b) x_1^{DC} is larger in game A than game B;
   c) x_1^{DD} is larger in game A than game B;
   d) x_2^{DC} is smaller in game A than game B;

e) x_2^{DD} is smaller in game A than game B.

3. The second-mover is more likely to defect after the first-mover's cooperation in game A than in game B if the increase of x_2^{CD} from game B to game A is at least as much as the increase of x_1^{CD}.

Prediction 1-(1) follows our assumption that $(x^{CC}, x^{Db}, C, b) \succeq_2 (x^{CC}, \emptyset, C, b)$. In other words, when the first-mover cooperates, the presence of context (if defection is also available to the first-mover) makes the second-mover more likely to cooperate than when there is no context (defection is not valid for the first-mover). This prediction is crucial for any empirical test of conditional cooperation, as it verifies whether such contextual effects on second-mover behavior actually exist. This is exactly what we find in Chapter 2, Section 3.1.

Prediction 1-(2)(a) follows from the assumption of quasi-monotone preferences, suggesting that if both players can benefit from cooperation, the second-mover will be willing to cooperate—but only if they benefit more than the first-mover. This behavior is exactly what we observed in Chapter 2, Section 3.1. Predictions 1-(2)(b) and -(2)(c) follow from the assumption of reciprocal preferences that focus on the context-dependent payoff of the first-mover. Although these predictions are not documented in the existing theoretical literature (we will discuss this in the next section), our model generates them, and Prediction 1-(2)(c) is also supported by the empirical findings in Chapter 2, Section 3.3. Predictions 1-(2)(d) and -(2)(e) also rely on reciprocal preferences, but focus on the context-dependent payoff of the second-mover. Prediction 1-(2)(e) is straightforward and well documented in the existing literature (e.g., Dufwenberg & Kirchsteiger (2004)), while few existing models make prediction-(2)(d). However, our model does, and it is also supported by the empirical findings in Chapter 2, Section 3.3.

Prediction 1-(3) follows from the assumption of quasi-monotone preferences, but focuses on when subjects are more likely to defect. From the experimental findings in Chapter 2, Section 3.2, we find that second-mover is more likely to defect when her own payoff increases, but there is no consistent effect when only first-mover's payoff increases. A plausible explanation is that, by design, the second-mover's payoff always exceeds the first-mover's payoff whenever the second-mover defects after the first-mover cooperates.

3.4 Predictions From Existing Behavioral Models

The rest of the section outlines the predictions of the sequential prisoner's dilemma game derived from six established behavioral models. Although some additional definitions and assumptions are necessary to present these models, we aim to minimize them to ensure analytical tractability. All proofs omitted from this section are provided in the Appendix C.2.

3.4.1 Cox et al. (2008)

Cox et al. (2008) provide a revealed preference-based approach to classify individuals in terms of altruism, assuming that their preferences can be represented by differentiable utility functions. We take their idea to the sequential prisoner's dilemma and check their predictions.

Cox et al. (2008) use *willingness to pay* (WTP) to denote the amount of payoff that the second-mover is willing to give up in order to increase the first-mover's payoff by a unit. Note that given general utility function form involving trade-off between own payoff and the other's payoff, one can always measure WTP. Consider preference orderings in terms of the trade-off between two players that are smooth and convex in R^2_+, then they define the Definition 1:

Definition 1. (Cox et al., 2008) . Preference ordering A is said to be *more altruistic than* **(MGT)** B if $WTP_A \geq WTP_B$.

Define an opportunity set F which belongs to a set of possible opportunity sets $\mathscr{F}$.

Definition 2. (Cox et al., 2008) Opportunity set C is said to be *more generous than* **(MGT)** another opportunity set D if (a) $x^*_{2,C} - x^*_{2,D} \geq 0$ (b)$x^*_{2,C} - x^*_{2,D} \geq x^*_{1,C} - x^*_{1,D}$

$x^*_{2,C}$ ($x^*_{1,C}$) is the highest payoff that second-mover (first-mover player) can get from the opportunity set C. Definition 2 delivers two key messages. (a) Opportunity set C is more generous than D if C can improve the monetary payoff for the second-mover compared to D, and (b) this is true as only if the first-mover does not increase her own potential payoff more than the first-mover. This implies that a mutually beneficial action can not be generous as this is the expected behavior from the first-mover.

Consider a SPD, $\mathscr{F} = \{C, D\}$, (a) $x^*_{2,C} - x^*_{2,D} = x_2^{CD} - x_2^{DD} \geq 0$ (b)$x^*_{2,C} - x^*_{2,D} = x_2^{CD} - x_2^{DD} \geq x^*_{1,C} - x^*_{1,D} = x_1^{CC} - x_1^{DC}$. Then we can conclude that the first-mover's cooperation is more generous than first-mover's defection.

AXIOM R. (Cox et al., 2008) Let the first-mover choose the actual opportunity set for the second-mover from $\mathscr{F}$. If C, D $\in \mathscr{F}$ and C MGT D, then A_C MAT A_D.

This axiom is intuitive. It suggests that if the first-mover chooses more generously, the second-mover will be more altruistic. By applying this Axiom to our games. Note that we have already obtained that C MGT D from Definition 2, therefore, C MAT D. This implies that second-mover is more likely to cooperate after first-mover's cooperation than after first-mover's defection. This result is proved by experimental literature in the sequential prisoner's dilemma that less than 15% subjects will cooperate after defection while around 40% subjects will cooperate after cooperation (Miettinen et al., 2020, Baader et al., 2024).

However, there is no additional information on whether the second-mover would feel differently from the cooperation chosen by the first-mover given different games with different parameters. In other words, we are not able to observe how generous that the first-mover is based on this model.

Cox et al. (2008) model also implies a distinction between context-dependent and context-free scenarios, highlighting how the environment influences revealed preferences.

To formalize the intuition, consider when the first-mover has no choice and we write $\mathscr{F} = \{F^0\}$ with corresponding the second-mover preferences A_{F^0}. Their alternative axiom provides an explanation when the first-mover has no choice:

AXIOM S. (Cox et al., 2008) Let the first-mover choose the actual opportunity set for the second-mover from the $\mathscr{F}$. Then: A_C MAT A_{C^0} if C MGT D for all D $\in \mathscr{F}$, and A_{D^0} MAT A_D if C MGT D for all C $\in \mathscr{F}$.

Axiom S posits that the effect of Axiom R is stronger when the second-mover faces an opportunity set that is either the most or least generous among the available options. The Axiom S suggests the following prediction which is the same as ours:

Prediction 2. (Cox et al., 2008) Suppose the first-mover has both cooperation and defection available, then the second-mover will be more likely to cooperate after observing cooperation, compared to a variant where the first-mover could only cooperate (passive player).

This prediction is the same as Prediction 1-(1) derived from our model and is confirmed by the empirical findings in Chapter 2, Section 3.1, where we found that subjects are significantly—by 10 percentage points—more likely to cooperate in the sequential prisoner's dilemma than in the corresponding modified dictator games, following the first-mover's cooperation.

3.4.2 He & Wu (2023)

He & Wu (2023) point out a flaw in Cox et al. (2008) model—it lacks a measure of the intensity of generosity. They extend their model with an additional definition.

Definition 3. (He & Wu, 2023)

Case 1: Consider three opportunity sets: H, G, E. Suppose H *MGT* E and G *MGT* E. We say H *MGT* E more than G *MGT* E if (1) $x^*_{2,H} \geq x^*_{2,G}$ and (2) $x^*_{1,G} \geq x^*_{1,H}$.

Case 2: Consider three opportunity sets: H, G, E. Suppose H *MGT* G and H *MGT* E. We say H *MGT* G more than H *MGT* E if (1) $x^*_{2,E} \geq x^*_{2,G}$ and (2) $x^*_{1,G} \geq x^*_{1,E}$.

AXIOM R'. (He & Wu, 2023)

Case 1: suppose H, E $\in \mathscr{F}_1 = \{H, E\}$ and G, E $\in \mathscr{F}_2 = \{G, E\}$. If H *MGT* E more than G *MGT* E, then $A_{H|E}$ MAT $A_{G|E}$

Case 2: suppose H, G $\in \mathscr{F}'_1 = \{H, G\}$ and H, E $\in \mathscr{F}'_2 = \{H, E\}$. If H *MGT* G more than H *MGT* E, then $A_{H|G}$ MAT $A_{H|E}$

He & Wu (2023) extend Cox et al. (2008) framework to a more general environment, allowing for the potential comparison of two distinct sequential prisoner's dilemma games. In their model, Case 1 exhibits similarities to the quasi-monotone preferences in our framework, while Case 2 exhibits similarities to our reciprocal preferences. However, He & Wu (2023) restrict their analysis to the maximum monetary payoffs of each opportunity set. We will now present the predictions derived from their model.

Prediction 3. (He & Wu, 2023) Consider two sequential prisoner's-dilemma games. The second-mover is more likely to cooperate after the first-mover's cooperation in game A than in game B if one of the following holds:

1. x_2^{CD} is larger in game A than game B;
2. x_1^{DC} is larger in game A than game B;
3. x_1^{CC} is smaller in game A than game B;
4. x_2^{DD} is smaller in game A than game B;

He & Wu (2023) is perhaps the first to propose that the first-mover's context-dependent payoff matters. Their Prediction 3-(1) corresponds to our Prediction 1-(3), yet we obtain the opposite result. Prediction 3-(1) violates our intuition and is also rejected by the experimental evidence reported in Chapter 2, Section 3.2. This discrepancy arises because their model considers only maximum payoff values, ignoring other possible outcomes. Prediction 3-(2) aligns with our Prediction 1-(2)(b). However, the stronger effect of x_1^{DD} documented in Chapter 2, also Prediction 1-(2)(c), is absent from their framework, again because the model focuses solely on maximum payoffs.

Prediction 3-(3) corresponds to our Prediction 1-(2)(a); however, we make no such prediction when only x_1^{CC} is changed. Chapter 2, Section 3.2 shows that altering x_1^{CC} alone does not necessarily increase the cooperation rate. Prediction 3-(4) aligns with our Prediction 1-(2)(e) and with the experimental evidence reported in Chapter 2, Section 3.3. It is also the standard prediction generated by reciprocity models such as Dufwenberg & Kirchsteiger (2004).

Although the model in He & Wu (2023) is not fully consistent with our experimental results in Chapter 2, it offers valuable insights into the role of sacrifice in reciprocity. Specifically, it highlights that the first-mover's context dependent payoff should also be considered when evaluating reciprocal behavior.

3.4.3 Charness & Rabin (2002)

Suppose that all individuals have a conditional concern for welfare, as expressed by the goal function in Charness & Rabin (2002). Applied to our setting, this goal function can be written as

$$U_2(x) = \begin{cases} (1-\rho)x_2 + \rho x_1, & \text{if } x_2 \geq x_1 \\ (1-\sigma)x_2 + \sigma x_1, & \text{if } x_2 < x_1 \end{cases}$$

The function includes parameters ρ and σ, both non-negative and constrained by $\sigma \leq \frac{1}{2}$, $\rho \leq 1$, and $\sigma \leq \rho$. This utility formulation reflects conditional altruism, where the weight assigned to the other player's payoff depends on who earns more.

From the utility function, then we can conclude:

Prediction 4. (Charness & Rabin, 2002)

1. The second-mover's choice will be the same following the first-mover's cooperation, regardless of whether defection is available to the first-mover.

2. Consider two sequential prisoner's-dilemma games. The second-mover is more likely to cooperate after the first-mover's cooperation in game A than in game B if one of the following holds:

   a) x_2^{CC} is larger in game A than game B;
   b) x_1^{CC} is larger in game A than game B;
   c) x_2^{CD} is smaller in game A than game B;
   d) x_1^{CD} is smaller in game A than game B.

In Charness & Rabin (2002), the model assumes unconditional social preferences only. This yields Prediction 4-(1), which contrasts with our Prediction 1-(1) and with the experimental evidence reported in Chapter 2, Section 3.1.

Prediction 4-(2)(a) aligns with our Prediction 1-(2)(a), which is also proved in Chapter 2, Section 3.2. Prediction 4-(2)(b) corresponds to our Prediction 1-(2)(a); however, we make no such prediction when only x_1^{CC} is changed. As reported in Chapter 2, Section 3.2, changing x_1^{CC} alone does not necessarily increase the cooperation rate. The same comments with Predictions 4-(2)(c) and -(2)(d). Prediction 4-(2)(c) aligns with our Prediction 1-(3), which is also proved in Chapter 2, Section 3.2. Prediction 4-(2)(d) corresponds to our Prediction 1-(3); however, there is no consistent effect when only x_1^{CD} increases from the experimental reports in Chapter 2, Section 3.2.

Some other models also present a similar prediction. For example, Becker (1976) model of (unconditional) altruism. The goal function is given by: $U_i = x_i + \theta \cdot x_j$ where $\theta \in (0, 1)$. This suggests that the second-mover derives higher utility whenever either player's payoff increases.

3.4.4 Dufwenberg & Kirchsteiger (2004)

In his seminal paper, Rabin (1993) proposes the first model of reciprocity in normal form games. It is further extended to extensive form games by Dufwenberg & Kirchsteiger (2004).

In Dufwenberg & Kirchsteiger (2004) model, the utility of a player depends on the sum of her material payoff and her reciprocity payoff: $U_2 = \pi_2 + r_2 k_{21} \lambda_{212}$. Here π_2 denotes the material payoff, r_2 denotes her sensitivity to reciprocity (a non-negative parameter), k_{21} is a kindness function of the second-mover to the first-mover, and λ_{212} is a kindness function of the first-mover to the second-mover. In their model k_{21} is determined by the first-mover's payoff and λ_{212} is determined by the second-mover's payoff. Thus we can analyze two terms separately and provide the predictions.

The kindness function of the second-mover to the first-mover if second-mover decides cooperation after cooperation is given by $k_{21}(c|C) = x_1^{CC} - (x_1^{CC} + x_1^{CD})/2 = (x_1^{CC} - x_1^{CD})/2$ where $(x_1^{CC} + x_1^{CD})/2$ is defined as a reference point in their model that is used to measure second-mover's kindnesses to first-mover corresponding to different choices. The same method we obtain $k_{21}(d|C) = x_1^{CD} - (x_1^{CC} + x_1^{CD})/2 = -(x_1^{CC} - x_1^{CD})/2$. Moreover, the model suggests that λ_{212} must be greater than zero as first-mover's cooperation must be perceived as a kind action. Therefore, an increase in x_1^{CC} (or a decrease in x_1^{CD}) makes the second-mover more likely to cooperate, as this change causes the kindness term $k_{21}(c|C)$ to increase and $k_{21}(d|C)$ to decrease.

The kindness function of the first-mover to the second-mover if second-mover decides cooperation after cooperation is given by $\lambda_{212}(c|C) = x_2^{CC} - (x_2^{CC} + x_2^{DD})/2 = (x_2^{CC} - x_2^{DD})/2$ where $(x_2^{CC} + x_2^{DD})/2$ is defined as a reference point that is used to measure how kind that the first-mover is to the second-mover. Here, we can observe the extent to which the second-mover benefits compared to the first-mover's defection. The same method we obtain $\lambda_{212}(d|C) = x_2^{CD} - (x_2^{CD} + x_2^{DD})/2 = (x_2^{CD} - x_2^{DD})/2$. As $k_{21}(d|C) < 0$, a decrease in x_2^{DD} makes the first-mover more kind and second-mover will be less likely to defect. But the net impact of x_2^{CD} is not directly observable because it presents a trade-off, leading to a reduction in the reciprocity payoff but an enhancement in the direct material payoff.

Moreover, Dufwenberg & Kirchsteiger (2004) model also implies that the second-mover will be more likely to cooperate after first-mover's cooperation when defection is also available to the first-mover than cooperation is the only choice for the first-mover. To see this, if cooperation is the only choice for the first-mover, then the model suggest that $\lambda_{212} = 0$, thus $U_2 = \pi_2$, defection will be the only best response for the second-mover.

To conclude, Dufwenberg & Kirchsteiger (2004) would make the following predictions:

Prediction 5. (Dufwenberg & Kirchsteiger, 2004)

1. Suppose the first-mover has both cooperation and defection available, then the second-mover will be more likely to cooperate after observing cooperation, compared to a variant where the first-mover could only cooperate (passive player).

2. Consider two sequential prisoner's-dilemma games. The second-mover is more likely to cooperate after the first-mover's cooperation in game A than in game B if one of the following holds:

   a) x_2^{CC} is larger in game A than game B;

b) x_1^{CC} is larger in game A than game B;

c) x_1^{CD} is smaller in game A than game B;

d) x_2^{DD} is smaller in game A than game B.

3. Consider two sequential prisoner's-dilemma games. The second-mover will behave the same after the first-mover's cooperation in game A and in game B if only x_1^{DD}, x_1^{DC}, and x_2^{DC} vary.

We first note that Prediction 5-(1) makes the same prediction as Predictions 1 and 2, and is also confirmed by the experimental findings in Chapter 2, Section 3.1.

Prediction 5-(2)(a) aligns with Prediction 1-(2)(a) and is also confirmed by the experimental results in Chapter 2, Section 3.2. Prediction 5-(2)(b) corresponds to our Prediction 1-(2)(a); but we make no such prediction when only x_1^{CC} is changed. As reported in Chapter 2, Section 3.2, changing x_1^{CC} alone does not necessarily increase the cooperation rate. Prediction 5-(2)(c) corresponds to our Prediction 1-(3); however, there is no consistent effect when only x_1^{CD} increases as shown in Chapter 2, Section 3.2. Prediction 5-(2)(d) corresponds to Prediction 1-(2)(c) and is supported by the experimental results in Chapter 2, Section 3.3.

Prediction 5-(3) suggests that x_1^{DD}, x_1^{DC}, and x_2^{DC} have no effect on the second-mover's decisions, because these payoffs are assumed not to enter the second-mover's utility function directly. This implication contradicts our Predictions 1-(2)(c), 1-(2)(b), and 1-(2)(d), respectively, and it is also at odds with the experimental evidence reported in Chapter 2. The discrepancy arises because Dufwenberg & Kirchsteiger (2004) posit that the perceived generosity of the first-mover depends only on the second-mover's payoff, thereby neglecting the first-mover's potential payoffs, and they also rule out the possibility of cooperation after a defection.

3.4.5 Fehr & Schmidt (1999)

In Fehr & Schmidt (1999) model, they assume that in addition to purely selfish subjects, there are subjects who will experience the disutility when inequitable distribution occurs. They experience inequity if they are worse off in material terms than others, and they also feel inequity if they are better off. According to their model,we have the following goal utility function for the second-mover:

$$U_2(x) = x_2 - \alpha_2 max\{x_1 - x_2, 0\} - \beta_2 max\{x_2 - x_1, 0\}$$

where $\beta_2 \le \alpha_2$ and $0 \le \beta_2 < 1$. In other words, players dislike inequity, and more so when they are worse off than the others.

In the environment of the sequential prisoner's dilemma game, following Fehr & Schmidt (1999) model, the utility for different choice would be:

$$U_2(c|C) = x_2^{CC} - \alpha_2 max\{x_1^{CC} - x_2^{CC}, 0\} - \beta_2 max\{x_2^{CC} - x_1^{CC}, 0\}$$

$$U_2(d|C) = x_2^{CD} - \alpha_2 max\{x_1^{CD} - x_2^{CD}, 0\} - \beta_2 max\{x_2^{CD} - x_1^{CD}, 0\}$$

The second-mover would like to cooperate conditional on the first-mover's cooperation if:

$$U_2(c|C) > U_2(d|C)$$

Then we can conclude:

Prediction 6. (Fehr & Schmidt, 1999)

1. The second-mover's choice will be the same following the first-mover's cooperation, regardless of whether defection is available to the first-mover.

2. Consider two sequential prisoner's-dilemma games. The second-mover is more likely to cooperate after the first-mover's cooperation in game A than in game B if one of the following holds:

   a) x_1^{CC} is larger in game A than game B, and x_1^{CC} is smaller than x_2^{CC} in game A;

   b) x_2^{CC} is larger in game A than game B;

   c) x_1^{CD} is smaller in game A than game B, and x_1^{CD} is smaller than x_2^{CD} in game B;

   d) x_2^{CD} is smaller in game A than game B.

Prediction 6-(1) suggests a non-existence of conditional cooperation/conditional social preferences that contradicts the Prediction 1-(1) as well as experimental findings in Chapter 2, Section 3.1. Prediction 6-(2)(a) matches our Prediction 1-(2)(a) and is supported by the experimental results in Chapter 2. Notably, this is the only model in this section that yields such a prediction. Predictions 6-(2)(b) and 6-(2)(d) aligns with our Predictions 1-(2)(a) and 1-(3), respectively, and with the findings reported in Chapter 2, Section 3.2. Prediction 6-(2)(c) corresponds to our Prediction 1-(3); however, Chapter 2, Section 3.2 shows no consistent effect when only x_1^{CD} is increased.

3.4.6 More models

There are also other models that aim to capture the idea of reciprocity. For example, Cheung (2025) propose a recent model that examines revealed reciprocity. According to their model, when a second-mover gives more to the first-mover due to *context*, the second-mover is not following baseline preferences (Fehr & Schmidt, 1999, Bolton & Ockenfels, 2000, Charness & Rabin, 2002, Becker, 1976), but rather a more altruistic preference, as in Cox et al. (2008). Their model suggests that if experimenters find that people behave differently in sequential prisoner's dilemma games compared to modified dictator games (as discussed in Chapter 2), we can argue that *context* matters and that conditional cooperation exists. Otherwise, if behavior does not differ, we can conclude that *context* does not matter, and people act as unconditional decision makers. The model by Cheung (2025) explains the situation and also provides an experimental strategy, similar to the one used in Chapter 2. While the model does not make specific predictions about the comparison between the two games, we do not comment on the prediction of their model here.

Reciprocity suggests that behavior changes in a particular direction depending on how generous another person has been. As proposed by Heufer et al. (2020) in another model, they use the Agreement Axiom similar to Cox et al. (2008) to give empirical meaning to the idea that one becomes more or less generous depending on the behavior of the other person. In other words, contexts can influence behavior.

3.5 Conclusion

Conditional cooperation in the sequential prisoner's dilemma is consistent with concerns about reciprocity. However, second-mover cooperation after first mover cooperation can be interpreted in two different ways. One is outcome-based idea that captures concerns over distributions. An example is inequity aversion Fehr et al. (1993) which allows people to compare their payoff with others and prefer payoffs that are more equal— Note that, even though the potential payoffs are formed by the first mover's cooperation, second mover's decision is independent of first mover's cooperative behaviour. Another explanation is the intention-based account, which reflects concern for the first mover's intentions. A typical example is reciprocity, which suggests that the second mover is more likely to cooperate if the first mover demonstrates kindness (Rabin, 1993, Dufwenberg & Kirchsteiger, 2004). Note that cooperation already implies that the first mover is acting generously. In this case, the second mover's behaviour does depend on the first mover's action, giving rise to conditional cooperation.

To disentangle the two effects and understand their importance in explaining cooperation, we distinguish between context-independent and context-dependent preferences. We use the concept of quasi-monotone preferences to represent the context-independent component, suggesting that the second mover cares about the final payoff distribution, regardless of how it is generated. Moreover, we argue that conditional cooperation should be context-dependent and can be linked to reciprocity. We therefore propose a reciprocal preference to explain conditional cooperation in the sequential prisoner's dilemma. The reciprocal preferences discussed in this chapter are connected to the intentional component of reciprocity introduced in Chapter 1. However, the definition presented here is more general and is supported by the experimental findings in Chapter 2.

The two preferences we proposed in the paper captures the workhorse criterion to identify conditional cooperation from an experiment-comparing the second mover's choice in a sequential prisoner's dilemma game to the case where the first mover plays no role in determining cooperation or defection.

Finally, we compare several prominent models of social preferences, including those that capture inequity aversion (Fehr & Schmidt, 1999), welfare concerns

(Charness & Rabin, 2002), altruism (Becker, 1976), and reciprocity (Dufwenberg & Kirchsteiger, 2004, He & Wu, 2023, Cox et al., 2008). These models offer valuable insights into the nature of social preferences, but each overlooks some certain effects. This highlights the need for further experimental work to detect whether the missing elements play an important role in shaping behaviour (Baader et al., 2024).

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APPENDIX

A

APPENDIX TO CHAPTER 1

A.1 Proof of the Theorem

Proof. The proof adopts the approach of Dufwenberg & Kirchsteiger (2004), given the close similarity between the two model environments.

Recall that we have defined that Δ is players' behavioural strategy space and $A_{i,h}$ is i's set of actions at history $h \in H$. Define $x_{i,h} \in \Delta(A_{i,h})$, and $\sigma_i/x_{i,h}$ be i's strategies that specifies the choice $x_{i,h}$, and otherwise the same as σ_i.

Define the local best response correspondence and the best response correspondence $f_{i,h} : \Delta \to \Delta(A_{i,h})$ and $f : \Delta \to \times_{(i,h)\in N\times H}$ by:

$$f_{i,h}(\sigma) = \underset{x_{i,h}\in\Delta A_{i,h}}{\arg\max}\ U_i(\sigma_i/x_{i,h}, b_{i,h}, c_{i,h})$$
$$f(\sigma) = \times_{(i,h)\in N\times H} f_{i,h}(\sigma)$$

As $\times_{(i,h)\in N\times H} f_{i,h}(\sigma)$ and Δ are topologically equivalent, we can define an equivalent function $\gamma : \Delta \to \Delta$ and look for a fixed point. A fixed point under γ satisfies the ERE conditions since player i at h maximizes their utility (condition (1) of Definition 9), and the first- and second order beliefs are correct and updated along the path given h (conditions (2) and (3) of Definition 9).

Since $\Delta(A_{i,h})$ is non-empty (recall that if i owns no information set then $\Delta(A_{i,h})$ is taken to be singleton) and compact and U_i is continuous (since π_i , Ψ_i, and Φ_i are all continuous; also recall that although our model and Dufwenberg & Kirchsteiger (2004) selects efficient strategies, they are independent of beliefs). Then Berge's maximum principle suggests that $f_{i,h}$ is non-empty, closed-valued, and upper hemi-continuous. Next, $f_{i,h}$ is convex as $\Delta(A_{i,h})$ is convex and U_i is indeed linear in i's own strategy. Therefore, $f_{i,h}$ is non-empty, closed-valued, upper hemi-continuous, and convex-valued. These properties extend from to $f_{i,h}$ to f and γ. According to Kakutani's fixed point theorem, γ admits a fixed point. Therefore, the ERE must exist.

□

A.2 Applications

Dufwenberg & Kirchsteiger (2004) primarily focus on analyzing a single case for each game type and do not explicitly compare multiple games, such as four games illustrated in Figures 1.1a–1.1d. To address this gap and facilitate comparison across multiple games, we first clarify our comparison strategy, which is also applicable in Dufwenberg & Kirchsteiger (2004) model:

Consider any two games game (i) and game (ii) with the same game type, in which equilibrium analysis implies that an individual will choose strategy s if their sensitivity parameter β (measuring how much they care about intentions) exceeds certain thresholds a in game (i) and b in game (ii). Here, a and b are game-specific thresholds and are calculated by the model. Suppose $a > b$; then, for any individual with a given β, if this person chooses strategy s in game (i), they must also choose strategy s in game (ii), but not vice versa. Consequently, if one assumes a distribution of reciprocity parameters, s will be more likely to be chosen in game (ii) than in game (i), which in turn implies that a greater proportion of individuals will choose s in game (ii) than in game (i). This logic also applies analogously when β is below certain thresholds, or when considering another parameter α, representing how much individuals care about consequences.

Four mini-ultimatum games

Result A1. In games (a) - (b), if the proposer chooses O_2, the responder will accept the offer (by choosing y) in every ERE.

Proof. Result A1 shows the responder would like to accept a sufficiently kind and fair offer. In games (a)-(b), we notice that if the proposer chooses O_2, the responder will never experience disutility by our definition of the consequence part: $\Phi_R(y|O_2) = 0$ and $\Phi_R(n|O_2) = 0$. Then we can look at proposer's intentions. The proposer chooses y after O_2 can take the highest material payoff in the whole game for the responder ($\Psi_R > 0$), while n after O_2 can take the lowest material payoff in the whole game for the responder ($\Psi_R < 0$). Therefore, the utility of the responder by choosing y after O_2 is always greater than choosing n after O_2. The responder must accept the offer (by choosing y) in every ERE.

□

Result A2. In game (a), when $\alpha_R \leq 1/3$ and proposer chooses O_1, the following holds in all ERE:

(1) if $\beta_R < \frac{(2-6\alpha_R)(1+e^5)}{40e^5}$, the responder will accept the offer (by choosing y).

(2) if $\beta_R > \frac{(2-6\alpha_R)(e^8+e^5)}{24e^5}$, the responder will reject the offer (by choosing n).

(3) if $\frac{(2-6\alpha_R)(1+e^5)}{40e^5} \leq \beta_R \leq \frac{(2-6\alpha_R)(e^8+e^5)}{24e^5}$, the responder will choose randomly.

Proof. Note that we have stated that if proposer chooses O_2, the responder will always accept the offer (by choosing y) in every SRE (Result A1).

In order to calculate how kind responder believes proposer is after choosing O_1, we have to specify responder's belief of proposer's belief about responder's choice after O_1. Denote this by $q \in [0,1]$[1].

[1]In principle we also need responder's belief about proposer's behavior, i.e. b_R. However, the belief updating rules suggest when responder already knows what proposer has done, responder's belief has to be in accordance with the truth.

In the ultimatum game in game (a), we obtain the responder's utility given that proposer chooses O_1:

$$U_R(y|O_1) = 2 - 6\alpha_R + 8\beta_R \cdot k_P$$

$$U_R(n|O_1) = 0 + 0\alpha_R + 0\beta_R \cdot k_P$$

where $k_P = 2q + 0 - [\frac{e^{8q+0(1-q)}}{e^{8q+0(1-q)}+e^5} \cdot 2q + \frac{e^5}{e^{8q+0(1-q)}+e^5} \cdot 5] = \frac{e^5}{e^{8q}+e^5} \cdot (2q-5)$. Note that here k_P is less than 0 since $q \in [0,1]$.

Reading two equations, we first note that find that the responder will never accept the offer if $\alpha_R > 1/3$ as $U_R(y|O_1) < U_R(n|O_1)$. That is why we assume that $\alpha_R \le 1/3$.

When having $\alpha_R \le 1/3$, the responder would like to choose y if and only if $U_R(y|O_1) > U_R(n|O_1)$. Because all beliefs must be correct, q=1 must hold when $U_R(y|O_1) > U_R(n|O_1)$. Therefore:

$$2 - 6\alpha_R + 8\beta_R \cdot k_P > 0 + 0\alpha_R + 0\beta_R \cdot k_P$$

$$2 - 3\beta_R \cdot \frac{e^5}{e^8+e^5} \cdot 8 - 6\alpha_R > 0$$

$$\beta_R < \frac{(2-6\alpha_R)(e^8+e^5)}{24e^5} \tag{A.1}$$

Similarly, the responder would like to choose n if and only if $U_R(y|O_1) < U_R(n|O_1)$ and q=0, therefore:

$$2 - 6\alpha_R + 8\beta_R \cdot k_P < 0 + 0\alpha_R + 0\beta_R \cdot k_P$$

$$2 - 6\alpha_R + 8\beta_R \cdot \frac{-5e^5}{1+e^5} < 0$$

$$\beta_R > \frac{(2-6\alpha_R)(1+e^5)}{40e^5} \tag{A.2}$$

According to above two thresholds, we find that $\frac{(2-6\alpha)(e^8+e^5)}{24e^5} > \frac{(2-6\alpha)(1+e^5)}{40e^5}$. It means that when $\beta \in [\frac{(2-6\alpha)(1+e^5)}{40e^5}, \frac{(2-6\alpha)(e^8+e^5)}{24e^5}]$, there is no difference for the proposer to choose either y or n. Therefore, the proposer will choose randomly. For $\beta \notin [\frac{(2-6\alpha)(1+e^5)}{40e^5}, \frac{(2-6\alpha)(e^8+e^5)}{24e^5}]$, we revise our (A.1) and (A.2) as follows (Result A2):

The responder would like to choose y when:

$$\beta_R < \frac{(2-6\alpha_R)(1+e^5)}{40e^5} \tag{A.3}$$

The responder would like to choose n when:

$$\beta_R > \frac{(2-6\alpha_R)(e^8+e^5)}{24e^5} \tag{A.4}$$

To explain the result, as stated in Dufwenberg & Kirchsteiger (2004), the intermediate value of β is characterized by self-fulfilling prophecies. Assume the beliefs are such that the offer is rejected, which will make the offer a very unkind action of proposer. This in turn leads responder to be unkind to proposer(reject the offer). On the other hand, if the beliefs imply acceptance of the offer, the offer is not so unkind, and this in turn leads responder to accept the offer. □

Result A3. In game (b), when $\alpha_R \leq 1/3$ and proposer chooses O_1, the following holds in all ERE:

(1) if $\beta_R < \frac{(2-6\alpha_R)(1+e^2)}{64e^2}$, the responder will accept the offer (by choosing y).

(2) if $\beta_R > \frac{(2-6\alpha_R)(e^8+e^2)}{48e^2}$, the responder will reject the offer (by choosing n).

(3) if $\frac{(2-6\alpha_R)(1+e^2)}{64e^2} \leq \beta_R \leq \frac{(2-6\alpha_R)(e^8+e^2)}{48e^2}$, the responder will choose randomly.

Proof. The proof process is exactly the same as Result A2, we briefly state the calculations:

In the ultimatum game (b), we obtain the responder's utility given that proposer chooses O_1:

$$U_R(y|O_1) = 2 - 6\alpha_R + 8\beta_R \cdot k_P$$

$$U_R(n|O_1) = 0 + 0\alpha_R + 0\beta_R \cdot k_P$$

where $k_P = 2q + 0 - [\frac{e^{8q+0(1-q)}}{e^{8q+0(1-q)}+e^2} \cdot 2q + \frac{e^2}{e^{8q+0(1-q)}+e^2} \cdot 8] = \frac{e^2}{e^{8q}+e^2} \cdot (2q-8)$. Note that here k_P is less than 0 since $q \in [0,1]$.

As in result A2, we assume that $\alpha_R \leq 1/3$.

When having $\alpha_R \leq 1/3$, the responder would like to choose y if and only if $U_R(y|O_1) > U_R(n|O_1)$. Because all beliefs must be correct, q=1 must hold when $U_R(y|O_1) > U_R(n|O_1)$. Therefore:

$$2-6\alpha_R+8\beta_R\cdot k_P > 0+0\alpha_R+0\beta_R\cdot k_P$$

$$2-6\beta_R\cdot\frac{e^2}{e^8+e^2}\cdot 8-6\alpha_R>0$$

$$\beta_R<\frac{(2-6\alpha_R)(e^8+e^2)}{48e^2} \tag{A.5}$$

Similarly, the responder would like to choose n if and only if $U_R(y|O_1) < U_R(n|O_1)$ and q=0, therefore:

$$2-6\alpha_R+8\beta_R\cdot k_P < 0+0\alpha_R+0\beta_R\cdot k_P$$

$$2-6\alpha_R+8\beta_R\cdot\frac{-8e^2}{1+e^2}<0$$

$$\beta_R>\frac{(2-6\alpha_R)(1+e^2)}{64e^2} \tag{A.6}$$

According to above two thresholds, we find that $\frac{(2-6\alpha_R)(e^8+e^2)}{48e^2} > \frac{(2-6\alpha_R)(1+e^2)}{64e^2}$. It means that when $\beta \in [\frac{(2-6\alpha_R)(1+e^2)}{64e^2}, \frac{(2-6\alpha_R)(e^8+e^2)}{48e^2}]$, there is no difference for the proposer to choose either y or n. Therefore, the proposer will choose randomly. For $\beta \notin [\frac{(2-6\alpha_R)(1+e^2)}{64e^2}, \frac{(2-6\alpha_R)(e^8+e^2)}{48e^2}]$, we revise our (A.5) and (A.6) as follows (Result A3):

The responder would like to choose y when:

$$\beta_R<\frac{(2-6\alpha_R)(1+e^2)}{64e^2} \tag{A.7}$$

The responder would like to choose n when:

$$\beta_R>\frac{(2-6\alpha_R)(e^8+e^2)}{48e^2} \tag{A.8}$$

Results A2-A3 provide us with a very plausible and empirically supported explanation. They show that as long as responder is sufficiently motivated by intentions, responder choice depends on the behavior of the proposer. Result A2 shows that as long as the responder is not too inequity-averse ($\alpha < 1/3$) and does not care too much about intentions ($\beta_R < \frac{(2-6\alpha)(1+e^5)}{40e^5}$), they would accept the unfair

O_1 offer. But if the responders care about the intentions ($\beta_R > \frac{(2-6\alpha)(e^8+e^2)}{48e^2}$), they will reject this unkind O_1 offer. The same in result A3.

□

Proof of Comparison 2.

Proof. We have obtained the different thresholds of choosing y and n in games (a) and (b) when $\alpha < 1/3$. To compare the y rate and n rate in game (a) and game (b), we can compare (A.3) and (A.7), (A.4) and (A.8).

First, we compare two different thresholds: (A.7) -(A.3) we obtain $\frac{(2-6\alpha)(1+e^2)}{64e^2} - \frac{(2-6\alpha)(1+e^5)}{40e^5} = (2-6\alpha)(\frac{1}{64} - \frac{1}{40} + \frac{1}{64e^2} - \frac{1}{60e^5}) < 0$. This implies that those who choose y in game (a) must also choose y in game (b), but not vice versa.

Then, we compare another two different thresholds: (A.8) - (A.4) we obtain $\frac{(2-6\alpha)(e^8+e^2)}{48e^2} - \frac{(2-6\alpha)(e^8+e^5)}{24e^5} = (2-6\alpha)\frac{(e^6-2e^3-1)}{48} > 0$. This implies that those who choose n in game (b) must also choose n in game (a), but not vice versa. Furthermore, for any intermediate case, we have proved that they would choose randomly.

In the ultimatum game (c), there does not exist any intention for the proposer, because he can not choose any intentional action, thus the intention term $\Psi_R = 0$.

In the ultimatum game (d), because O_2 is not efficient, there does not exist any intention for the proposer, so the intention term $\Psi_R = 0$.

Hence, in games (c) and (d), we only consider the consequence term $\Phi_R = -6\alpha$ for choosing y and $\Phi_R = 0$ for choosing n, the utility of proposer:

$$U_R(y|O_1) = 2 - 6\alpha_R$$

$$U_R(n|O_1) = 0 + 0$$

Therefore, the responder chooses y after O_1 if $U_R(y \mid O_1) > U_R(n \mid O_1)$, that is, if $\alpha < \frac{1}{3}$, regardless of the value of β_R; and the responder chooses n after O_1 if $U_R(y|O_1) < U_R(n|O_1)$, that is, $\alpha > 1/3$; and proposer would like to choose randomly after O_1 if $U_R(y|O_1) = U_R(n|O_1)$, that is, $\alpha = 1/3$.

Taken together, these results yield our model of Comparison 2.

□

The sequential prisoner's dilemma

General sequential prisoner's dilemma ($m = 6.5$)

We discuss the general sequential prisoner's dilemma with $m = 6.5$ in this section. We now move to the detailed calculations. We focus on player 2's behaviour, which can be summarized by two results::

Result A4. If player 1 defects (by choosing D), player 2 will always defect (by choosing d) as a response in every ERE.

Proof. To explain player 2's behavior in this result, note that if player1 chooses D, then for any possible response by player 2, their payoff will always be lower than if player 1 had played C. This implies that, regardless of what player1 believes player 2 will choose, player 1 cannot be considered kind when playing D. Moreover, consider the two possible consequences: $\Phi_2(d|D) = 0$ and $\Phi_2(c|D) = \alpha_2 \cdot (0.5 - 6.5) - (1 - 4) = -3\alpha_2$. Therefore, both the reciprocity payoff (from intentional and consequential kindness) and the material payoff lead player 2 to choose d.

□

Result A5. If player 1 cooperates (by choosing C), the following holds in all ERE:

(1) if $\beta_2 > \frac{(2+12\alpha_2)(e^{5.5}+e^4))}{5e^4}$, player 2 will cooperate (by choosing c).

(2) if $\beta_2 < \frac{(2+12\alpha_2)(e^3+e^4)}{10e^4}$, player 2 will defect (by choosing d).

(3) if $\frac{(2+12\alpha_2)(e^3+e^4)}{10e^4} \leq \beta_2 \leq \frac{(2+12\alpha_2)(e^{5.5}+e^4))}{5e^4}$, player 2 will cooperate (by choosing c) with probability p that satisfies $2 + 12\alpha_2 = 5\beta_2(2-p)\frac{e^4}{e^{5.5p+3(1-p)}+e^4}$.

Proof. Note that we have stated that if player 1 chooses D, player 2 will always defect (by choosing d) in every SRE (Result A4).

For simplicity, in this section, we first set player 2's belief about player 1's belief about his choice c after C is $p \in [0,1]$. According to our model, we obtain player 2's utility given player 1 chose C:

$$U_2(c|C) = 1.5 + \alpha_2(1.5 - 5.5) + 5.5\beta_2 \cdot k_1$$

$$U_2(d|C) = 2 + \alpha_2(2-3) + 3\beta_2 \cdot k_1$$

where $k_1 = [p \cdot 1.5 + (1-p) \cdot 2] - [\frac{e^{5.5p+3(1-p)}}{e^{5.5p+3(1-p)}+e^4}(p \cdot 1.5 + (1-p) \cdot 2) + \frac{e^4}{e^{5.5p+3(1-p)}+e^4} \cdot 1] = (p \cdot 1.5 + (1-p) \cdot 2 - 1)\frac{e^4}{e^{5.5p+3(1-p)}+e^4}$.

The player 2 would like to choose c if $U_2(c|C) > U_2(d|C)$. Because all beliefs must be correct, we get p=1, and we then have:

$$1.5 - 3\alpha_2 + 5.5\beta_2 \cdot k_1 > 2 + 3\beta_2 \cdot k_1$$

$$2 + 12\alpha_2 - 5\beta_2 \frac{e^4}{e^{5.5} + e^4} < 0$$

$$\beta_2 > \frac{(2 + 12\alpha_2)(e^{5.5} + e^4))}{5e^4} \tag{A.9}$$

The player 2 would like to choose d if $U_2(c|C) < U_2(d|C)$. Because all beliefs must be correct, we get p=0, and we then have:

$$1.5 - 3\alpha_2 + 5.5\beta_2 \cdot k_1 < 2 + 3\beta_2 \cdot k_1$$

$$2 + 12\alpha_2 - 10\beta_2 \frac{e^4}{e^3 + e^4} > 0$$

$$\beta_2 < \frac{(2 + 12\alpha_2)(e^3 + e^4)}{10e^4} \tag{A.10}$$

When $\frac{(2+12\alpha)(e^3+e^4)}{10e^4} \le \beta \le \frac{(2+12\alpha)(e^{5.5}+e^4)}{5e^4}$, neither cooperation nor defection can be part of an equilibrium. In order to have an equilibrium that involves randomized choice, the utility of cooperation must be equal to the utility of defection. That is, $U_2(c|C) = U_2(d|C)$.

$$1.5 - 3\alpha_2 + 5.5\beta_2 \cdot k_1 = 2 + 3\beta_2 \cdot k_1$$

$$2 + 12\alpha_2 = 5\beta_2(2-p)\frac{e^4}{e^{5.5p+3(1-p)} + e^4} \tag{A.11}$$

□

Sequential prisoner's dilemma with punishment ($m = 1.5$)

Next, we move to the sequential prisoner's dilemma with punishment where $m = 1.5$. The same reason as when $m = 6.5$, player 1 is viewed as unkind if they play D. The difference here is that player 2 might choose punishment after D to punish the unkind behaviour at a cost to themselves. Therefore, we set $q \geq 0$ (q denotes the probability of punishment after player 1's defection) when $m = 1.5$. In this section, we still focus on player 2's behaviour, and our predictions can be summarized as follows:

Result A6. If player 1 defects (by choosing D), defection (by choosing d) for player 2 is not the unique ERE.

Proof. When the player 2 has the chance to punish player 1's defection, the process would be slightly different as the defection is not the unique ERE given player defects. So in this section, we set the player 2's belief about player 1's belief about his choice c after C is p. In addition, we set the player 2's belief about player 1's belief about his choice $punishment$ after D is q.

First, consider that if player 1 decides D, we can obtain player 2's utility as follows:

$$U_2(p|D) = 0.5 + \alpha_2(0.5 - 1.5) + 1.5\beta_2 \cdot k_1$$

$$U_2(d|D) = 1 + \alpha_2(1 - 4) + 4\beta_2 \cdot k_1$$

where $k_1 = [q \cdot 0.5 + (1-q) \cdot 1] - [\frac{e^{5.5p+3(1-p)}}{e^{5.5p+3(1-p)} + e^{1.5q+4(1-q)}}(p \cdot 1.5 + (1-p) \cdot 2) + \frac{e^{1.5q+4(1-q)}}{e^{5.5p+3(1-p)} + e^{1.5q+4(1-q)}}(q \cdot 0.5 + (1-q) \cdot 1)] = (q \cdot 0.5 + (1-q) \cdot 1 - p \cdot 1.5 - (1-p) \cdot 2)\frac{e^{5.5p+3(1-p)}}{e^{5.5p+3(1-p)} + e^{1.5q+4(1-q)}}$. Because $q, p \in [0,1]$, $k_1 < 0$ is satisfied.

So now player 2 would like to choose d if $U_2(p|D) < U_2(d|D)$. To verify Result 9, we need to prove that $U_2(p|D) < U_2(d|D)$ is not always held. When choosing d after D, we must have q=0, so:

$$0.5 + 1.5\beta \cdot k_1 < 1 - 2\alpha + 4\beta \cdot k_1$$

$$-2.5\beta \cdot k_1 < 0.5 - 2\alpha \tag{A.12}$$

Since k_1 is less than 0 and $\beta_2 \geq 0$, so we can get $-2.5\beta_2 \cdot k_1 \geq 0$. Furthermore, we know $\alpha_2 \geq 0$. It suggests that if $\alpha_2 > 0.25$, the equation (A12) will never be satisfied. Therefore, if player 1 defects (by choosing D), defection (by choosing d) for player 2 is not the unique equilibrium.

□

Result A7. If player 1 cooperates (by choosing C), the following holds in all ERE:

(1) if $\beta_2 > \frac{(2+12\alpha_2)(e^{5.5}+e^{1.5q+4(1-q)})}{5(1+q)e^{1.5q+4(1-q)}}$, player 2 will cooperate (by choosing c).

(2) if $\beta_2 < \frac{(2+12\alpha_2)(e^{3}+e^{1.5q+4(1-q)})}{5(2+q)e^{1.5q+4(1-q)}}$, player 2 will defect (by choosing d).

(3) if $\frac{(2+12\alpha_2)(e^{3}+e^{1.5q+4(1-q)})}{5(2+q)e^{1.5q+4(1-q)}} \leq \beta_2 \leq \frac{(2+12\alpha_2)(e^{5.5}+e^{1.5q+4(1-q)})}{5(1+q)e^{1.5q+4(1-q)}}$, player 2 will cooperate (by choosing c) with a probability p that satisfies $2+12\alpha_2 = 5\beta_2(2-p+q)\frac{e^{1.5q+4(1-q)}}{e^{5.5p+3(1-p)}+e^{1.5q+4(1-q)}}$.

Proof. We move to our main discussion of the player 2's behaviour given player cooperates. The only difference compared to Result 8 is that we have the player 2's belief about player 1's belief about his choice $punishment$ after D is $q \geq 0$.

We then obtain player 2's utility given player 1 chooses C:

$$U_2(c|C) = 1.5 + \alpha_2(1.5-5.5) + 5.5\beta_2 \cdot k_1$$

$$U_2(d|C) = 2 + \alpha_2(2-3) + 3\beta_2 \cdot k_1$$

where $k_1 = [p\cdot 1.5 + (1-p)\cdot 2] - [\frac{e^{5.5p+3(1-p)}}{e^{5.5p+3(1-p)}+e^{1.5q+4(1-q)}}(p\cdot 1.5+(1-p)\cdot 2) + (q\cdot 0.5 + (1-q))\frac{e^{1.5q+4(1-q)}}{e^{5.5p+3(1-p)}+e^{1.5q+4(1-q)}}] = (p\cdot 1.5 + (1-p)\cdot 2 - q\cdot 0.5 - (1-q))\frac{e^{1.5q+4(1-q)}}{e^{5.5p+3(1-p)}+e^{1.5q+4(1-q)}}$.

The player 2 would like to choose c if $U_2(c|C) > U_2(d|C)$. Because all beliefs must be correct, p=1 must hold, so:

$$1.5 - 3\alpha_2 + 5.5\beta_2 \cdot k_1 > 2 + 3\beta_2 \cdot k_1$$

$$2 + 12\alpha_2 - 5\beta_2(1+q)\frac{e^{1.5q+4(1-q)}}{e^{5.5}+e^{1.5q+4(1-q)}} < 0$$

$$\beta_2 > \frac{(2+12\alpha_2)(e^{5.5}+e^{1.5q+4(1-q)})}{5(1+q)e^{1.5q+4(1-q)}} \tag{A.13}$$

The player 2 would like to choose d if $U_2(d|C) > U_2(c|C)$. Now p=0, and we have:

$$1.5 - 3\alpha_2 + 5.5\beta_2 \cdot k_1 < 2 + 3\beta_2 \cdot k_1$$

$$1 + 6\alpha_2 - 5\beta_2(1+0.5q)\frac{e^{1.5q+4(1-q)}}{e^3 + e^{1.5q+4(1-q)}} > 0$$

$$\beta_2 < \frac{(2+12\alpha_2)(e^3 + e^{1.5q+4(1-q)})}{5(2+q)e^{1.5q+4(1-q)}} \tag{A.14}$$

When $\frac{(2+12\alpha)(e^3+e^{1.5q+4(1-q)})}{5(2+q)e^{1.5q+4(1-q)}} \leq \beta \leq \frac{(2+12\alpha)(e^{5.5}+e^{1.5q+4(1-q)})}{5(1+q)e^{1.5q+4(1-q)}}$. The player 2 would like to choose c with probability p if $U_2(c|C) = U_2(d|C)$. We have:

$$1.5 - 3\alpha_2 + 5.5\beta_2 \cdot k_1 = 2 + 3\beta_2 \cdot k_1$$

$$2 + 12\alpha_2 = 5\beta_2(2-p+q)\frac{e^{1.5q+4(1-q)}}{e^{5.5p+3(1-p)} + e^{1.5q+4(1-q)}} \tag{A.15}$$

□

The sequential prisoner's dilemma v.s. with punishment

Proof of Comparison 4.

Proof. Recall that we have shown in the treatment with $m = 1.5$ that $\alpha_2 > 0.25$ implies $q = 1$ (see the proof of Result A6). In contrast, in the treatment with $m = 6.5$, we must have $q = 0$ regardless of the value of α_2 (Result A4).

Therefore, to prove Comparison 4, we should prove that the threshold in (A.13) is greater than (A.9); threshold in (A.14) is greater than (A.10); for the same values of α_2 and β_2 will have a higher cooperation rate p in (A.11) than in (A.15).

First, we compare two different thresholds:(A.13) - (A.9), we obtain $\frac{(e^{5.5}+e^{4-2.5q})(2+12\alpha)}{5(1+q)e^{4-2.5q}} - \frac{(e^{5.5}+e^4)(2+12\alpha)}{5e^4}$, notice α is a non-negative value. We set $D = (2+12\alpha)[\frac{(e^{5.5}+e^{4-2.5q})}{5(1+q)e^{4-2.5q}} - \frac{(e^{5.5}+e^4)}{5e^4}]$ where $q \in (0,1]$. Let us derive the smallest value of D. We can find the FOC with respect to q: $\frac{\partial D}{\partial q} = (2+12\alpha)\frac{-2.5e^{4-2.5q}\cdot 5(1+q)e^{4-2.5q} - [5e^{4-2.5q}+5(1+q)(-2.5)e^{4-2.5q}](e^{5.5}+e^{4-2.5q})}{[5(1+q)e^{4-2.5q}]^2}$ $= (2+12\alpha)\frac{e^{8-5q}\cdot(-5+7.5e^{1.5+2.5q})+12.5\cdot q\cdot e^{9.5-2.5q})}{[5(1+q)e^{4-2.5q}]^2} > 0$ since $q \in (0,1]$ and $\alpha_2 \geq 0$. Then let us look at when $q = 0$, then $D = (2+12\alpha)[\frac{(e^{5.5}+e^4)}{5e^4} - \frac{(e^{5.5}+e^4)}{5e^4}] = 0$. As a result, $D > 0$. This means that the threshold value of β_2 with $m = 1.5$ is greater than for $m = 6.5$. Thus, more player 2s will choose c with $m = 6.5$ than with $m = 1.5$.

Next, we compare two different thresholds:(A.14) - (A.10), similarly, we obtain $D = \frac{(2+12\alpha)(e^3+e^{1.5q+4(1-q)})}{5(2+q)e^{1.5q+4(1-q)}} - \frac{(2+12\alpha)(e^3+e^4)}{10e^4} = \frac{2+12\alpha}{5}\cdot(\frac{e^{2.5q-1}+1}{2+q} - \frac{e^{-1}+1}{2})$ where $\alpha \geq 0$ and $q \in (0,1]$. Let us derive the smallest value of D. First, $\frac{\partial D}{\partial q} = \frac{2+12\alpha}{5}\cdot(\frac{2.5e^{2.5q-1}(2+q)-(e^{2.5q-1}+1)}{(2+q)^2}) = \frac{2+12\alpha}{5}\cdot(\frac{4e^{2.5q-1}+2.5qe^{2.5q-1}-1}{(2+q)^2}) > 0$ since $q \in (0,1]$ and $\alpha_2 \geq 0$. $D = 0$ when q=0. Then $D > 0$. This means that the threshold value of β_2 now with $m = 1.5$ is greater than for $m = 6.5$. Thus, more player 2s will choose d with $m = 1.5$ than with $m = 6.5$.

Finally, we compare the two treatments and show that, for the same values of α_2 and β_2, whether the cooperation rate p is higher in equation (A.11) than in equation (A.15).

We set $M = \frac{2+12\alpha}{5\beta} = \frac{2-p+q}{e^{2.5p+2.5q-1}+1}$. The equation (A.11) is the case where $q = 0$ and that equation (A.15) is the case where $q \in [0,1]$.

Notice that M is a fixed value, so we only need to show that an increase in q leads to a decrease in p.

Notice that M is a fixed value, $\frac{\partial M}{\partial p} = \frac{-(e^{2.5p+2.5q-1}+1)-2.5e^{2.5p+2.5q-1}(2-p+q)}{(e^{2.5p+2.5q-1}+1)^2} < 0$ means that p decreases will lead to M increasing. On the other hand, we also found that $\frac{\partial M}{\partial q} = \frac{(e^{2.5p+2.5q-1}+1)-2.5e^{2.5p+2.5q-1}(2-p+q)}{(e^{2.5p+2.5q-1}+1)^2} = \frac{1-2.5e^{2.5p+2.5q-1}(1.6-p+q)}{(e^{2.5p+2.5q-1}+1)^2} < 0$ means that p decreases will lead to M increasing. Therefore, when q is nonzero, to keep M the same as when $q = 0$, p must decrease. This suggests that for the same person (M is fixed), they are more willing to cooperate when $m = 6.5$ than when $m = 1.5$.

To summarize these three cases, player 2s is more likely to cooperate given that player 1 cooperates when $m = 6.5$ than when $m = 1.5$.

□

Dufwenberg & Kirchsteiger (2004) in Applications

The model by Dufwenberg & Kirchsteiger (2004) differs from ours in three main aspects: (1) their notion of efficient strategy differs from ours (see Section 1.5); (2) they do not incorporate consequential kindness; and (3) their definition of intentional kindness is different.

In Dufwenberg & Kirchsteiger (2004) model, player i's utility is

$$U_i(\sigma_{i,h}, b_{i,h}, c_{i,h}) = \pi_i(\sigma_{i,h}, b_{i,h}) + \beta_i \cdot \kappa_{ij}(\sigma_{i,h}, b_{i,h}) \cdot \lambda_{iji}(b_{i,h}, c_{i,h})$$

where k_{ij} measures how kind player i is being to player j by choosing a_i, and λ_{iji} captures how kind player i thinks player j is being to player i.

The kindness of player i to player j is the difference between the material payoff player i expects player j to obtain due to his action a_i and an equitable payoff for player j: $\kappa_{ij}(a_i, b_{ij}) = \pi_j(\sigma_i, b_{ij}) - \frac{1}{2}\{\max(\pi_j(\sigma_i, b_{ij})) + \min(\pi_j(\sigma_i, b_{ij}))\}$, where $\sigma_i \in E^{Dk}$ and the equitable payoff is defined as half minimum and half maximum payoff player j could obtain as a result of actions available to player i. The perception of how kind player i thinks player j is being to player i is $\lambda_{iji}(b_{ij}, c_{iji}) = \pi_i(b_{ij}, c_{iji}) - \frac{1}{2}\{\max(\pi_i(b_{ij}, c_{iji})) + \min(\pi_i(b_{ij}, c_{iji}))\}$.

Ultimatum games (a) and (b)

Note first that if the proposer chooses O_1, responder can give the proposer at least 0 and at most 8, Therefore, the responder's kindness of y is 4, and of n is -4.

To calculate how kind responder believes proposer is after choosing O_1, we have to specify the belief $p \in [0,1]$ that denotes responder believes that the proposer believes the responder would choose after O_1. Then responder's belief about how much payoff proposer intends to give to responder by choosing O_1 is $2p + 0(1-p) = 2p$, and since responder's payoff resulting from proposer's choice of O_2 would be 5 (note that we can prove that y in the equilibrium choice after O_2), responder's belief about proposer's kindness from choosing O_1 is $2p - [0.5(2p+5)] = p - 2.5$.

This implies that when proposer decides O_1 and the second order belief is p, responder's utility of y is given by $2 + \beta_R \times 4 \times (p - 2.5)$, whereas of n is $0 + \beta_R \times (-4) \times (p - 2.5)$. The former is larger than the latter if $2 + \beta_R \times 8 \times (p - 2.5) > 0$. In equilibrium, the second order belief must be correct. Hence, if in equilibrium responder decides y, the condition must hold for p = 1. This is the case if $\beta_R < 1/6$. On the other hand, if in equilibrium responder decides n, the condition must not hold for p = 0. This is the case if $\beta_R > 1/10$. The same idea as in Result A2, we can have the following observation:

Game (a). in Dufwenberg & Kirchsteiger (2004), when proposer chooses O_1, the following holds in all SRE:

(1) if $\beta_R < 1/10$, the responder will accept the offer (by choosing y).

(2) if $\beta_R > 1/6$, the responder will reject the offer (by choosing n).

(3) if $1/10 \leq \beta_R \leq 1/6$, the responder will choose randomly.

Similarly, we obtain a similar result for Game (b)

Game (b). in Dufwenberg & Kirchsteiger (2004), when proposer chooses O_1, the following holds in all SRE:

(1) if $\beta_R < 1/16$, the responder will accept the offer (by choosing y).

(2) if $\beta_R > 1/12$, the responder will reject the offer (by choosing n).

(3) if $1/16 \leq \beta_R \leq 1/12$, the responder will choose randomly.

Compare results in game (a) and game (b), it is obvious that the offer will be more likely to be accepted in game (a) than game (b) from the condition (1) from two games. The offer will be more likely to be rejected in game (b) than game (a) from the condition (2) from two games. Overall, responder is more likely to accept O_1 offer in game (a) than game (b).

Sequential prisoner's dilemma

One can apply the same logic as in the Ultimatum Game (a) to derive the following results. For reference, see Dufwenberg & Kirchsteiger (2004) and Orhun (2018), the latter of which also provides detailed calculations for both treatments.

Treatment m=6.5. in Dufwenberg & Kirchsteiger (2004), If player 1 cooperates (by choosing C), the following holds in all SRE:

(1) if $\beta_2 > 4/5$, player 2 will cooperate (by choosing c).

(2) if $\beta_2 < 2/5$, player 2 will defect (by choosing d).

(3) if $2/5 \le \beta_2 \le 4/5$, player 2 will cooperate (by choosing c) with a probability $p = 2 - \frac{4}{5\beta_2}$.

Treatment m=1.5. in Dufwenberg & Kirchsteiger (2004), If player 1 cooperates (by choosing C), the following holds in all SRE:

(1) if $\beta_2 > 2/5$, player 2 will cooperate (by choosing c).

(2) if $\beta_2 < 2/5$, player 2 will defect (by choosing d).

Compare results in two treatments, it is obvious that player 2 will be more likely to cooperate in treatment m=1.5, as $\beta_2 > 2/5$ player 2 must cooperate in treatment m=1.5 while not true in treatment m=6.5.

A.3 Discussion

Proof of Prediction 1 (Dufwenberg & Kirchsteiger, 2004)

Proof. Note first that if player 1 chooses C, player 2 can give the player 1 at least 1 and at most 4, Therefore, the player 2's kindness of c is 1.5, and of n is -1.5.

To calculate how kind player 2 believes player 1 is after choosing C, we have to specify the belief $p \in [0,1]$ that denotes player 2 believes that the player 1 believes the player 2 would choose after C. Then player 2's belief about how much payoff player 1 intends to give to player 2 by choosing C is $4p + 5(1-p) = 5 - p$, and since player 2's payoff resulting from player 1's choice of D would be n (note that we can prove that d in the equilibrium choice after D), player 2's belief about player 1's kindness from choosing C is $5 - p - [0.5(5 - p + n)] = 0.5(5 - p - n)$.

This implies that when player 1 decides C and the second order belief is p, player 2's utility of c is given by $4 + \beta_R \times 1.5 \times 0.5(5 - p - n)$, whereas of y is $5 + \beta_R \times (-1.5) \times 0.5(5 - p - n)$. The former is larger than the latter if $-1 + \beta_R \times 3 \times 0.5(5 - p - n) > 0$. In equilibrium, the second order belief must be correct. Hence, if in equilibrium player

2 decides c, the condition must hold for p = 1. This is the case if $\beta_R > \frac{1}{6-1.5n}$. On the other hand, if in equilibrium player 2 decides n, the condition must not hold for p = 0. This is the case if $\beta_R < \frac{1}{7.5-1.5n}$. When $\frac{1}{7.5-1.5n} \leq \beta_2 \leq \frac{1}{6-1.5n}$, $U_2(c|C) = U_2(d|C)$, so $p = 5 - n - \frac{2}{3\beta_2}$

So we can see that if n decreases, the threshold of $\beta_R > \frac{1}{6-1.5n}$ also decreases. This implies more player 2s will choose to cooperate; the threshold of $\beta_R < \frac{1}{7.5-1.5n}$ also decreases. This implies less player 2s will choose to defect; Moreover $p = 5 - n - \frac{2}{3\beta_2}$ will increases if n decreases. Taken together, a lower value of n leads to greater cooperation rate from player 2s. We can not find any effects on the player 2's cooperation after cooperation when m varies, □

Proof of Prediction 2

Proof. The same as in Section 1.4, we can easily prove that if player 1 chooses D, player 2 will always defect (by choosing d) in every SRE.

We first set player 2's belief about player 1's belief about his choice c after C is $p \in [0,1]$. According to our model, we obtain player 2's utility given player 1 chose C:

$$U_2(c|C) = 4 + 4\beta_2 \cdot k_1$$

$$U_2(d|C) = 5 + 1\beta_2 \cdot k_1$$

where $k_1 = [p \cdot 4 + (1-p) \cdot 5] - [\frac{e^{4p+(1-p)}}{e^{4p+(1-p)}+e^m}(p \cdot 4 + (1-p) \cdot 5) + \frac{e^m}{e^{4p+(1-p)}+e^m} \cdot n] = \frac{e^m}{e^{4p+(1-p)}+e^m} \cdot (5 - p - n)$.

The player 2 would like to choose c if $U_2(c|C) > U_2(d|C)$. Because all beliefs must be correct, we get p=1, and we then have:

$$4 + 4\beta_2 \cdot k_1 > 5 + 1\beta_2 \cdot k_1$$

$$3\beta_2 \cdot k_1 - 1 > 0$$

$$\beta_2 > \frac{e^4 + e^m}{3e^m(4-n)} \tag{A.16}$$

The player 2 would like to choose d if $U_2(c|C) < U_2(d|C)$. Because all beliefs must be correct, we get p=0, and we then have:

$$\begin{aligned} 4 + 4\beta_2 \cdot k_1 &< 5 + 1\beta_2 \cdot k_1 \\ 3\beta_2 \cdot k_1 - 1 &< 0 \\ \beta_2 &< \frac{e + e^m}{3e^m(5-n)} \end{aligned} \tag{A.17}$$

When $\frac{e+e^m}{3e^m(5-n)} \leq \beta_2 \leq \frac{e^4+e^m}{3e^m(4-n)}$, neither cooperation nor defection can be part of an equilibrium. In order to have an equilibrium that involves randomized choice, the utility of cooperation must be equal to the utility of defection. That is, $U_2(c|C) = U_2(d|C)$.

$$\begin{aligned} 4 + 4\beta_2 \cdot k_1 &= 5 + 1\beta_2 \cdot k_1 \\ 3\beta_2 \cdot k_1 - 1 &= 0 \\ 1 &= 3\beta_2 \frac{e^m}{e^{3p+1} + e^m} \cdot (5 - p - n) \end{aligned} \tag{A.18}$$

From(16) and (17), we can see that if n decreases, the threshold of β_2 also decreases. This implies that, in equation (16), more player 2s will choose to cooperate, while in equation (17), fewer player 2s will defect. For any intermediate case, if n decreases, the whole right term of equation (18) will increases, then to maintain the condition in equation (18), p must increase (as increasing p can decrease the whole right term of equation (18)). Taken together, a lower value of n leads to greater cooperation rate from player 2s.

The same idea, a higher value of m leads to greater cooperation rate from player 2s.

□

APPENDIX

B

APPENDIX TO CHAPTER 2

B.1 Summary of Experimental Results

B.1.1 Decision description

Table B.1: Summary of the DG results

Dictator Game	Cooperation Rate
D1	21.71%
D2	44.74%
D3	36.84%
D4	48.68%
D5	40.79%
D6	19.74%
D7	44.74%
D8	26.97%
D9	20.39%
D10	35.53%
D11	13.82%
D12	33.55%
D13	12.50%
D14	14.47%

Table B.2: Summary of the SPD results

SPD Game	Second Mover		First Mover
	CAC rate	CAD rate	Cooperation
G1	36.84%	23.03%	30.92%
G2	25.66%	21.05%	38.16%
G3	46.05%	28.95%	24.34%
G4	29.61%	13.82%	31.58%
G5	41.45%	26.97%	32.24%
G6	45.39%	16.45%	35.53%
G7	43.42%	14.47%	42.11%
G8	47.37%	23.03%	32.89%
G9	40.79%	27.63%	23.68%
G10	50.66%	23.68%	29.61%
G11	44.74%	22.37%	32.24%
G12	30.92%	23.03%	32.89%
G13	51.97%	23.68%	42.76%
G14	53.29%	26.32%	40.13%
G15	40.78%	16.45%	32.89%
G16	62.50%	15.13%	33.55%

Notes: CAC denotes the cooperation after cooperation; CAD denotes the cooperation after defection.

Table B.3: CAC: distribution of elicited beliefs

Guess CAC strategy					
Game	probability (%) that SM will cooperate after cooperation				
	$\in [0,20]$	$\in [21,40]$	$\in [41,60]$	$\in [61,80]$	$\in [81,100]$
$G1$	26.32	14.47	26.32	20.39	12.50
$G2$	20.39	22.37	23.68	22.37	11.18
$G6$	20.39	21.71	25.00	19.74	13.16
$G7$	19.74	15.79	27.63	21.05	15.79
$G8$	14.47	13.16	24.34	26.32	21.71
$G13$	11.18	14.47	19.74	34.21	20.39
$G11$	15.13	13.16	26.97	30.92	13.82

Notes: CAC denotes the cooperation after cooperation.

Table B.4: CAD: distribution of elicited beliefs

Guess CAD strategy					
Game	probability (%) that SM will cooperate after defection				
	$\in [0,20]$	$\in [21,40]$	$\in [41,60]$	$\in [61,80]$	$\in [81,100]$
$G1$	34.87	15.79	21.05	14.47	13.82
$G2$	44.74	16.45	17.76	10.53	10.53
$G6$	51.32	7.89	14.47	14.47	11.84
$G7$	59.21	7.24	13.82	7.89	11.84
$G8$	34.21	17.76	23.03	12.50	12.50
$G13$	34.21	20.39	21.71	11.18	12.50
$G11$	35.53	18.42	18.42	17.11	10.53

Notes: CAD denotes the cooperation after defection.

B.1.2 Subjects' behaviour

Table B.5 (Teble B.6) shows the cooperation rate after cooperation of SM (cooperation of FM) when we change the payoff parameters in the baseline game.

Table B.5: Rates of cooperation after cooperation

		$x_1^{DD}=200$	$x_1^{DD}=580$	$\Delta(x_1^{DD})$
x_2^{DD}	$x_2^{DD}=200$	36.84%	46.05%	+9.21%***
	$x_2^{DD}=580$	25.66%	29.61%	+3.95%
	$\Delta(x_2^{DD})$	−11.18% ***	−16.45%***	

Panel–(a)

		$x_1^{DC}=700$	$x_1^{DC}=1000$	$\Delta(x_1^{DC})$
x_2^{DC}	$x_2^{DC}=20$	43.42%	45.39%	+1.97%
	$x_2^{DC}=180$	41.45%	36.84%	−4.61%
	$\Delta(x_2^{DC})$	−1.97%	−8.55%**	

Panel–(b)

		$x_1^{CD}=20$	$x_1^{CD}=180$	$\Delta(x_1^{CD})$
x_2^{CD}	$x_2^{CD}=700$	50.66%	47.37%	−3.29%
	$x_2^{CD}=1000$	40.79%	36.84%	−3.95%
	$\Delta(x_2^{CD})$	−9.87%**	−10.53%***	

Panel–(c)

		$x_1^{CC}=600$	$x_1^{CC}=850$	$\Delta(x_1^{CC})$
x_2^{CC}	$x_2^{CC}=600$	36.84%	30.92%	−5.92%
	$x_2^{CC}=850$	44.74%	51.97%	+7.24%*
	$\Delta(x_2^{CC})$	+7.89%**	+21.05%***	

Panel–(d)

$Note: *p < 0.1; **p < 0.05; ***p < 0.01$ (McNemar's test);

Table B.6: Cooperation rate of FM

		$x_1^{DD}=200$	$x_1^{DD}=580$	$\Delta(x_1^{DD})$
x_2^{DD}	$x_2^{DD}=200$	30.92%	24.34%	−6.58%
	$x_2^{DD}=580$	38.16%	31.58%	−6.58%
	$\Delta(x_2^{DD})$	+7.24%*	+7.24%**	

Panel-(a)

		$x_1^{DC}=700$	$x_1^{DC}=1000$	$\Delta(x_1^{DC})$
x_2^{DC}	$x_2^{DC}=20$	42.11%	35.52%	−6.58%
	$x_2^{DC}=180$	32.24%	30.92%	−1.32%
	$\Delta(x_2^{DC})$	−9.87%**	−4.61%	

Panel-(b)

		$x_1^{CD}=20$	$x_1^{CD}=180$	$\Delta(x_1^{CD})$
x_2^{CD}	$x_2^{CD}=700$	29.61%	32.89%	+3.29%
	$x_2^{CD}=1000$	23.68%	30.92%	+7.24%*
	$\Delta(x_2^{CD})$	−5.92%	−1.97%	

Panel-(c)

		$x_1^{CC}=600$	$x_1^{CC}=850$	$\Delta(x_1^{CC})$
x_2^{CC}	$x_2^{CC}=600$	30.92%	32.89%	+1.97%
	$x_2^{CC}=850$	32.23%	42.76%	+10.53%**
	$\Delta(x_2^{CC})$	+1.32%	+9.87%**	

Panel-(d)

$Note: *p < 0.1; **p < 0.05; ***p < 0.01$ (McNemar's test)

B.2 Experimental Instructions

Main Instructions

Welcome to ESSEXLab

- Welcome and thank you for participating in this experiment!
- Please read these instructions carefully.
- Please switch off your mobile phone and place all of your personal belongings away.
- **Please do not attempt to browse or refresh the web or use programs unrelated to the experiment**. Use the computer only as instructed.
- Should you have any questions, please, raise your hand. Our researchers will come to you and answer your questions.
- From now on, communication with other participants is forbidden. If you do not conform to these rules, we are sorry to have to exclude you from the experiment.

Guidelines

- The experiment should take about 60 minutes.
- You have each earned a £5 payment for showing up on time.
- You can earn more. **How much you earn in this experiment depends on your decisions, the decisions of other participants and random chance**.
- This experiment consists of two Blocks and a Survey. Each block will be precluded by a set of instructions as well as a short comprehension check.

How final earnings are computed

- You will receive £5 for showing up on time (as the show-up fee).
- At the end of the experiment one round from each block will be randomly selected for your additional payment.
- All rounds in each block are equally likely to be selected.
- You will be paid privately and in cash at the end of the experiment.

Good Luck!

BLOCK 1: Instructions

Structure of the block

- You will face 14 rounds in this block.
- **Each round is independent of other rounds**.
- **Each round is equally likely to be selected for your payment**.
- Thus, it is important for you to take each round seriously.

Structure of the round

- In each round there are two players: First Mover and Second Mover.
- **First Mover is the only active player.**
- First Mover decides what action to take: A or B.
- First Mover's decision **determines** the payment for both First Mover and Second Mover.
- An example below illustrates the payment structure:

		First Mover payment	Second Mover payment
First Mover choice	A	400 tokens	350 tokens
	B	500 tokens	150 tokens

- In this example, if First Mover decides:
  - A, then First Mover will earn 400 tokens and Second Mover will earn 350 tokens
  - B, then First Mover will earn 500 tokens and Second Mover will earn 150 tokens.
- In each round, once you made a decision you can proceed to the next round.
- In each round you will be presented with the new payment structure within the same decision problem:
  - The only decision is done by First Mover picking A or B.
  - Payments corresponding to each of actions vary.

Payment

Your payment in Block 1 is determined as follows.

- One of the rounds will be randomly selected for your payment.
- You are randomly matched with the other participant in this room.
- You are randomly assigned a role: First Mover or Second Mover.
- The decision of First Mover is implemented.
- You will only see outcomes at the end of the experiment.
- Your payment: **1 token = 1 penny**

BLOCK 2: Instructions

Structure of the block

- In this block there are **two active players: First Mover and Second Mover.**
- In this block you will face 32 rounds:
    - 16 assuming the role of First Mover, and,
    - 16 assuming the role of Second Mover.
- **Each round is independent of other rounds when assuming the role of First Mover or Second Mover**.
- **Each round is equally likely to be selected for your payment** .
- Thus, it is important for you to take each round seriously.

Structure of the round

- There are two active players in each round, where
    - **First Mover:**
        - moves first
        - chooses A or B
    - **Second Mover:**
        - moves after knowing the choice of First Mover, then
        - decides to choose A or B
- The table below provides an example of the payoff structure depending on the decisions of First Mover and Second Mover:

				First Mover payment	Second Mover payment
First Mover choice	A	Second Mover choice	A	350 tokens	400 tokens
			B	150 tokens	500 tokens
	B	Second Mover choice	A	550 tokens	180 tokens
			B	320 tokens	200 tokens

- That is, if First Mover chooses:
    - A, then if Second Mover chooses:
        - A, then First Mover will earn 350 tokens and Second Mover will earn 400 tokens;
        - B, then First Mover will earn 150 tokens and Second Mover will earn 500 tokens.
    - B, then if Second Mover chooses:
        - A, then First Mover will earn 550 tokens and Second Mover will earn 180 tokens;
        - B, then First Mover will earn 320 tokens and Second Mover will earn 200 tokens.

Decision of First Mover

- **As First Mover you need to take a decision of A or B**
- You will be presented with the following interface:

				Your payment	Second Mover payment
Your choice (First Mover)	A	Second Mover choice	A	350 tokens	400 tokens
			B	150 tokens	500 tokens
	B	Second Mover choice	A	550 tokens	180 tokens
			B	320 tokens	200 tokens

- In each round, once you made a decision you can proceed to the next round.

Decision of Second Mover

- **As Second Mover you need to take two decisions,**
    - Choose A or B given First Mover has chosen A
    - Choose A or B given First Mover has chosen B

- You will be presented with the following interface:

				First Mover payment	Your payment
First Mover choice	A	Your choice (Second Mover)	A	350 tokens	400 tokens
			B	150 tokens	500 tokens
	B	Your choice (Second Mover)	A	550 tokens	180 tokens
			B	320 tokens	200 tokens

- That is, you need to take two decisions:
    - Choose A or B if First Mover chose A (the Yellow row)
    - Choose A or B if First Mover chose B (the Gray row)

- Note that **both decisions are important to determine your payment because until the end of the experiment you do not know what First Mover will choose.**
- In each round, once you made your decisions you can proceed to the next round.

Payment

Your payment in Block 2 is determined as follows.

- You are **randomly**,
    - matched with the other participant in the room.
    - assigned a role: First Mover or Second Mover.
- One of the rounds will be **randomly** selected for payment.
- The decision you and the other participant made will be implemented (in the corresponding roles) and thus the payoff will be determined. Two examples should make this clear.
    - **Example 1**. Assume that the <u>computer randomly selects you to be First Mover. This implies that your payoff relevant decision will be your First Mover's decision</u>. Assume that you choose A as the First Mover's decision in the above example screen (Decision of First Mover). Assume that the other participant matched with you makes the following Second Mover's decisions: he/she chooses A if you choose A, and chooses B if you choose B. As a consequence, you will earn 350 Tokens and the other participant will earn 400 Tokens.
    - **Example 2**. Assume that the <u>computer randomly selects the other participant to be the First Mover. This implies that your payoff relevant decision will be your Second Mover's decision.</u> Assume that you make the following Second Mover's decisions: you choose B if the First Mover chooses A, and choose B if the First Mover chooses B in the above example screen (Decision of Second Mover). Assume that the other participant matched with you chooses A as the First Mover's decision. As a consequence, you will earn 500 Tokens and the other participant will earn 150 Tokens.
- You will only see outcomes at the end of the experiment.
- Your payment: **1 token = 1 penny**

APPENDIX

C

APPENDIX TO CHAPTER 3

C.1 Proof of Propositions

Proof of Proposition 3.1. Let's start the proof of the 'only if' part of the Proposition 1.

Assume $\mathscr{D}_2$ can be rationalized by some complete and transitive order $\succeq_2$ that contains $Q_2 \cup R_2$ and satisfies

$$\mathbf{x}^t_{a^t} \succeq_2 \mathbf{x}^t_a \quad \forall\, t,\, \forall\, a \in A^t. \tag{1}$$

Suppose, for contradiction, that the revealed preference relation $\hat{\succeq}_2$ admits a *cycle* of length $k \geq 2$ in which all are weak and *at least one* is strict. That is, the following contains at least one link that is $\hat{\succ}_2$.

$$\mathbf{x}^1 \hat{\succeq}_2 \mathbf{x}^2,\ \mathbf{x}^2 \hat{\succeq}_2 \mathbf{x}^3,\ \ldots,\ \mathbf{x}^{k-1} \hat{\succeq}_2 \mathbf{x}^k,\ \mathbf{x}^k \hat{\succeq}_2 \mathbf{x}^1, \qquad k \geq 2. \tag{2}$$

For each strict comparison $\mathbf{x}^i \hat{\succeq}_2 \mathbf{x}^{i+1}$, Definition 3 provides an *observable choice problem* A^i such that (a) $\mathbf{x}^i \in c(A^i)$ (the actual choice), (b) $\mathbf{x}^{i+1} \in A^i$

In fact, for (i) of Definition 3, A^i is the original opportunity set of the observation generating the comparison. For (ii)–(iii) the comparison is produced by downward closure via Q_2 or R_2; the observation delivering $\mathbf{x}^i$ as the chosen alternative again furnishes A^i with (b) satisfied by construction.

Because of (1) and (b), $\mathbf{x}^i \succeq_2 \mathbf{x}^{i+1}$ for every $i = 1, \ldots, k$. Chaining it yields

$$\mathbf{x}^1 \succeq_2 \mathbf{x}^2 \succeq_2 \cdots \succeq_2 \mathbf{x}^k. \tag{3}$$

Next, $\mathbf{x}^k \in c(A^k)$ while $\mathbf{x}^1 \in A^k$ by (b) and last part of (2); from (1) we have $\mathbf{x}^k \succeq_2 \mathbf{x}^1$. Together with (3) this implies

$$\mathbf{x}^1 \sim_2 \mathbf{x}^k. \tag{4}$$

However, the assumed cycle (2) contains at least one strict relation $\mathbf{x}^j \hat{\succ}_2 \mathbf{x}^{j+1}$; the construction above then gives $\mathbf{x}^j \succ_2 \mathbf{x}^{j+1}$, contradicting (4) once the chain is closed. Therefore $\hat{\succeq}_2$ cannot contain a strict cycle; it is acyclic.

Let's start the proof of the "if" part of the Proposition 1. We take the idea from Nishimura et al. (2017).

Assume $\hat{\succeq}_2$ is acyclic. Let $S_2 := \hat{\succeq}_2 \cup Q_2 \cup R_2$ be the union of (i) all revealed comparisons, (ii) the monotonicity preorder Q_2, and (iii) the reciprocity preorder R_2. Define $\tilde{S}_2 := \text{tran}(S_2)$ where $x \tilde{S} y$ whenever a finite S_2–chain connects x to y. Because $\hat{\succeq}_2$, Q_2, and R_2 are each reflexive and acyclic, their union is acyclic; taking its transitive closure cannot create a strict cycle, so $\tilde{S}_2$ is a reflexive, transitive, acyclic —i.e. a *partial order*. Then by Szpilrajn's Theorem there exists a complete, transitive weak order $\succeq_2$ satisfying $\tilde{S}_2 \subseteq \succeq_2$.

Because $\succeq_2$ already contains Q_2 and R_2, it is itself second mover consistent. And because it contains $\hat{\succeq}_2$, for every observation (t, a_t) and every unchosen action a we have $\mathbf{x}^t_{a^t} \succeq_2 \mathbf{x}^t_a$, so $\succeq_2$ rationalizes $\mathscr{D}_2$.

□

Proof of Proposition 3.2. Recall that a data set $\mathscr{D}_1$ is **rationalizable** if there is a first-mover consistent preference relation and first-mover consistent belief function such that

$$(\mathbb{x}^t_{a^t}, q^t_{a^t}) \succeq_1 (\mathbb{x}^t_a, q^t_a) \forall t, \; \forall a \in A^t. \tag{5}$$

Assume, toward a contradiction, that the revealed preference relation $\hat{\succeq}_1$ admits a *cycle* of length $k \geq 2$ in which all are weak and *at least one* is strict. That is, the following contains at least one link that is $\hat{\succ}_1$.

$$(\mathbb{x}^1, q^1) \hat{\succeq}_1 (\mathbb{x}^2, q^2), (\mathbb{x}^2, q^2) \hat{\succeq}_1 (\mathbb{x}^3, q^3), \ldots, (\mathbb{x}^k, q^k) \hat{\succeq}_1 (\mathbb{x}^1, q^1). \tag{6}$$

For each link pick the choice problem A^i provided by Definition 4: (a) $(\mathbb{x}^i, q^i) \in c(A^i)$ and (b) $(\mathbb{x}^{i+1}, q^{i+1}) \in A^i$. It implies $(\mathbb{x}^i, q^i) \succeq_1 (\mathbb{x}^{i+1}, q^{i+1})$, for $i = 1, \dots, k$. Chaining it yields

$$(\mathbb{x}^1, q^1) \succeq_1 (\mathbb{x}^2, q^2) \succeq_1 \cdots \succeq_1 (\mathbb{x}^k, q^k). \tag{7}$$

Consider the last comparison in the cycle (6). Then $(\mathbb{x}^k, q^k) \in c(A^k)$ while $(\mathbb{x}^1, q^1) \in A^k$ by (b); from (5) we have $(\mathbb{x}^k, q^k) \succeq_2 (\mathbb{x}^1, q^1)$. Together with (7) this implies

$$(\mathbb{x}^1, q^1) \sim_1 (\mathbb{x}^k, q^k) \tag{8}$$

Since the assumed cycle (6) contains at least one strict relation $(\mathbb{x}^j, q^j) \hat{\succ}_1 (\mathbb{x}^{j+1}, q^{j+1})$; the construction above then gives $(\mathbb{x}^j, q^j) \succ_1 (\mathbb{x}^{j+1}, q^{j+1})$. Contradicting (8) once the chain is closed. Therefore $\hat{\succ}_1$ cannot contain a strict cycle; it is acyclic. □

C.2 Proof of Predictions

Proof of Prediction 1. First, Prediction 1-(1). Recall that the assumption of the preference relation we made: $(x^{CC}, x^{Db}, C, b) \succeq_2 (x^{CC}, \varnothing, C, b)$. This suggests that the realized outcome x^{CC} is (weakly) preferred when the context-dependent outcome x^{Db} exists to the same realized outcome x^{CC} but when context do not exit.

In two sequential prisoner's dilemma games A and B. First, note that we have quasi-monotone preferences: if $\mathbf{x} = (x^{Ca}, x^{Db}, a, b)$ and $\tilde{\mathbf{x}} = (\tilde{x}^{Ca}, x^{Db}, a, b)$ such that $x^{Ca} Q_2 \tilde{x}^{Da}$ we have $\mathbf{x} \succeq_2 \tilde{\mathbf{x}}$. This implies that if $x^{CC,A} Q_2 x^{CC,B}$, cooperation after cooperation in game A will be (weakly) preferred to game B. $x^{CC,A} Q_2 x^{CC,B}$ further implies $x_2^{CC,A} - x_2^{CC,B} \geq x_1^{CC,A} - x_1^{CC,B}$ (Prediction 1-(2)(a)). In the same manner, if $x^{CD,A} Q_2 x^{CD,B}$, defection after cooperation in game A will be (weakly) preferred to game B. $x^{CD,A} Q_2 x^{CD,B}$ further implies $x_2^{CD,A} - x_2^{CD,B} \geq x_1^{CD,A} - x_1^{CD,B}$ (Prediction 1-(3)).

Then, note that we have reciprocal preference: if $\mathbf{x} = (x^{CC}, x^{Db}, C, b)$ and $\tilde{\mathbf{x}} = (x^{CC}, \tilde{x}^{Db}, C, b)$ such that $x^{Db} R_2 \tilde{x}^{Db}$ we have $\mathbf{x} \succeq_2 \tilde{\mathbf{x}}$. This implies that if $x^{Db,A} Q_2 x^{Db,B}$, cooperation after cooperation in game A will be (weakly) preferred to game B. $x^{Db,A} Q_2 x^{Db,B}$ further implies $x_1^{Db,A} \geq x_1^{Db,B}$ and $x_2^{Db,A} \leq x_2^{Db,B}$ and b can be either cooperation or defection. Thus we have (Predictions 1-(2)(a)-(d)). □

Proof of Prediction 2. let $\mathscr{F} = \{C, D\}$ denote the opportunity sets generated by the first-mover's C or D. By Definition 2, we have already concluded that $C\ MGT\ D$. Axiom R then implies $A_C\ MAT\ A_D$, and Axiom S strengthens the comparison when the passive baseline {C} (only cooperation is possible) is used as reference. Since "more altruistic than" maps to a higher likelihood of cooperation in their revealed-preference analysis, the second mover cooperates weakly more often after C than in the passive variant, proving the prediction 2. □

Proof of Prediction 3. He & Wu (2023) refine Cox's generosity order. Consider two sequential prisoner's dilemma games A and B. Let $\mathscr{F}_A = \{C_A, D\}$ and $\mathscr{F}_B = \{C_B, D\}$. Consider the case 1 in Definition 3. If, say, (1) $x^{CD}_{2,A} \geq x^{CD}_{2,B}$ (Prediction 3-(1)) and (2) $x^{CC}_{1,A} \leq x^{CC}_{1,B}$ (Prediction 3-(3)), then $C_A\ MGT\ D$ more than $C_B\ MGT\ D$. Axiom R′ therefore yields $A_{C_A|D}\ MAT\ A_{C_B|D}$, i.e. the second mover is more altruistic (cooperative) in game A than game B.

The same reasoning applies to the case 2 of Definition 3. Let $\mathscr{F}_A = \{C, D_A\}$ and $\mathscr{F}_B = \{C, D_B\}$. If, say, (1) $x^{DC}_{1,A} \geq x^{DC}_{1,B}$ (Prediction 3-(2)) and (2) $x^{DD}_{2,A} \leq x^{DD}_{2,B}$ (Prediction 3-(4)), then $C\ MGT\ D_A$ more than $C\ MGT\ D_B$. Axiom R′ therefore yields $A_{C|D_A}\ MAT\ A_{C|D_B}$.

□

Proof of Prediction 4. First, note that the payoffs after first mover's defection will not enter the second mover's utility. Thus will have no effect on second mover's behaviour after cooperation (Prediction 4-(1)).

Consider the Prediction 4-(2)(a), consider in two sequential prisoner's dilemma games A and B, suppose that $x^{CC}_{2A} > x^{CC}_{2B}$, there are three possible cases: (1) $x^{CC}_{2B} > x^{CC}_{1}$ (2) $x^{CC}_{2A} < x^{CC}_{1}$ (3) $x^{CC}_{2B} < x^{CC}_{1}$ and $x^{CC}_{2A} \geq x^{CC}_{1}$.

Case (1): given the utility function provided in Section 4.3, $U_{2A}(C|C) = (1-\rho)x^{CC}_{2A} + \rho x^{CC}_{1}$, $U_{2B}(C|C) = (1-\rho)x^{CC}_{2B} + \rho x^{CC}_{1}$. Since $x^{CC}_{2A} > x^{CC}_{2B}$, we have $U_{2A}(C|C) \geq U_{2B}(C|C)$

Case (2): given the utility function provided in Section 4.3, $U_{2A}(C|C) = (1-\sigma)x^{CC}_{2A} + \sigma x^{CC}_{1}$, $U_{2B}(C|C) = (1-\sigma)x^{CC}_{2B} + \sigma x^{CC}_{1}$. Since $x^{CC}_{2A} > x^{CC}_{2B}$, we have $U_{2A}(C|C) \geq U_{2B}(C|C)$

Case (3): given the utility function provided in Section 4.3, $U_{2A}(C|C) = (1-\rho)x_{2A}^{CC} + \rho x_1^{CC}$, $U_{2B}(C|C) = (1-\sigma)x_{2B}^{CC} + \sigma x_1^{CC}$. Since $x_{2A}^{CC} > x_{2B}^{CC}$, and $\sigma \leq 1/2 \leq \rho \leq 1$, therefore $U_{2A}(C|C) \geq U_{2B}(C|C)$.

All cases suggest a higher utility of cooperation after cooperation in game A than Game B, plus that $U_2(C|C) > U_2(D|C)$ is possible given the utility function. Therefore, we can confirm the Prediction 4-(2)(a). The same reasoning applies to the Prediction 4-(2)(c).

Consider the Prediction 4-(2)(b), consider in two sequential prisoner's dilemma games A and B, suppose that $x_{1A}^{CC} > x_{1B}^{CC}$, there are three possible cases: (1) $x_{1B}^{CC} > x_2^{CC}$ (2) $x_{1A}^{CC} < x_2^{CC}$ (3) $x_{1B}^{CC} \leq x_2^{CC}$ and $x_{1A}^{CC} > x_2^{CC}$.

Case (1): given the utility function provided in Section 4.3, $U_{2A}(C|C) = (1-\sigma)x_2^{CC} + \sigma x_{1A}^{CC}$, $U_{2B}(C|C) = (1-\sigma)x_2^{CC} + \sigma x_{1B}^{CC}$. Since $x_{1A}^{CC} > x_{1B}^{CC}$, we have $U_{2A}(C|C) \geq U_{2B}(C|C)$

Case (2): given the utility function provided in Section 4.3, $U_{2A}(C|C) = (1-\rho)x_2^{CC} + \rho x_{1A}^{CC}$, $U_{2B}(C|C) = (1-\rho)x_2^{CC} + \rho x_{1B}^{CC}$. Since $x_{1A}^{CC} > x_{1B}^{CC}$, we have $U_{2A}(C|C) \geq U_{2B}(C|C)$

Case (3): given the utility function provided in Section 4.3, $U_{2A}(C|C) = (1-\sigma)x_2^{CC} + \sigma x_{1A}^{CC}$, $U_{2B}(C|C) = (1-\rho)x_2^{CC} + \rho x_{1B}^{CC}$. Since $x_{1A}^{CC} > x_{1B}^{CC}$, and $\sigma \leq 1/2 \leq \rho \leq 1$, therefore $U_{2A}(C|C) \geq U_{2B}(C|C)$.

All cases suggest a higher utility of defection after cooperation in game A than game B. Therefore, we can confirm the Prediction 4-(2)(b). The same reasoning applies to the Prediction 4-(2)(d).

□

Proof of Prediction 5. In Dufwenberg & Kirchsteiger (2004) model, player i's utility is

$$U_2(a_2, b_{21}, c_{212}) = \pi_i(a_i, b_{21}) + r_i \cdot \kappa_{21}(a_i, b_{21}) \cdot \lambda_{212}(b_{21}, c_{212})$$

According to their model, and the kindness term we discussed in the Section 4.4. we can conclude the following the second-mover's utility given the first-mover's cooperation:

$U_2(C|C) = x_2^{CC} + r_2 \cdot [x_1^{CC} - 1/2(x_1^{CC} + x_1^{CD})] \cdot [x_2^{CC} - 1/2\{x_2^{CC} + x_2^{DD}\}]$

$U_2(D|C) = x_2^{CD} + r_2 \cdot [x_1^{CD} - 1/2(x_1^{CC} + x_1^{CD})] \cdot [x_2^{CD} - 1/2\{x_2^{CD} + x_2^{DD}\}]$

First, let us check Prediction 5-(1). From the utilition function, we find that x_2^{DD}- the payoff after first mover's defection directly enters second mover's utility. Note that $[x_1^{CC} - 1/2(x_1^{CC} + x_1^{CD})] > 0$, $[x_1^{CD} - 1/2(x_1^{CC} + x_1^{CD})] < 0$, $[x_2^{CC} - 1/2\{x_2^{CC} + x_2^{DD}\}] > 0$, and $[x_2^{CD} - 1/2\{x_2^{CD} + x_2^{DD}\}] > 0$ because of the properties of the sequential prisoner's dilemma. Then we can conclude that if x_2^{DD} increases, second mover will be more likely to cooperate (Prediction 5-(2)(d)). Moreover, x_2^{DD} plays a positive role in improving the cooperation (Prediction 5-(1)).

In the same manner, we can conclude that x_2^{CC} increases, second mover will be more likely to cooperate (Prediction 5-(2)(a)). x_1^{CC} increases, second mover will be more likely to cooperate (Prediction 5-(2)(b)). x_1^{CD} decreases, second mover will be more likely to cooperate (Prediction 5-(2)(c)). The effect of a change in x_2^{CD}, however, is ambiguous. A higher x_2^{CD} raises the second mover's own payoff, but it simultaneously reduces $[x_2^{CD} - 1/2\{x_2^{CD} + x_2^{DD}\}]$, so the net impact on behaviour cannot be signed.

Moreover, we can not find any effects of x_1^{DD}, x_1^{DC} and x_2^{DC} as they can not affect the utility.

□

Proof of Prediction 6. First, note that the payoffs after first mover's defection will not enter the second mover's utility. Thus will have no effect on second mover's behaviour after cooperation (Prediction 6-(1)).

Consider the Prediction 6-(2)(a), consider in two sequential prisoner's dilemma games A and B, suppose that $x_{1A}^{CC} > x_{1B}^{CC}$, there are three possible cases: (1) $x_{1B}^{CC} > x_2^{CC}$ (2) $x_{1A}^{CC} < x_2^{CC}$ (3) $x_{1B}^{CC} \leq x_2^{CC}$ and $x_{1A}^{CC} > x_2^{CC}$.

Case (1): given the utility function provided in Section 4.5, $U_{2A}(C|C) = x_2^{CC} - \alpha_2(x_{1A}^{CC} - x_2^{CC})$, $U_{2B}(C|C) = x_2^{CC} - \alpha_2(x_{1B}^{CC} - x_2^{CC})$, we have $U_{2A}(C|C) < U_{2B}(C|C)$

Case (2): given the utility function provided in Section 4.5, $U_{2A}(C|C) = x_2^{CC} - \beta_2(x_2^{CC} - x_{1A}^{CC})$, $U_{2B}(C|C) = x_2^{CC} - \beta_2(x_2^{CC} - x_{1B}^{CC})$, we have $U_{2A}(C|C) > U_{2B}(C|C)$

Case (3): given the utility function provided in Section 4.3, $U_{2A}(C|C) = x_2^{CC} - \alpha_2(x_{1A}^{CC} - x_2^{CC})$, $U_{2B}(C|C) = x_2^{CC} - \beta_2(x_2^{CC} - x_{1B}^{CC})$. Here, we can not make any comparison without know the exact value of α_2 and β_2

Combine cases (1)-(3), we can conclude that if the second mover is more likely to cooperate after the first mover's cooperation in game A than in game B, then only Case (2) can promise it (Prediction 6-(2)(a). The same reasoning applies to the Prediction 6-(2)(c).

For the Prediction 6-(2)(b), consider two sequential prisoner's dilemma games A and B, suppose that $x_{2A}^{CC} > x_{2B}^{CC}$, there are three possible cases: (1) $x_{2B}^{CC} > x_{1}^{CC}$ (2) $x_{2A}^{CC} < x_{1}^{CC}$ (3) $x_{2B}^{CC} < x_{1}^{CC}$ and $x_{2A}^{CC} \geq x_{1}^{CC}$.

Case (1): given the utility function provided in Section 4.5, $U_{2A}(C|C) = x_{2A}^{CC} - \beta_2(x_{2A}^{CC} - x_{1}^{CC})$, $U_{2B}(C|C) = x_{2B}^{CC} - \beta_2(x_{2B}^{CC} - x_{1}^{CC})$, because $\beta_2 < 1$, we must have $U_{2A}(C|C) > U_{2B}(C|C)$.

Case (2): given the utility function provided in Section 4.5, $U_{2A}(C|C) = x_{2A}^{CC} - \alpha_2(x_{1}^{CC} - x_{2A}^{CC})$, $U_{2B}(C|C) = x_{2B}^{CC} - \alpha_2(x_{1}^{CC} - x_{2B}^{CC})$, we must have $U_{2A}(C|C) > U_{2B}(C|C)$

Case (3): given the utility function provided in Section 4.5, $U_{2A}(C|C) = x_{2A}^{CC} - \beta_2(x_{2A}^{CC} - x_{1}^{CC})$, $U_{2B}(C|C) = x_{2B}^{CC} - \alpha_2(x_{1}^{CC} - x_{2B}^{CC})$, we must have $U_{2A}(C|C) > U_{2B}(C|C)$

Taken cases (1) - (3) together, we find that $x_{2A}^{CC} > x_{2B}^{CC}$ would lead the second mover to be more likely to cooperate in game A than game B. (Prediction 6-(2)(b)). The same reasoning applies to the Prediction 6-(2)(d).

□