GROUP COOPERATION UNDER UNCERTAINTY

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ABSTRACT

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Previous research has shown an ‘interindividual-inter-group discontinuity effect’: inter-group interactions generally lead to less cooperative outcomes than interindividual interactions. In this dissertation, I replicate the discontinuity effect in the deterministic prisoner’s dilemma, but find that groups are more cooperative than individuals in a stochastic version of the game.

Three major factors that underlie the usual discontinuity effect, were reduced in the stochastic environment: greed, fear, and persuasion power. Two group mechanisms are proposed to explain the reversed discontinuity effect: the motivation to avoid guilt and blame when making decisions that affect others' welfare, and the social pressure to conform to certain norms when one is in a group setting. Follow-up studies reject the social pressure mechanism, but confirm that guilt aversion and blame avoidance drive groups to be more risk concerned than individuals and more likely to invest to reduce risks when uncertainty is present. There is also evidence that

uncertainty reduces inter-group distrust that usually exists in group interactions, and may even increases inter-group trust to be higher than inter-individual trust.

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Chapter 1

Introduction

1. Research Motivation

Psychologists have been interested in group decision making for more than half century, from group superiority relative to individual performance in the fifties, and risk drift of groups in the sixties, to group size, group procedure, and inter-group interactions in more recent research (Davis 1992). It has long been known that we cannot infer group behavior directly from individual-level studies (see Davis, 1992 for a review), and groups behave differently from individuals with regard to judgmental biases (Kerr et al., 1996; Bottom et al, 2002), cooperation and competition (Insko et al. 1987), risk and uncertainty (Charness et al 2007), trust and trustworthiness (Bornstein et al., 2002; Kocher and Sutter, 2005), and strategy learning (Sutter 2005; Kocher and Sutter, 2007).

This dissertation examines the degree of group cooperation with uncertain outcomes, an important but largely ignored topic in both psychology and economics. The current topic involves three components that are essential to many social dilemmas: cooperation, uncertainty, and group decision. Although most research on social dilemmas has been conducted in the certainty domain, the outcomes of those dilemmas are often of probabilistic in nature, such as potential effects of pollution or likelihood of global warming.

Similarly, group decision is an important but largely ignored topic among researchers on social dilemmas. Traditional game theoretical models focus on

individuals choosing between alternatives, even though in many real-life situations, the decision makers are nations, firms, or families (Bornstein et al., 2004). It has long been known that we cannot infer group behavior directly from individual-level studies, and groups behave differently from individuals with regard to a variety of issues (see Davis, 1992 for a review).

To my knowledge, no research has been conducted on the degree of group cooperation under uncertainty. Previous research has shown that usually inter-group interactions are more competitive than inter-individual ones, a well-replicated phenomenon termed "interindividual-inter-group discontinuity effect" (Insko et al., 1987; Wildschut et al., 2003). Does the discontinuity effect exist when outcomes are uncertain? No previous studies have addressed this question. There are at least two reasons why we may not be able to generalize the discontinuity effect found in deterministic games to a stochastic environment. First, previous research has found that groups have a tendency to behave in a more extreme manner when outcomes are uncertain than if individuals make choices on their own. This phenomenon, known as group risk and cautious shift, or group risk polarization, has been studied extensively by social psychologists (Stoner 1961; See Section 1.3 for a review). Depending on the risk attitudes of individual members of the group, groups may make more conservative or aggressive decisions than individuals.

If group risk preference polarization can be generalized to a strategic setting under uncertainty, such as a stochastic prisoner's dilemma in which cooperation reduces risks and is considered the more risk-averse strategy, we would predict that groups are less cooperative than individuals only if the majority of individual players have a tendency not to cooperate. Otherwise, groups may cooperate more than

individuals if the majority of individual players have a tendency to cooperate. This group polarization prediction partially conflicts with the prediction of the discontinuity effect, because if we assume that the discontinuity effect can be generalized to scenarios under uncertainty, then we would expect groups to be always less cooperative than individuals, independent of how individual members of the group feel about cooperating.

Another reason why we cannot generalize the discontinuity effect from the deterministic to a stochastic setting is that previous studies report that individual players learn to cooperate more slowly and in general cooperate less in stochastic prisoner's dilemmas than in deterministic prisoner's dilemmas (Bereby-Meyer and Roth, 2006). In Berger and Hershey (1994), subjects are less likely to contribute to a public good when returns are stochastic rather than deterministic. Since our focus here is comparing inter-group and interindividual differences under uncertainty, the difference in behavior of individual players in the stochastic game and deterministic game complicates the comparison.

To summarize, when uncertainty is introduced into the picture, we cannot simply assume that the discontinuity effect still holds and groups are less cooperative than individuals. The major purpose of this dissertation is to study how uncertainty affects group cooperative decisions in a game theoretical setup, and why the phenomenon exists. We believe that the findings in the current study will serve as a starting point towards integrating three important factors in many social dilemmas -uncertainty, cooperation, and group decision, and have prescriptive implications in encouraging cooperation to improve social welfare in the real world.

The structure of the dissertation is as follows. In the rest of the introduction

chapter, I will a brief review of pertinent research to the current topic, including inter-group conflict and prejudice, interindividual–inter-group discontinuity effect, and group polarization. Chapter 2 presents a preliminary investigation of how uncertainty affects the interindividual-inter-group discontinuity effect. Specifically, we study group cooperation in a two-party game where a party is either an individual or a group and the cooperation of one party reduces the risks of both parties. Mutual cooperation completely removes the risk for both parties. We found that there was an interaction between the game type and the player type: groups are less cooperative than individuals in the deterministic game, but more cooperative than individuals in the stochastic game. Three major factors, that underlie the usual discontinuity effect, were reduced in the stochastic environment: greed, fear, and persuasion power. Two group mechanisms are proposed to explain the reversed discontinuity effect: the motivation to avoid guilt and blame when making decisions that affect other's welfare, and the social pressure to conform to certain norms when one is in a group setting.

Three follow-up studies are reported in Chapter 3. Jointly, the follow-up studies reject the social pressure mechanism, but confirm that guilt aversion and blame avoidance drive groups to be more risk concerned than individuals and more likely to invest to reduce risks when uncertainty is present. There is also some evidence that uncertainty reduces inter-group distrust that usually exists in group interactions, and may even increases inter-group trust to be higher than inter-individual trust.

Chapter 4 concludes this dissertation by discussing the major findings and their implication, as well as providing several potential extensions on future research, especially on the generality of the group cooperative behavior under uncertainty.

2. Relevant Literature Review

There are three strands of research that are most pertinent to group cooperation under uncertainty: including inter-group conflict and prejudice, interindividual–inter-group discontinuity effect, and group polarization.

2.1 Inter-group Conflict and Prejudice

Research on inter-group conflict and prejudice is relevant to group cooperation under uncertainty because it shed light on how groups view each other in the game and possible biases existing in inter-group interactions.

Sherif et al.'s (1961) Robber's Cave experiment is probably the earliest and most influential study on inter-group conflict. Two groups of eleven year-old boys were sent to a summer camp. When the boys are told to compete for medals, within days, nasty behavior toward the other group developed. The experimenters then try various methods to reduce the inter-group conflict. Among those methods that do not help reduce the conflict, there are contact between groups, watching movies together, etc. The experimenter eventually successfully mitigate inter-group aggression by arranging some "superordinate" goals that require both groups' effort and cooperation, such as pulling an allegedly broken truck uphill.

Earlier research, such as the Robber's Cave experiment described above, believes that group aggression occurs mainly because of the competition for limited resource. The minimal group paradigm (Tajfel 1970, 1982), however, illustrates that in-group favoritism exists in even temporary and meaningless group categories. For example, in one study, Tajfel and his colleges grouped British schoolboys solely on whether they overestimate or underestimate the number of dots on a slide, which hardly had any meaning to either group. However, later in the experiment the boys

tended to allocate more money to those in their own group than those in the other group.

A major reason for the existence of in-group out-group bias is a tendency to stereotype out-group members and view them as faceless and homogeneous. Groups also tend to exaggerate the similarity between members in their own group to form cohesiveness, and exaggerate the difference between in-group members and out-group members, especially when making comparisons with inferior out-group members. The in-group out-group bias is also manifested on the ultimatum attribution error that people tend to view good actions as achievements of the in-group and lucky circumstances of the out-group, and attribute bad actions as situational to the in-group and intrinsic to the out-group (Giliovich 2006).

2.2 The Discontinuity Effect

The most related line of research to my dissertation topic is the research one the "interindividual–inter-group discontinuity effect": interactions between groups are generally more competitive and less cooperative than individual interactions in the context of mixed-motive matrix game[1], usually the prisoner's dilemma game (for a review, see Wildschut et al., 2003). In the past two decades, this interesting individual-group difference with respect to cooperation has been well replicated in empirical studies in social psychology and experimental economics. As mentioned in the motivation section, whether the discontinuity effect exists under uncertainty is a question to be answered in this dissertation. All studies reviewed in the current section

[1] Mixed-motive matrix game is defined as "any game in which the players' preferences among the outcomes are partly coincident and partly opposed, motivating the players both to cooperate and to compete, as in the Prisoner's Dilemma game." (Colman 2001)

are in the deterministic world and involve no uncertainty.

After performing a quantitative review of 130 comparisons of interindividual and inter-group interactions, Wildschut et al. (2003) summarize three complimentary explanations for less cooperation between groups relative to between individuals: 1) anonymity shields the group members from social sanction of the other party; 2) social support for pursuing self-interest in the name of the group; 3) out-group schemata cause schema-based distrust toward the other party. The first two explanations cause greater greed in inter-group (compared to interindividual) interactions, and the third explanation points to greater fear. Greed is defined as "wiliness to take advantage the other party's cooperation", and fear as "fear of being exploited by the other party if self cooperates".

According to the identifiability explanation, the anonymity of being in a group shields each individual member from social sanctions by the other group members, thus encouraging groups to act more competitively and less cooperatively out of greed when the other group cooperates (Schopler et al., 1995). The source of greed based on the social support explanation is that group members provide mutual reinforcement for the group to defect in the name of group interest should the other group decide to cooperate (Insko et al. 1990; Schopler et al., 1993).

According to the fear explanation, groups are less willing to cooperate than individuals because groups have greater fear than individuals that their cooperation will not be reciprocated by the other group and that, instead, the other group will take advantage of their cooperation by defecting (Insko and Schopler, 1998; Wildschut etal., 2003; Camerer and Fher, 2006). This explanation assumes an out-group schema of distrust (Sherif et al., 1961), "consisting of learned beliefs and expectations that

inter-group interactions are aggressive, deceitful, and competitive" (Wildschut etal., 2003). That is, foreseeing greater competition between groups than between individuals, a group is more likely to suspect that its counterpart group will defect than an individual suspects that her counterpart individual will defect.

The most recent example on the discontinuity effect is Song (2008) in which the author replicates the basic discontinuity effect in a trust game and finds people trust less when they make decisions as representatives of 3-person groups than when they make decisions for themselves only.

2.3 Group Polarization and Risk Drift

The third strand of research that is pertinent to group cooperation under uncertainty is group polarization and risk drift. It reveals how groups react to uncertainty differently than individuals, and was briefly mentioned in the motivation section when I discussed why we might be unable to generalize the group-individual discontinuity effect from a deterministic world to a stochastic world.

Groups have been known to have a polarization tendency that an initial attitude of “individual group members toward a given direction is enhanced following group discussion”(Isenberg 1986). Earlier group polarization research focuses on group risk drift: groups usually arrive at a more extreme risk attitude than individual decision makers (Stoner 1961, Moscovici and Zavalloni, 1969). Thus, depending on the initial average tendency of individual members, groups can be either more or less risk averse than individuals. Empirically evidence also supports that group decisions may increase risks (Stoner 1961) as well as limit risks (Marquis, 1962).

Group polarization also exists on a variety of topics other than risk drift. For example, moderately pro-feminist women become more strongly pro-feminist when

forming a group and their initial pro-feminist tendency is enhanced by group discussion (Myers, 1975).

In a meta-analysis, Isenberg (1986) identifies two mechanisms underlying group polarization process. The first mechanism, social comparison (or interperson comparison), assumes that people are motivated to present themselves in a socially desirable way. Many of us have the drive to appear "more favorable than what we perceive to be the average tendency" (Isenberg 1986). To do that, people constantly adjust their attitude and self-presentation so that they can present themselves in a more favorable light than others. All group members engaging in this adjusting process causes the group to shift in the direction of "greater perceived social value".

The second mechanism that drives group polarization is information influence. The most widely accepted version of the information influence explanation for group polarization is called persuasive argument theory (PAT; Burnstein &Vinnokur 1975, 1977). According to the PAT, a person's attitude and decision depend on the number and persuasiveness of pro and con arguments that she recalls from memory. Group discussion exposes individuals to a pool of persuasive arguments. If the initial average attitude of individuals favors certain direction, it is likely that group members will be exposed to more persuasive arguments in that direction, which drives the group toward the direction of initial tendency.

According to Isenberg (1986), group polarization can be driven by both social comparison and persuasive argument simultaneously, or only one of them. However, he also acknowledges that persuasive argument seems to have a stronger effect than social comparison.

Although most group risk polarization research was conducted by

psychologists asking subjects' risk preferences directly, the group risk preference polarization has been confirmed by experimental economists inferring subjects' preference from their decisions using monetary incentives. For example, Shupp and Williams (2008) ask both individuals and three-person groups to evaluate lottery tickets that have a 10% to 90% of chance of winning $20 for individuals and $60 for 3-person groups. They find that "the average group is more risk averse than the average individual in high-risk situations, but groups tend to be less risk averse in low-risk situations". This behavior is consistent with group polarization theory, since in the same study they also find that individuals are more risk averse in high-risk situations than in low-risk situations. Individuals' risk-aversion tendency in high-risk situations and risk-seeking tendency in low-risk situations are enhanced and polarized by the group process. Therefore, the average group becomes more risk-averse (risk-seeking) than the average individual in high-risk (low-risk) situations.

Chapter 2

Group Cooperation under Uncertainty

Previous research has shown an 'interindividual-inter-group discontinuity effect': inter-group interactions generally lead to less cooperative outcomes than interindividual interactions. Research presented in this chapter is a preliminary investigation of how uncertainty affects the interindividual-inter-group discontinuity effect. Specifically, we study group cooperation in a two-party game where a party is either an individual or a group and the cooperation of one party reduces the risks of both parties. Mutual cooperation completely removes the risk for both parties.

The chapter is organized as follows. Section 1 presents the experimental design and procedure. Two games, a deterministic prisoner's dilemma and a stochastic prisoner's dilemma, were played with individuals and 3-person groups as player types. The study was a 2x2 between-subject design [(2 game types) X (2 player types)]. The study results and data analysis are reported in Section 2. We found that there was an interaction between the game type and the player type: groups are less cooperative than individuals in the deterministic game, but more cooperative than individuals in the stochastic game. The effects were significant and large. Sections 3 and 4 compare our findings with previous research, and provide evidence from survey questionnaires and recorded discussion as to the underlying mechanisms of the phenomenon. Three major factors, greed, fear, and persuasion power that underlie the usual inter-group competitiveness, were reduced in the stochastic environment. Two group mechanisms were proposed to explain group cooperativeness under uncertainty: the motivation to avoid guilt and blame when making decisions that affect other's welfare, and the

social pressure to conform to certain norms when one is in a group setting. Section 5 concludes and discusses future extensions.

1. Study 1: Experimental Design and Procedure

1.1 The Games

Two games were played in the current study: one stochastic prisoner's dilemma (SPD) and one deterministic prisoner's dilemma (DPD).

The SPD game adopts the structure of the Interdependent Security (IDS) game proposed by Kunreuther and Heal (2003) and extends IDS experiments with individuals (Kunreuther et al., 2008) to group decision-making. In an IDS game each player decides whether or not to invest (incurring an investment cost) to reduce his or her own risk of experiencing a larger loss. If one player invests, both players' risks are reduced, but the investor's risk is reduced more than her counterpart's. Joint cooperation (both investing) eliminates uncertainty completely and each incurs the investment cost only. As shown in Heal and Kunreuther (2007), a variety of problems fit into the interdependent security game model, such as airline security, bankruptcy of an entire company caused by a catastrophic loss from one of its divisions, etc. The stochastic prisoner's dilemma (SPD) is a special case of the Interdependent Security game.

The SPD game matrix is shown in Table 1. Negative numbers represent losses. Percentages are probabilities of various outcomes in certain decision combinations (cells). We used an experimental currency, Taler, with an exchange rate of 1 Taler=2 cents in the individual game, and 1 Taler=6 cents in the group game where a group consisted of three individuals making a joint decision[2]. Subjects were

[2] The difference in the value of the taler for the two games was designed to make the payoff magnitudes the

told at the beginning of the experiment that their payoffs would be based on a show-up fee ($10) and might also be based on their performance in the game.

Table 1: Possible outcomes in the SPD game

		Player 2	
		Invest	Not Invest
Player 1	Invest	*-45; -45*	*20% lose 145,80% lose 45; 40% lose 100,60% lose 0*
	Not Invest	*40% lose 100,60% lose 0; 20% lose 145,80% lose 45*	*52% lose 100,48% lose 0; 52% lose 100,48% lose 0*

By removing the uncertainty and substituting the four cells in the SPD game with the expected values, we have the corresponding DPD game as shown in Table 2. The Nash equilibrium assuming risk neutrality and using expected values is (Not Invest, Not Invest).

Table 2: Possible outcomes in the DPD game

		Player 2	
		Invest	Not Invest
Player 1	Invest	*-45;- 45*	*-65;- 40*
	Not Invest	*-40;- 65*	*-52;- 52*

1.2 The Players

There were two kinds of players: individuals and groups. When two individuals played against each other, each person made a decision simultaneously as to whether or not to invest. In the group experiment the three subjects within each group made a collective decision and shared the final payoffs equally among the group members. Subjects were instructed to make unanimous decisions or use a 2 to 1 majority rule to specify their course of action[3]. The personal identities of subjects

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same for individuals making decisions on their own and for those in 3 person groups.

[3] Out of the 36 groups who indicated how they made their decisions in the survey questionnaires, 32 groups

were never revealed, but all subjects were aware as to whether their counterpart was an individual or group. An individual player's counterpart was always another individual while a group player's counterpart was always another group.

There were 202 subjects in the study, 88 of whom were male, 105 were female and 9 subjects did not report their genders. Most subjects were college students. 176 out of 193 subjects who reported their age were between 19 and 25.

1.3 The Experimental Design

The study was conducted in a behavioral lab of a northeastern university using Z-tree, a software for developing economic experiments (Fischbacher, 2007). Each individual or group used one computer to make their decisions. The computers were placed in two connecting rooms and in separate stations surrounded by cardboards to provide anonymity. Subjects were approximately 6 feet apart. One group could probably hear other groups talking, but it was very unlikely they could tell which one was their counterpart since there were usually 24 to 30 people in the two rooms. Most group discussions were recorded with the consent of the subjects[4].

Each of the 202 subjects played either a deterministic or a stochastic prisoner's dilemma game, either as members of three-person groups or as individuals. That is, the study was a 2X2 between-subject design (2 game types X 2 player types). Table 3 shows the subject distribution in the four conditions.

Table 3: Subject distribution in the four conditions

	Individual Player		**Group Player**	
	# of Subjects	# of Decisions	# of Subjects/# of Groups	# of Decisions
DPD	22	2400	48/16	1440
SPD	42	3100	90/30	2080

reached unanimous decisions and 4 groups applied majority voting.

[4] We had a mechanical failure in the study which prevented us from recording some group discussions.

Each player played multiple Supergames in the study. Players played against the same counterpart in one Supergame (10 rounds), then switched counterparts in the next Supergame. At the beginning of each Supergame, players were given 1500 Talers; one Taler is exchangeable for 2 cents in the individual condition, and 6 cents in the group condition; their wealth from the previous Supergame did not carry over to the current one. All rules, such as the number of rounds in a Supergame, the size of a player's endowment at the start of each Supergame, and the fact that one was playing with the same counterpart for one Supergame and then switching to another counterpart, were common knowledge. Depending on the decision speed and time available for the experiment, players played 5 to 12 Supergames, with a median of 8 Supergames. That is, each individual/group made 50 to 120 decisions during the experiment.

Subjects were told that their final payoffs might depend on one random Supergame of theirs before the game began. About 20 percent of the subjects were randomly chosen at the end of the experiment and received their actual payoff from one random Supergame. All subjects had to answer quiz questions regarding the procedure, game rules, and payment determinants before playing the game. Group players were aware at the beginning of the experiment that their discussion would be recorded unless they objected. No one objected. All subjects answered a survey at the end of the study that included questions regarding their strategies, decision rules, risk preferences, self-rated rationality, and demography.

2. Data Analysis and Results

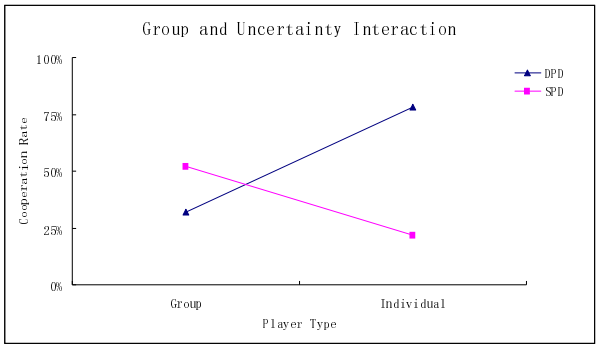
2.1 Average Propensity to Cooperate

Before proceeding with a formal statistical model, we first investigate the data at its mean level by assuming the decisions in each round is independent of previous decisions and there are no significant differences in cooperation tendency among players. Table 4 shows the average cooperation rate (the proportion of times players invested) in each of the four conditions. These data are depicted graphically with respect to player type and game type in Figure 1. As one can see there is an interaction effect between player type and game type: groups were less cooperative than individuals in the DPD game, but more cooperative than individuals in the SPD game.

Table 4: Cooperation Rates in the Four Conditions

	Group Player	**Individual Player**
DPD	32%	78%
SPD	52%	22%

Figure 1: Player Type and Game Type Interaction



2.2 The Random-Effect Logit Model and Results

Since subjects made a binomial choice and the 2X2 design was unbalanced, we applied a logistic regression model to analyze the interaction, assuming the investment decision depends on both the player types and the game types. But a standard logistic regression model cannot address two issues in our data.

First, each subject made repeated decisions in one Supergame (10 rounds) and played multiple Supergames. The round order as well as Supergame order may have had an effect on the cooperation decisions. Second, each subject made multiple

decisions. It is unreasonable to assume that the decisions made by the same subject were independent of each other because of the heterogeneity of investment propensity among subjects. This interdependency among observations, if ignored, will cause one to more easily reject a null hypothesis than justified by the data because the estimated variances of coefficients are biased downward.

To account for the above concerns, we applied a random-effect clustering model (Baayen et al, 2008). To control for the round and Supergame order effect, we included two sets of fixed effect variables, one for rounds and one for Supergames. To address to the second concern, subject individual difference, a random effect variable (α_i) was included in the logit regression as shown in Equation (1). α_i varied randomly between subjects and represents the deviation of each subject from the general investment propensity. It had a probability distribution with expectation zero and variance σ_α^2.

Specifically we regressed each decision (1 for Investing, 0 for Not Investing) as the dependent variable on the following independent variables: Player Type (group or individual), Game Type (DPD or SPD), the interaction of Player Type and Game Type, Round numbers and Supergame numbers. Formally, let *i* index the subject numbers, *j* index the Supergame numbers, and *k* index the round numbers, D_{ijk} is the binomial decision regarding whether or not to invest (cooperate) made by the Subject *i* in Supergame *j*, Round *k*. D_{ijk} is 1 if the subject invested and 0 if the subject did not invest. Let p_{ijk} be the probability that the *i*th subject invested in Supergame *j*, Round *k*. That is, p_{ijk} =Pr(D_{ijk} =1). The mixed effect logit model can be written as:

$$\begin{aligned}\log(p_{ijk}/(1-p_{ijk})) &= \beta_0 + \beta_1 Group_{ijk} + \beta_2 Sgame_{ijk} + \beta_3 Group_{ijk} Sgame_{ijk} \\ &+ \beta_4 Supergame_j + \beta_5 Round_k + \alpha_i + \varepsilon_{ijk}\end{aligned} \quad (1)$$

where β_0 is the log odds of investing when there are no subject differences and all fixed effects are zero; $Group_{ijk}$ is 1 if the decision was made by a group, 0 if made by an individual; $Sgame_{ijk}$ is 1 if the decision was a SPD game decision, 0 if it was a DPD game decision; $Group_{ijk}\ Sgame_{ijk}$ is the interaction term between Play Type and Game Type; $Supergame_j$ is a 12-element-long row vector with the jth element being 1 and all others being zeroes; β_4 is a 12-element-long column vector representing the fixed effect of each Supergame order, 1st, 2nd, …., 12th; $Round_k$ is a 10-element-long row vector with the *k*th element being 1 and all others being zeroes; β_5 is a 10-element-long column vector representing the fixed effect of each round order, 1st, 2nd, …., 10th; α_i is the subject random effect distributed $N(0,\sigma_\alpha^2)$ representing the deviation of each subject from the general investment propensity; ε_{ij} are model errors distributed $N(0,\sigma^2)$; random variables and model errors are independent.

Equation (1) was estimated using the lme4 package in R (Bates 2005). Because of the existence of the interaction term in the logit model, one has to be careful when interpreting the coefficients. We calculated the marginal effects following Ai and Norton (2003). Note that with the interaction term in the logit regression, marginal effects are qualified by one of the interaction variables. For example, we found that groups were less cooperative than individuals in the DPD game (β1=-3.05, z=-5.9, p<0.01, marginal effect= -0.484). The marginal effect, 48%, is the probability difference between groups cooperating and individual cooperating in the DPD game, not their difference in the study in general. That is, the probability of groups cooperating in the DPD game was 48% lower than the probability of individuals cooperating in the DPD game, which is in line with the literature.

The marginal effects of all four possible comparisons and their interpretations are reported in Table 5. There was a significant interaction between Player Type and Game Type ($\beta 3=4.97$, $z=7.92$, $p<0.01$, marginal effect= 0.793). A reversed discontinuity effect was found in the SPD game: groups were more cooperative than individuals in the SPD game (marginal effect= 0.309). We also found individuals to be less cooperative in the SPD game than in the DPD game ($\beta 2=-3.51$, $z=-8.95$, $p<0.01$, marginal effect= -0.549), which is consistent with previous research (Bereby-Meyer and Roth, 2006; Kunreuther et al., 2008). The opposite was true for the groups: groups were more cooperative in the SPD game than in the DPD game (marginal effect= 0.244).

Table 5: Cooperation Probability Comparison (Marginal Effects)

			Marginal Effects	Interpretation
Game Type	DPD	Group-Individual Difference	-0.484	Groups are 48.4% less likely to cooperate than individuals in the DPD game
	SPD	Group-Individual Difference	0.309	Groups are 30.9% more likely to cooperate than individuals in the SPD game
Player Type	Group	SPD-DPD Difference	0.244	individuals are 24.4% more likely to cooperate in the SPD game than in the DPD game
	Individual	SPD-DPD Difference	-0.549	individuals are 54.9% less likely to cooperate in the SPD game than in the DPD game

Table 6 reports a complete list of estimates. Besides the interaction effect, the data also showed an interesting learning process as subjects played the game repeatedly. The marginal effects were monotonically decreasing as the round number increased, implying that subjects learned not to cooperate over time.

Table 6. Estimates of logit model for probability of cooperation

Variable	Mean	Coefficient	Standard Error	z value	Pr(>|z|)	Marginal Effect[1]
Dependent Variable						
Cooperation	0.458					
Independent Variables						
Constant		2.838	0.341	8.335	0.000	0.343
Sgame	0.574	-3.513	0.398	-8.834	0.000	-0.549
Group	0.390	-3.051	0.517	-5.902	0.000	-0.484
Fixed Effects						
Round2	0.100	-0.341	0.123	-2.778	0.005	-0.050
Round3	0.100	-0.378	0.123	-3.082	0.002	-0.055
Round4	0.100	-0.503	0.122	-4.107	0.000	-0.073
Round5	0.100	-0.633	0.122	-5.182	0.000	-0.092
Round6	0.100	-0.741	0.122	-6.070	0.000	-0.107
Round7	0.100	-0.877	0.122	-7.183	0.000	-0.127
Round8	0.100	-1.185	0.123	-9.663	0.000	-0.169
Round9	0.100	-1.935	0.127	-15.291	0.000	-0.268
Round10	0.100	-3.064	0.141	-21.721	0.000	-0.388
Supergame2	0.120	-0.594	0.112	-5.283	0.000	-0.087
Supergame3	0.120	0.013	0.112	0.113	0.910	0.002
Supergame4	0.120	-0.163	0.112	-1.464	0.143	-0.024
Supergame5	0.120	-0.765	0.116	-6.564	0.000	-0.112
Supergame6	0.111	-0.320	0.122	-2.633	0.008	-0.047
Supergame7	0.095	-0.411	0.122	-3.373	0.001	-0.060
Supergame8	0.095	0.081	0.135	0.604	0.546	0.012
Supergame9	0.071	-0.176	0.139	-1.264	0.206	-0.026
Supergame10	0.062	-0.115	0.166	-0.690	0.490	-0.017
Supergame11	0.038	-0.289	0.189	-1.527	0.127	-0.042
Supergame12	0.024	-0.528	0.186	-2.830	0.005	-0.077
Interaction Term						
Sgame*Group	0.224	4.973	0.632	7.868	0.000	0.793
Random Effect						
Subject			Standard Deviation = 1.4648			
Log likelihood			-4170			
Sample size			9020			

Notes: Because of the existence of binary independent variables, we actually calculated discrete changes as in Long (1997). Please refer to Table 5 for the interpretations of the marginal effects.

3. Four Complementary Explanations and Validity Discussion

The major finding of the current study is a significant interaction between Player Type and Game Type. The magnitude of the interaction was large enough to reverse the discontinuity effect: groups were more cooperative than individuals in the stochastic game (SPD).

To better understand the large differences in groups' cooperation when payoffs are known or uncertain, we first provide a brief review of three mechanisms suggested by previous research to explain the discontinuity effect in the DPD game

and then propose a fourth explanation that is complementary to the other three. All four explanations assume no uncertainty. We then discuss the how uncertainty may affect the validity of the four explanations in the SPD game.

3.1 Three Mechanisms Underlying the Discontinuity Effect

After performing a quantitative review of 130 comparisons of interindividual and inter-group interactions, Wildschut et al. (2003) summarize three complementary explanations for the discontinuity effect in the DPD game: identifiability, social support, and schema-based distrust.[5] The first two explanations center on greater greed by groups than individuals, and the third explanation points to greater fear by groups than individuals.[6]

According to the *identifiability explanation*, the anonymity of being in a group shields each individual member from social sanctions by the other group members, thus encouraging groups to act more competitively and less cooperatively out of greed when the other group cooperates (Schopler et al., 1995). The source of greed based on the *social support explanation* is that group members provide mutual reinforcement for the group to defect in the name of group interest should the other group decide to cooperate (Insko et al. 1990).

According to the fear explanation, groups are less willing to cooperate than individuals are because groups have greater fear than individuals that their cooperation will not be reciprocated by the other group and that, instead, the other group will take advantage of their cooperation by defecting (Insko and Schopler,

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[5] Wildschut et al. (2003) also identify four moderators of the discontinuity effect: opponent strategy, procedural interdependence, communication, and conflict of interest, which are not very relevant to this paper because our experimental design made the four moderators the same in all treatments.

[6] Following research on cooperation, greed is defined as greed for larger profit by taking advantage of the other party's cooperation, and fear as fear of being exploited by the other party if self cooperates.

1998). This explanation assumes an out-group schema of distrust (Sherif et al., 1961), "consisting of learned beliefs and expectations that inter-group interactions are aggressive, deceitful, and competitive" (Wildschut etal., 2003). That is, foreseeing greater competition between groups than between individuals, a group is more likely to suspect that its counterpart group will defect than an individual suspects that her counterpart individual will defect.

3.2 Smart-strategy Persuasion – A Fourth Explanation

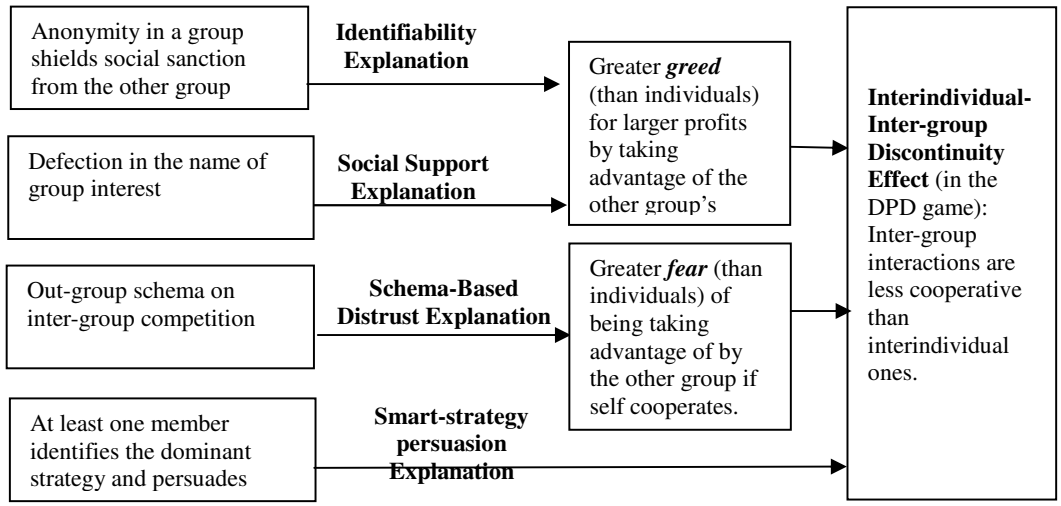
Besides the identifiability, the social support, and the fear explanations, we propose a fourth mechanism that helps explain why inter-group interactions were less cooperative than interindividual ones. This explanation, which we name *smart-strategy persuasion*, argues that group members can be persuaded by their team members to apply the "smart" strategy which, in the case of the Prisoner's Dilemma game, is defection (Not Invest).

The smart-strategy persuasion explanation is based on the recorded group discussions and after-study surveys undertaken in our experiments. In the DPD game, once one member figured out that defection was the dominant strategy, it was quite easy for him or her to use numbers to persuade other groups that defection was the smart thing to do. This process was also reported in subjects' after-study surveys. For example, when asked how her group made decisions, one subject said: "One proposed and explained. We all nodded." In a sense, the deterministic game with certain payoff numbers is an "eureka-type" problem in which once certain insight is provides, the truth wins (Cooper and Kagel, 2005). Smart-strategy persuasion process greatly improved the group's chance of discovering and following the dominant strategy (Not

Invest) relative to an individual operating on his or her own.[7] Hence groups became less cooperative than individuals.

Figure 2 summarizes all four explanations underlying the interindividual-inter-group discontinuity effect observed in the DPD game. The identifiability issue (the difficulty to identify individual group members from the group), and social support to maximize total profits, encourage groups to be more greedy and defect more than individuals; the fear of being taken advantage of by the other group discourages groups from cooperating; and a smart-strategy persuasion process enables groups to discover and choose defection as the profit-maximization strategy more effectively than individuals. As shown in Figure 2, greed and fear coupled with a smart strategy argument decrease groups' tendency to cooperate and jointly function as an explanation of the discontinuity effect in the DPD game.

Figure 2: Four Complementary Explanations for the Discontinuity Effect in the DPD



[7] Imagine that an average subject has a 1/2 chance to figure out the dominant strategy. If we assume that once one member figures it out, the whole group follows her, an average group with 3 subjects has 1-(1/2)^3 = 7/8 chance to find the dominant strategy.

3.3 Validity of the Four Explanations in the SPD Game

The current study found that groups behaved dramatically differently in the DPD game than in the SPD game. The discontinuity effect in the DPD game was reversed in the SPD game. Are the four explanations for the discontinuity effect in the DPD game still valid in the SPD game? How does uncertainty influence subjects' emotion (greed and fear) levels and their decision processes? Can one or any combination of the four explanations explain the reversed discontinuity effect in the SPD game? In this subsection we will address those questions by discussing the validity of each of the four explanations in the SPD game and how uncertainty may interfere with the group decision process.

As shown in Figure 2, the first explanation for the discontinuity effect is identifiability. There is no reason that being shielded from social sanctions should be a function of whether a game has deterministic or stochastic outcomes. So it is difficult to see how this could be the reason for differences in group cooperation in the DPD and SPD games.

The second explanation for the discontinuity effect is the social support explanation: group members provide mutual social support for the pursuit of self-interest in the name of group interest. This social-supported-greed explanation seemed reasonable in the DPD game in which defection obviously maximized the group profit, but was questionable in the SPD game because expected-profit maximization might not be in the best interest of the group when uncertainty is present. Although defection in the SPD game had a higher expected value than cooperation for the party making the decision, defection also had a higher variance. This uncertainty could be reduced by investing and would be completely removed if

both players invested. Some group members might have thus considered cooperation to be in the interest of the group because it was a "safer" strategy than defection.

This possibility is supported by evidence from recorded discussions and survey questionnaires. We successfully recorded 14 groups in the DPD game and 30 groups in the SPD game. 13 out of these 14 groups in the DPD game always accepted the proposal whenever a group member suggested defection for higher profits when compared to cooperation. In the SPD game, however, 11 out of these 30 groups rejected a member's defection suggestion at least once, several groups rejecting this idea multiple times. Interestingly 59% of the rejections were based on risk preference differentials, such as "I prefer a safer bet and cooperate." or "The probability of loss looks too high to me if we defect." Results from the post-study survey questionnaire indicate that there existed a positive correlation between subjects' risk-averse propensity and their influence on the group decisions[8]. Those who were more concerned about risks had a greater influence on the group decisions ($t(157)=2.20$, $p=0.03$), which often led to cooperative behavior.

Turning to the third explanation, the schema-based distrust, or fear, the source of this concern in the DPD game was from the "expectation" that the other group would defect and exploit a decision on our part to cooperate. In the SPD game, it is possible that the schema-based fear was reduced because group members observed reduced social-supported greed of their own group (as discussed above) and inferred less greed from the other group as well (Dawes and Thaler 1988). Thus groups expected less competitiveness from the other group than in the DPD game. That is, Group A would be less afraid of being taken advantage of by Group B if

[8] Data are from another study in which subjects played the same game as the current one except that the investment was 36 instead of 45. Subjects in that study were from the same subject pool as the current study.

Group A cooperated in the SPD game than in the DPD game. The reason for this reduced concern is because Group A itself is less likely to take advantage Group B if Group B cooperates in the SPD game than in the DPD game.

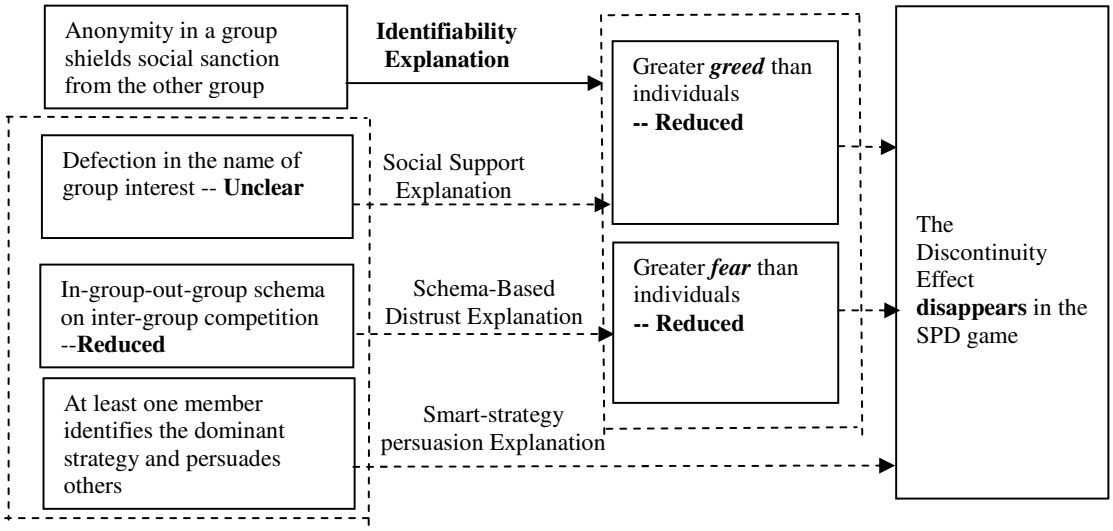
To test the above possibility of reduced fear in the SPD game, we counted the frequencies of groups expressing explicit or implicit fear (to be exploited by the other group), such as "I do not trust them", or "what if they defect?", etc. The absolute frequencies of fear expressions in the DPD or SPD game were not significantly different ($t(42)=0.62$, $p=0.54$). But considering the fact that subjects talked considerably more in the SPD game than in the DPD game[9], the relative frequency of fear expressions or the salience of fear in the SPD game was probably lower than in the DPD game. This is consistent with our theory that the fear underlying the discontinuity effect was modified and less salient in the SPD game.

Regarding the validity of the fourth explanation under uncertainty, we believe that smart-strategy persuasion had less influence in pushing groups to defect in the SPD game than in the DPD game for three reasons. First, in the SPD game, the probabilities associated with different payoffs made it more difficult to determine the smart strategy. Data compiled from recorded group discussion indicate that only 17% of the groups in the SPD game had at least one member who discovered the dominant strategy (defection), while 50% of the groups in the DPD game had at least one member who knew that defection was the game theoretic strategy to follow. Second, in the SPD game, even if one member successfully identified defection as the smart strategy, it was harder to persuade other members that this was the appropriate action to take given the complexity of probabilities, outcomes and expected-value

[9] This is an observation we made while listening to the tapes, not quantitative data.

calculations required in the SPD game that were absent in the DPD game with certain and clear-cut payoffs. Third, even after the smart member convinced the whole group that defection was the rational strategy with higher expected payoff, the group might still refuse to apply the "smart" strategy because it was unclear that being smart and defection was in the best interest of the group because of risk preference differentials among group members. Some members might prefer a safer strategy (cooperation) with lower expected payoffs than a riskier strategy (defection) with higher expected payoffs.

Figure 3: the Disappearance of the Discontinuity Effect in the SPD



In summary, we argue that three out of four mechanisms underlying the discontinuity effect in the DPD game were affected by uncertainty in the SPD game. As summarized in Figure 3, the three arguments in the DPD game shown in Figure 2 are circled by dotted-lines because they are mitigated by the uncertainty in the SPD game. Those mitigated reasons then cause reduced greed, fear, and persuasion power, which explains why the discontinuity effect disappeared in the SPD game. However, the reversed discontinuity effect remains a puzzle. There is no evidence or reason why

groups would have less greed or fear, or the persuasion process would make groups less smart (in terms of identifying the smart strategy) than individuals. Then why were groups more cooperative than individuals in the SPD game? This question will be the focus of the next section.

4. Two Group Processes Underlying the Reversed Discontinuity Effect

In this section, we propose two possible complementary explanations for the reversed discontinuity effect in the SPD game based on previous literature. We argue that groups were more cooperative than individuals in the SPD game for two reasons: an aversion to guilt and the motivation to avoid blame when making decisions that affect the welfare of others (Charness and Dufwenberg 2006; Charness and Jackson, 2009), and the social pressure to conform to certain norms when in a group and observed by others (see Turner 1991 for a review on social conformity).

4.1 Guilt Aversion and Blame Avoidance under Uncertainty

The first explanation is based on how group members perceive responsibility when making decisions with collective outcomes. It has been known that people suffer from guilt if they inflict harm on others (Baumeister et al. 1994). The term, guilt aversion, is adopted from Charness and Dufwenberg (2006) where they define a guilt-averse player as someone who "suffers from guilt to the extent he believes he hurts others relative to what they believe they will get." They find that, in a trust game, people try to live up to others' expectations to avoid guilt. In a more recent paper, Charness and Jackson (2008) find that, in a Stag Hunt game, one third of the subjects are sensitive to the responsibility issue and make different decisions whether or not

their actions impact on another person's outcome. More specifically, 90% of those responsibility-sensitive subjects take on more risk when choosing only for themselves only than when choosing for both themselves and a silent partner. In that paper, the risky choice is the one with which the player either gets a high (9) or low (1) payoff depending on the other player's choice, while the safe choice is the one that gets the fixed payoff (8) no matter what the other player chooses. The authors argue that one of the reasons for opting for the safe option is to avoid blame, which is related to the notion of guilt aversion.

Similar reasoning can be applied to the group decision process in the SPD game. Imagine that a smart group member in the SPD game figured out that defection had a higher expected payoff for the group. But she was also aware of the higher probability of suffering a loss associated with defection than with cooperation. Similar to players in the Stag Hunt game in Charness and Jackson (2008), even if she believed that defection was the rational strategy and she by herself was willing to take the risk for the sake of higher expected payoff, she might be reluctant to suggest that the group defect, because the person would foresee the *ex post* guilt she would feel and the ex post blame she would get from other members, if the group followed her suggestion to defect and a large loss occurred. When all group members engage in such a safety-first adjustment process, the group becomes more conservative and less willing to take on risks than when individuals act on their own. Hence more groups than individuals opted for cooperation to reduce risks in the SPD game. Note that here we argue that guilt aversion and blame avoidance are two different motivations associated with the same risk-reduction action.

4.2 Social Pressure to be Pro-group, Smart, and Nice

The second mechanism underlying group cooperativeness (reversed discontinuity effect) in the SPD game has to do with the conformity process in groups (see Turner, 1991, for a review). That is, a group member feels social pressure from other members to conform to certain norms. Under a strategic setting, such as in a Prisoner's Dilemma, three norms are especially relevant for a group member whose behavior is observed by other members: the norm of being pro-group, the norm of being smart, and the norm of being nice.

The norm of being pro-group arises from the in-group favoritism existing in even temporary and meaningless group categories (Tajfel 1982). For example, in one study, Tajfel and his colleges grouped British schoolboys solely on whether they over- or underestimate the number of dots on a slide, which hardly had any meaning to either group. However, later in the experiment the boys tended to allocate more money to those in their own group than those in the other group. In a PD game, in-group favoritism is manifested in striving for the best interest of the group (Bornstein and Ben-Yossef, 1994; Baron 2001).

The being-smart norm states that in a strategic setting with conflicting interests, one should struggle for good outcomes and avoid being a sucker. Previous research has found that people are averse to playing the sucker so that others can and let others free ride (Orbell and Dawes, 1981). Fear of being a sucker plays an important role in people's cooperation decisions in social dilemmas (Rapaport and Eshed-Levy, 1989). One feature of being smart is not being a sucker and thus being taken advantage of by the other party. In the case of the Prisoner's Dilemma, this implies defection because of a fear that the other party will defect. Another feather of

being smart in the Prisoner's Dilemma indicates following one's own interest, which also implies defection because one is better off by defecting than by cooperating, independent of the other party's decision.

The norm of being nice indicates a desire to cooperate with others. For example, people may cooperate in social dilemmas because "they are not the kind of people who benefit at the expense of others" (Dawes 1980). Note that the niceness norm implies another form of guilt aversion: people may feel guilty when their action (Not Investing) harms the other group, especially when they cannot adequately justify themselves, as will be discussed below. The motivation of being nice when one's behavior is observed by group members may drive people to choose cooperation over defection, because in a PD game both parties cooperating leads to better outcomes than both parties defecting, and cooperation is regarded as socially desirable behavior.

In the DPD game, both the pro-group norm and the smartness norm implied defection since the group was always better off defecting than cooperating regardless of the other group's decision. As discussed before, inflated greed and fear, together with smart-strategy persuasion, reinforced the defection strategy as the *smart* strategy that maximizes group profits and is in the best interest of *group* (as well as individuals). The niceness strategy of cooperation was clouded by being pro-group and being smart. Hence we observed the discontinuity effect in the DPD game that groups were less cooperative than individuals.

In the SPD game, however, the salience and importance of norms was changed by the uncertainty. As summarized in Figure 3, it was ambiguous as to whether defection was really in the best interest of the group when uncertainty was present, and it was harder for the group to identify and agree on defection as being the

smart strategy in the SPD game. As a result, being pro-group and being smart became less obvious, and being nice became more salient in the SPD game than in the DPD game. In other words, when defection could not be justified by being pro-group and being smart, more weight was put on being nice and not to cause harm to the other party, thus encouraging cooperation as socially desirable. When one is in a group, there is social pressure to conform to social norms and perform social desirable behaviors, especially when one's behavior is observable by other members in the group (Turner 1991). Thus, in the SPD game, group member were more likely to conform to the niceness norm and choose the socially desirable strategy (cooperation) than individuals. Hence a reversed discontinuity effect was observed in the SPD game.

5. Conclusions and General Discussions

Previous research has shown a 'discontinuity effect': groups are less cooperative than individuals when outcomes are deterministic (Insko et al., 1987; Wildschut, 2003). We replicated the discontinuity effect in the DPD game, but found a reversed discontinuity effect when outcome uncertainty existed: groups were more cooperative than individuals in the SPD game. We suggest the three major factors that underlie the usual discontinuity effect, greed, fear, and persuasion power, were reduced in the stochastic environment. Two complementary explanations for the reversed discontinuity effect in the SPD game were proposed: guilt-aversion tendency and blame-avoidance motivation when making decisions that affect others' welfare, and the social pressure to conform to the niceness norm when it was unclear what strategy was pro-group and smart.

As a summary, Table 7 illustrates all decision mechanisms discussed in this

paper and provides a general framework for explaining both the discontinuity effect in the DPD game and the reversed discontinuity effect in the SPD game.

Table 7: A summary of Group Cooperation in the DPD and SPD game

<table>
<tr><td colspan="3" rowspan="3"></td><td colspan="6">Game Types</td></tr>
<tr><td colspan="3">DPD Game</td><td colspan="3">SPD Game</td></tr>
<tr><td>Effect of No Uncertainty</td><td>Effect on Cooperation</td><td>Group-Individual Difference</td><td>Effect of Uncertainty</td><td>Effect on Cooperation</td><td>Group-Individual Difference</td></tr>
<tr><td rowspan="5">Group Processes</td><td rowspan="2">Role of Responsibility</td><td>Guilt Aversion</td><td>No ex post guilt from uncertain outcome (Section 4.1)</td><td></td><td rowspan="5">Discontinuity Effect</td><td>Foreseeing ex post guilt safer strategy (cooperation) (Section 4.1)</td><td>Increase</td><td rowspan="5">Reversed Discontinuity Effect.</td></tr>
<tr><td>Blame Avoidance</td><td>No ex post blame from uncertain outcome (Section 4.1)</td><td></td><td>Foreseeing ex post blame safer strategy(cooperation) (Section 4.1)</td><td>Increase</td></tr>
<tr><td rowspan="3">Conformity Pressure</td><td>Pro-group</td><td>Pro-group strategy (defection) is reinforced by greater greed and fear(Section 3.1)</td><td>Decrease</td><td>Unclear what the pro-group strategy is (Section 3.3)</td><td></td></tr>
<tr><td>Smart</td><td>Smart strategy (defection) is reinforced by smart-strategy persuasion (Section 3.2)</td><td>Decrease</td><td>Hard to figure out and convince other members what the smart strategy is (Section 3.3)</td><td></td></tr>
<tr><td>Nice</td><td>Nice strategy (cooperation) is clouded by being pro-group and being smart (Section 4.2)</td><td></td><td>Niceness is more salient than being pro-group and being smart; Social pressure pushes groups to be more cooperative than individuals (Section 4.2)</td><td>Increase</td></tr>
</table>

In the DPD game, it is fairly easy to identify defection as the pro-group and smart strategy. The greater greed and fear in groups, as shown by previous research, and the persuasion argument we proposed, encourage groups to defect by following a smart strategy and behaving with the best interest of the group in mind. Hence groups

defect more than individuals and the discontinuity effect is observed.

In the SPD game, however, uncertainty influences group preferences through two mechanisms: role of responsibility and conformity pressure. Guilt-aversion and blame-avoidance cause groups to opt for the safer strategy (cooperation) when facing uncertain outcomes. The existence of uncertainty complicates the game, and makes it harder to identify defection as the pro-group and smart strategy. The norm of being nice, which was clouded by the norm of being pro-group and smart in the DPD game, becomes more salient in the SPD game where the pro-group and smart norm no longer play a central role. With the social pressure to conform to the niceness norm, groups become more cooperative than individuals under uncertainty, and a reversed discontinuity effect is observed in the SPD game.

The current chapter reports a curious finding that may have implications for many social dilemma problems. We may actually be able to use uncertainty to improve inter-group cooperation. But before drawing any conclusion and providing any prescriptive suggestion, there are questions that warrant further investigation, among which the most important question is to understand why the phenomenon exists. Although the discussion data in Study 1 provide evidence on why uncertainty reduced the inter-group competitiveness or why the discontinuity effect disappeared, the two mechanisms we proposed in the paper to explain the inter-group cooperation or the reversed discontinuity effect were based on previous literature instead of empirical studies. That is, the data from Study 1 were not sufficient to either verify or refute those two mechanisms. In the next chapter, I will present three follow-up studies conducted to answer why groups cooperate more than individuals under uncertainty.

Chapter 3

Why do Groups Cooperate More than Individuals under Uncertainty?

Introduction

In the last chapter, I reported a curious phenomenon that groups cooperated less than individuals in a deterministic Prisoner's Dilemma game (the discontinuity effect), but cooperated more than individuals in a stochastic Prisoner's Dilemma game (the reversed discontinuity effect). Four mechanisms, both consistent with previous research and discussion data from Study 1, were provided to explain the disappearance of the discontinuity effect. Those four mechanisms shed light on why uncertainty reduced the usual inter-group competitiveness, but not on why there was a reversed discontinuity effect. That is, they explain why groups were no longer more competitive than individuals, as often observed in previous literature, but not why groups were *more* cooperative than individuals.

In trying to explain why groups cooperated more than individuals under uncertainty, at the end of the last chapter, I proposed two possible group processes that are underlying the group cooperation decision: the safety-first motivation driven by guilt aversion and blame avoidance when making decisions that affect the welfare of others (Charness and Dufwenberg 2006; Charness and Jackson, 2009), and the social pressure to conform to certain norms when in a group and observed by others (see Turner 1991 for a review on social conformity). Unfortunately the data from Study 1 were not sufficient to either verify or refute those two mechanisms. In other words, they were educated speculations based on previous literature, not scientific proof derived from experimental data.

In the current chapter, I will present three studies to investigate why groups cooperate more than individuals in the SPD game, especially on how uncertainty interacts with player type to affect the cooperation decisions. The structure of the chapter is as follows. Study 2 examines whether groups and individuals have different risk preferences that are consistent with the safety-first mechanism, followed by Study 3 that looks into possible group-individual trust level and further investigates the risk preference of them. Study 4 is a comprehensive survey study that provides insights on a variety of issues, including risk preference, trust level, and the social pressure mechanism. The chapter will conclude by discussing the strengths and weaknesses of current studies, as well as the generality of the group cooperation phenomenon.

Group-individual Risk Preference Difference

The first group mechanism (safety-first motivation) we proposed in the last chapter to explain the group cooperativeness involves two components, guilt aversion and blame avoidance, both of which boil down to risk preference difference. That is, if the safety-first motivation is underlying the group cooperation behavior under uncertainty, groups should be more risk averse or less risk seeking than individuals in this kind of scenario. From now on, we will refer this hypothesis as “group risk concern”, reflecting the fact that it could be driven by either group risk aversion or individual risk seeking, or both.

Were groups more concerned about risk than individuals in the SPD game? Was the increase in cooperation motivated at least partially by group-individual risk preference difference? To answer those questions, we ran Study 2 in which a similar SPD game was applied, but instead of playing against a real player, each player played with a computer with known probabilities of investing. This design adopted

the basic structure and incentives in Study 1, but removed any interactive motivations for cooperation, such as social pressure to be nice, expectation of future cooperation, etc. The only benefit from one player's investment was to reduce her own probability of suffering a loss and had no effect on the decision of the computer, nor potential future benefits from mutual cooperation as playing with a real player. Thus, investing in Study 2 is solely driven by risk reduction. The investment difference between groups and individuals in this game should be completely determined by their difference in risk preference.

Study 2: Play with a Computer Player

Method

Participants. 182 people participated in a between-subject study. 150 were in the Group condition (50 groups in total), and 32 were in the Individual condition. All were paid $10 show-up fee. About 20% of the participants were randomly chosen to be paid the dollar values of Talers they earned in Study 2.

Game Design and Procedure. Similarly as in previous studies, participants played the game either as a member in a 3-person group playing against another group, or an individual playing against another individual. Each player played multiple Supergames. There were 10 rounds in each Supergame.

Participants were given a payoff table similar to Table 1. The major difference between Study 2 and Study 1 was that in Study 2, the players were told that they would play with a computer player, not a real player. The computer was programmed to invest with a certain probability in each round. The probabilities were known to the players before they made their decisions in each round. The values of the probabilities, shown in Table 8, were selected based on the average investment

tendency of real players in Study 1.

Table 8: Invest Probabilities of the Computer Player in Study 2

Round Number	1	2	3	4	5	6	7	8	9	10
Probability of Investing	60%	55%	54%	53%	50%	49%	47%	42%	31%	17%

Hypothesis. The hypothesis we are to test in Study 2 is the group risk concern hypothesis as discussed before:

H1: Groups are more risk concerned and invest more often than individuals in Study 2.

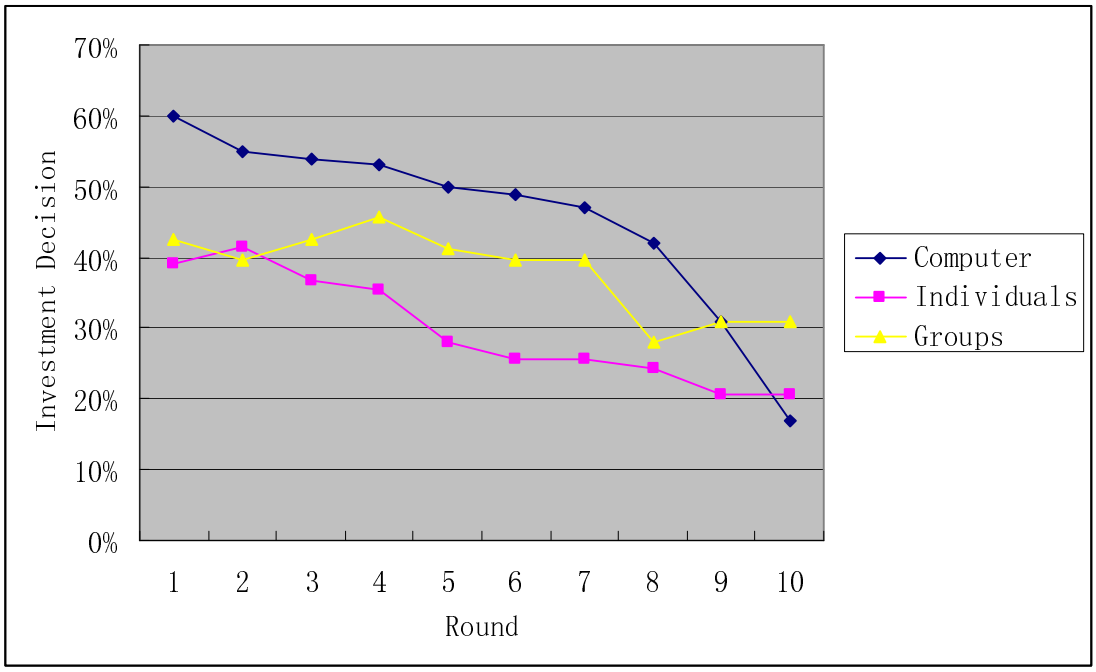
Results

When facing a computer player whose investing probability was known, on average groups invested 38% of the time, and individuals invested 29% of the time. A logit model similar to Equation 1) was estimated and confirmed that groups invested more frequently than individuals ($z=2.25$, $p<0.05$), which supports H1 that groups were more risk concerned than individuals in the SPD game.

More details on the investment decisions of groups and individuals in each round are illustrated in Figure 4. Interestingly, although there was no interaction between the participants and the computer player, participants responded to the investment probability changes of the computer over time as if there had been an interaction. The investment tendency decreased as the probability of computer investing decreased. One possible reason for that behavior is that participants might try to be “efficient” in terms of investing to reduce risks. When there was a higher probability that the computer would invest, it was more likely that the participants could completely remove the risk of losing 100 Talers by investing 45 Talers. When the computer investing probability was low, however, the participants realized that

investing 45 Talers by herself would not be enough to remove the risk. It could only partially reduce her risk if the computer did not invest.

Figure 4: Group-Individual Investments when Playing with a Computer



Although both groups and individuals responded to the probability changes, there are a few noticeable groups-individuals differences in terms of how they responded to the changes. First, as stated before, groups invested significantly more than individuals, indicating that in general, groups were more risk concerned than individuals in the SPD game. But the group-individual risk preference difference was not always of the same magnitude in all rounds with various investment probabilities. As shown in Figure 4, when the computer investing probability was high (Round 1 and 2), roughly the same percentage (around 40%) of the groups and individuals thought that it was worth 45 Talers to have a high chance of removing the risk completely. As the probability of the computer investing and likelihood of removing the risk decreased (Round 3-8), groups and individuals illustrated different risk

reduction tendency. A higher percentage of groups than individuals chose to invest to reduce their own risk, even though they knew that the computer's investing probability was low.

Second, individuals had a monotonically decreasing invest tendency over time. Groups, on the other hand, had a kink at Round 8 after which groups increased their investment to reduce their risk unilaterally, as if groups had a safety threshold for the highest allowable probability of suffering a loss. When the probability of the computer investing became very low as in later rounds, players might treat it as though that the computer would not invest and the probability of suffering a loss is high assuming both not investing. A player with high risk concern would want to invest to reduce her own risk. Note that both groups and individuals flatted out at Round 9 with different investment levels (31% for the groups, and 21% for the individuals), signaling that individuals probably also had a safety threshold probability that was lower than that of the groups. This is again consistent with the hypothesis that groups were less risk tolerant than individuals.

Discussion

Study 2 matched real group and individual players with a computer player whose investment probability in each round was pre-set and known the real players. This design kept the context and structure of the SPD game, but removed any interactive factors that may have caused the group cooperativeness observed in Study 1. Consistent with H1, groups invested more frequently than individuals, which supported our prior assumption that groups were more risk concerned and more likely to invest to reduce their own risk even if their action had no effect on their computer counterpart's decisions.

As encouraging as the results in Study 2 seems, there are still at least three issues relevant to the first group process, the safety-first motivation, to be resolved before we can conclude that groups risk concern had motivated group cooperativeness under uncertainty. First, note that the investment difference between groups and individuals in Study 2 (38% vs. 29%) was much smaller than that in Study 1 (52% vs. 22%). The difference in the magnitude implies that group risk reduction in the SPD game can probably only partially explain the group cooperativeness. That is, the magnitude of the group-individual investment difference in Study 1 was probably too large to be driven by the group risk concern alone. Additional motivations need to be identified to explain the difference.

Second, the group risk concern hypothesis was based on previous research on guilt aversion and blame avoidance when one faces responsibility issue in a group context (Baumeister et al. 1994; Charness and Dufwenberg, 2006). Study 2 confirms the existence of group risk aversion, but provides no specific information on whether the risk aversion was driven by guilt aversion or blame avoidance or other unidentified factors.

Third, so far we have focused on uncertainty encouraging group cooperation. An alternative or complimentary reason for the interaction between Player Type and Uncertainty in Figure 1 is that uncertainty reduces individual cooperation. This is consistent with previous research (Bereby-Meyer and Roth, 2006; Kunreuther et al., 2008) and the data from Study 1 (Table 5). One possible reason for uncertainty reducing individual investment is that individuals may engage in more risk seeking behavior under uncertainty than groups, especially given that the game was in the loss domain (Kahneman and Tversky, 1979). In other words, it is possible the risk

preference difference we observed in Study 2 is a mixture of groups being risk averse and individuals being risk seeking. It would be helpful to investigate specifically the individual risk seeking hypothesis, which will be one of purposes of Study 3.

In the remainder of this chapter, I will present two more studies that were designed to investigate the above three issues as well as testing other group processes that might have motivated groups to invest, besides group-individual risk preference differences.

Cooperation Expectation and Trust

Study 2 provided evidence on the existence of higher group risk concern compared to the individuals and argued that the higher risk concern is one of the reasons why groups cooperated more than individuals in the SPD game. The fact that on average groups were more risk concerned than individuals does not exclude the possibility that some groups might had similar risk preference with individuals. Given that the group risk aversion cannot fully explain the magnitude of the group-individual cooperation difference, it is reasonable to suspect that some groups who had similar risk preference as individuals invested more than individuals for reasons other than risk concern.

One possible reason for those groups who were no more risk concerned than individuals to invest more than individual is that groups and individuals may have different expectations on whether their counterpart would invest. In the SPD game, groups cooperated in the belief that the other group would cooperate, while individuals defected expecting the other individual to defect. The reasoning underlying the expectation-driven investment hypothesis is similar to the one in Study

2 in which players invested more when the computer investing probability was high than when it was low. Note that although both the risk concern hypothesis and the cooperation expectation hypothesis are related to risk preference, they try to explain group cooperation under uncertainty from two different perspectives. The risk concern hypothesis is based on whether "acting as a group under uncertainty" pushes group members to be more risk concerned, while the cooperation expectation hypothesis considers whether "interacting with a group under uncertainty" changes players expectation on how their counterpart will act. In other words, one hypothesis treats groups as" actors", the other focuses on groups as "observers".

Note that the risk concern hypothesis and cooperation expectation hypothesis can be correlated. Observing one's own group's risk concern and high cooperation tendency can induce one to believe that one's opponent group will experience similar process and has similar cooperation tendency. Hence, group risk concern not only encourages groups to invest (as an actor), but also serves as a hint that the other group will invest as well (as an observer).

A related line of research to the cooperation expectation hypothesis is trust. Previous research has revealed multiple aspects of trust, such as belief in others' competence, expectation of goodwill intent, assurance of benign behavior in fear of being punished, etc. (Barber 1983; Yamagishi and Yamagishi, 1994). Following Insko et al. (2005), we define trust in the current context as "an expectation that the opponent will cooperate," regardless of the basis of the expectation. Recall that in the last chapter, we reviewed that one of the four reasons underlying the inter-group competitiveness in the deterministic PD game was the fear of being exploited. In that sense, lack of trust was the source of the fear underlying the discontinuity effect.

Previous research on group trust in trust games yields mixed results. For example, Cox (2002) studied individual and group difference in trust and trustworthiness in an investment game and found that 3-person groups were as trusting as individuals, but less trustworthy. Kugler et al. (2007) reran the trust game and obtain the opposite result that "groups are less trusting than individuals but just as trustworthy." In a gift-exchange game, Kocher and Sutter (2007) reported that groups were more trustworthy than individuals. Bornstein and Kugler (2004) applied a two-party centipede game (Rosenthal 1981) and found that groups were both less trusting and trustworthy than individuals.

Fortunately research using the PD game to study the discontinuity effect yields more consistent results on group trust. As reviewed in the last chapter, in the DPD game, groups were often less trustful of each other than are individuals. The most relevant experimental evidence to the current study is from research on group-individual difference in a 3-option PD game, or referred as PDG-Alt matrix in the discontinuity effect literature (Insko et al. 1990, 2005). Groups consistently show less trust in the 3-option PD game than individuals in a variety of studies (Insko et al. 2005). More details on the 3-option PD game will be revealed later when we present Study 3.

To summarize, the cooperation expectation hypothesis we are to test is in fact a group trust hypothesis. Previous research using trust games reported mixed results on inter-group trust, but the discontinuity effect research consistently found that groups were less trustful than individuals. None of above studies I reviewed had uncertainty in the context. How does uncertainty affect the trust issue between groups? How does risk preference interact with trust or expectation of cooperation? The

discussion data in Study 1 provided partial evidence that uncertainty reduced inter-group distrust and fear (Section 3). Could it be that the reduction in distrust was so big that groups actually trusted each other more than individuals under uncertainty? Was higher trust the third possible reason, besides risk aversion and niceness norm, for the group cooperativeness under uncertainty? Study 3 was conducted to show how the combinations of group risk aversion, individual risk seeking, and cooperation expectation (trust) difference affect players' decision in the SPD game.

Study 3: 3-Option Stochastic Prisoner's Dilemma

Purpose

Two hypotheses will be tested in Study 3, the Individual Risk Seeking Hypothesis as described in the discussion to Study 2, and the Group Trust Hypothesis above. The Individual Risk Seeking Hypothesis states that one source of the group-individual risk preference difference was from individual being more risk seeking than groups. The Group Trust Hypothesis tests whether groups were more trustful of the other group than individuals were of the other individual when uncertainty is present.

Method

Participants. 154 participants played the 3-option SPD game. 114 were in the Group condition (38 groups in total), and 40 were in the Individual condition. Groups always played with another group, and individuals always played with another individual. All were paid $10 show-up fee. About 20% of the participants were randomly chosen to be paid the dollar values of Talers they earned in Study 3.

*Procedure. A*s in previous studies, participants played the game either as a member in a 3-person group playing against another group, or as an individual

playing against another individual. Each player played multiple Supergames. There were 10 rounds in each Supergame. The players played with the same counterpart for one Supergame, then switched counterparts to play the next Supergame. Each Supergame was completely independent of each other.

Game. The 3-option SPD game was very similar to the SPD game. The major difference was that players had a third option, Withdraw, besides Invest and Not Invest. If either or both players decided to withdraw, both players would pay a withdrawal cost (50) that was lower than the potential loss (100), but higher than the investment cost (45), and the game was over. No additional loss would occur. If nobody withdrew, the players' payoffs were calculated as in the normal SPD game, depending on their decisions and the random numbers.

Table 9 shows all possible payoffs in the 3-option SPD game. Clearly, the expectation of one's counterpart's decision matters in this game. If we assume risk neutrality and calculate the expected payoffs (Table 10), then Not Invest yields the smallest expected loss when one expects her counterpart to Invest, and Withdraw yields the smallest loss when one expects her counterpart Not to Invest.

Table 9: Possible outcomes in the 3-option SPD game

		Player 2		
		Withdraw	Invest	Not Invest
Player 1	**Withdraw**	**-50,-50**	**-50,-50**	**-50,-50**
	Invest	**-50,-50**	*-45; -45*	*20% lose 145,80% lose 45; 40% lose 100,60% lose 0*
	Not Invest	**-50,-50**	*40% lose 100,60% lose 0; 20% lose 145,80% lose 45*	*52% lose 100,48% lose 0; 52% lose 100,48% lose 0*

Table 10: Expected Payoffs in the 3-option SPD game

		Player 2		
		Withdraw	Invest	Not Invest
Player 1	**Withdraw**	**-50,-50**	**-50,-50**	**-50,-50**
	Invest	**-50,-50**	*-45; -45*	*-65;-40*
	Not Invest	**-50,-50**	*-40; -65*	*-52;-52*

The deterministic version of this game (Table 10) is often referred in literature as PDG-Alt matrix (Insko et al., 2005) or 3-option PD game. In previous discontinuity effect research, the 3-option deterministic PD game usually involves no uncertainty, and has been mainly used to study distrust. For example, Insko et al. (1990) found that groups both withdrew and defected more frequently than individuals, consistently with the fear and greed motivation underlying the discontinuity effect (Wildschut et al., 2003). Withdrawal in the deterministic game is often regarded as a signal of distrust, or evidence that the player expects the other play not to cooperate.

With the uncertainty in the picture and different risk preference of the players, the decision is more complicated and depends on both the players' risk preference and their expectation of their counterparts. Table 11 shows how the combinations of different risk preference and expectation affect the players' investment decision in the 3-option SPD game. The rows specify the player's risk preference and the columns list the player's expectations. Risk aversion and Risk neutral are combined in one row because in the current payoff structure, they imply similar risk preference and strategy.

Table 11: Player's Decision in the 3-option SPD game

		Player 1's **Expectation** of Player 2	
		Invest (Trust)	***Not Invest (Distrust)***
Risk Preference of Player 1	***Risk Seeking***	***Preference:*** Paying 50 <Paying 45 < 40% losing 100	***Preference:*** Paying 50 < 20% losing 100, plus paying 45 < 52% losing 100
		Behavior: Not Invest	
	Risk Averse or Risk Neutral	***Preference:*** 40% losing 100 < paying 50< paying 45	***Preference:*** 52% losing 100 < 20% losing 100, plus paying 45 < paying 50
		Behavior: Invest	***Behavior:*** Withdraw

In the first column, if a player is certain that her counterpart will invest, she

will never withdraw regardless of her risk preference because -50 is strictly dominated by -45. Similarly in the first row, if a player is risk seeking enough, she will never withdraw regardless her expectation on the other player. For the risk seeking player, if it is expected that her counterpart will invest, she will be better off playing Not Investing than withdrawing because she prefers a 40% risk of losing 100 to paying 50 to withdraw. If it is expected that her counterpart will not invest, she is still better off playing Not Invest than withdrawing because a 52% risk of losing 100 is still preferable than paying 50 withdrawal cost for sure.

The more interesting row is when a player is risk averse or risk neutral. In that scenario, the player's decision depends on her expectation of what her counterpart will do. If she expects that her counterpart will invest, she will invest because both paying 45 (investment cost) to remove the risk is better than paying 50 to withdraw. If, however, the player expects the other players not to invest, then she will withdraw to avoid either a 52% risk of losing 100 (both not investing), or a 20% risk of losing 100, plus paying the investment cost of 45 (self investing, counterpart not investing).

Similarly, in the second column when a player expects the other player not to invest, her decision will depend on her risk preference. She will withdraw if she is risk averse or risk neutral, but will stay in the game and choose not to invest if she is risk seeking and thinks that 52% of losing 100 is preferable to paying 50.

The above discussion infers players' strategies from their preference and expectations. In the actual study, what was really observable was the players' behavior instead of their preference. Table 12 applies a reversed process based on Table 11 and reports the risk preference and expectation of the players implied by her observed

behavior in the 3-option SPD game.

Table 12: Implications of Three Possible Decisions

Decisions	Risk Preference	Trust
Withdraw	Risk averse or neutral	Distrust
Invest	Risk averse or neutral	Trust
Not Invest	Risk seeking	Irrelevant

Hypotheses. We have two hypotheses in the 3-option SPD game, the Individual Risk Seeking Hypothesis, and the Group Trust Hypothesis. Translating them into behavior, we have the following two more concrete hypotheses:

H2 (Individual Risk Seeking Hypothesis): Individuals choose Not Invest (Risk Seeking) more frequently than Groups do;

H3 (Group Trust Hypothesis): For those players who are risk averse or neutral, groups choose Invest (Trust) more frequently than individuals. Individuals are more likely to Withdraw (Distrust).

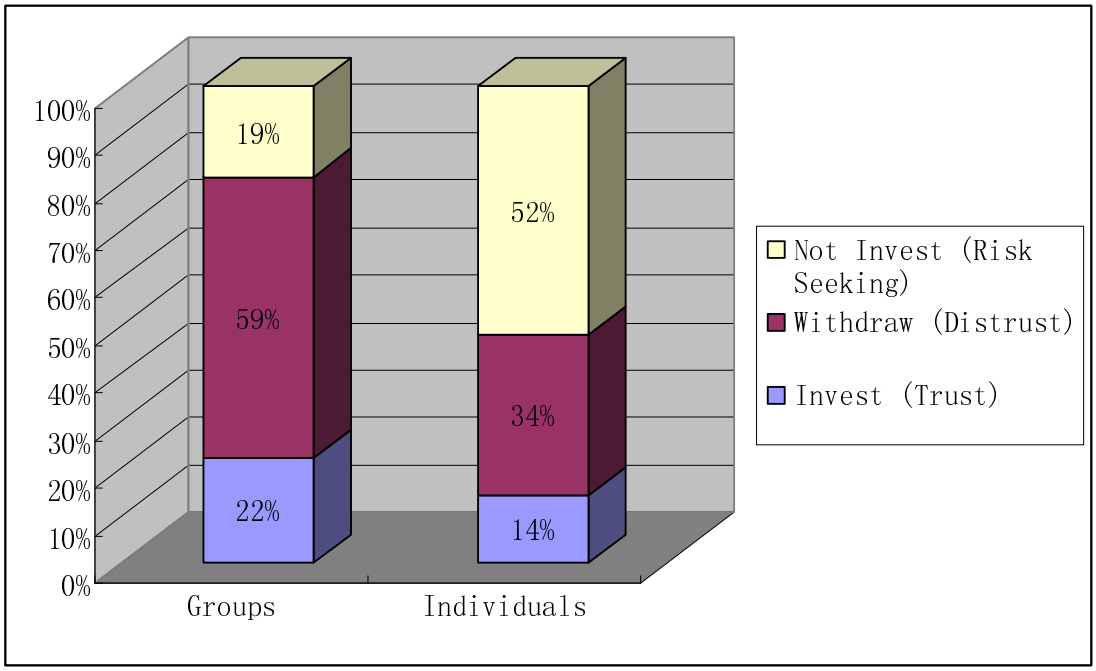
Note that the Group Trust Hypothesis is qualified by "For those players who are risk averse or neutral," because in the current design, it is hard to identify the players' trust level if they are risk seeking and choose Not Invest.

Results and Discussion

Figure 5 shows the mean proportion of all three possible decisions in the 3-option SPD game.

Risk Preference: Risk Seeking versus Risk Aversion or Neutral. As shown in Table 12, in the current game, Not Invest implies risk seeking, while both Withdraw and Invest imply risk aversion or neutral. Consistent with the risk seeking reasoning in Table 12, when players were asked why they chose Not Invest, the commonest answer was "because it was the only way to have a chance to losing nothing."

Figure 5: Mean Proportions of the Three Options



The mean proportions of Not Invest for groups and individuals were 19% and 52% respectively, as illustrated in Figure 5. A logit model that was similar to Equation 1 was estimated and confirmed H2 that individuals chose the risk seeking option (Not Invest) more frequently than groups did ($z=5.65$, $p<0.01$).

The confirmation of individual risk seeking or lack of group risk seeking supports our earlier discussion on group risk aversion and individual risk seeking under uncertainty jointly shaping the interaction between Player Type and Uncertainty. A related issue has to do with the fact that the game was played in the loss domain. In a sense, the individuals behaved more consistently with the risk seeking tendency in the loss domain predicted by the Prospect theory (Kahneman and Tversky, 1979) than the groups did. Will the group cooperation replicate in a gain domain game? A separate study (which is not to be reported in this dissertation) has confirmed that groups did cooperate more than individuals in the gain domain, but the magnitude was

smaller than in the loss domain game. This implies that individual risk seeking plays a role in the group cooperation phenomenon, but is not the only reason.

As a side note, the lack of risk seeking behavior for groups in the loss domain is of theoretical interest in a more general sense than in the framework of the PD game. Is it possible that risking seeking in the loss domain in the prospect theory might be a better theory to describe individual behavior than group behavior? How is this phenomenon related to guilt aversion and blame avoidance mechanism? It would be interesting to see further research on this topic.

Cooperation Expectation: Trust versus Distrust. According to Table 12, for people who were risk averse or neutral, Withdraw implied distrust and Invest indicated trust. Indeed, when players were asked why they chose Invest, not Withdraw, the most frequently answer given was: “because -45 is better than -50”. That answer implied that they expected (trusted) the other player to cooperate.

As shown in Figure 5, 59% out of 81% of the groups and 34% out of 48% of the individuals who were risk averse or neutral distrusted the other group/individual and withdrew. A logit model similar to Equation 1 found that there was no significant difference in withdrawal rate between groups and individuals who were risk averse or neutral ($z=0.95$, $p=0.33$). In other words, there was no evidence supporting H3.

Note that although there was no evidence that groups were more trustful than individual under uncertainty, there was no indication that groups were less trustful either, which had been frequently observed in previous discontinuity effect studies. Uncertainty reducing inter-group distrust is consistent with the reduced fear argument we proposed in the last chapter, as one of the reasons why uncertainty mediated the discontinuity effect.

One thing that is worthy emphasizing here is that "no difference in trust level between groups and individuals who were risk averse or neutral" does not automatically generalize to "no difference in trust level between groups and individuals." In the current game, trust were irrelevant to players who were risk seeking and were ready to take the risk by Not Investing regardless what the other players action. For that reason, we could not track the trust levels of the risk-seeking players. Fortunately, for the same reason, to analyze how trust affected players' decision in the SPD game, we only need to focus on players who were risk averse or neutral, since cooperation expectation (trust) mattered only to those players, not to the risk-seeking players.

General Discussion of Study 2 and Study 3

So far, we have focused on the possibility that the difference between group and individual risk preference was one of the reasons why groups cooperated more than individuals under uncertainty. Both Study 2 and 3 provided evidence that groups were more risk averse, or less risk seeking, than individuals in the SPD game. We also investigated the group trust hypothesis that groups might be more trustful than individuals under uncertainty, which might be another reason for the group cooperativeness. Study 3 rejected the group trust hypothesis and illustrated that for players whose trust level affected their decisions (who were not risk seeking), groups and individuals had the same level of trust toward their counterparts. Note that this is consistent with the reduced inter-group distrust or fear argument we proposed in the last chapter.

Although we are now more confident than before in believing that the group-individuals risk preference difference was indeed underlying the group

cooperativeness under uncertainty observed in Study 1, we do not know yet what was driving groups to be more risk concerned. Recall that in the last chapter we proposed two components that might have driven group risk aversion, ex post guilt aversion and ex post blame avoidance. Study 2 and 3 provided no additional information on those two components.

Another factor Study 2 and 3 have left out on purpose is the social pressure to conform to certain norms as a possible explanation for the group cooperativeness under uncertainty. As mentioned in the last chapter, we suspected that groups might be under more social pressure to be nice and cooperative than individuals, especially when they did not have a good excuse to defect and take advantage of others, as they did in the deterministic PD game. When discussing the withdraw behavior in Study 3, we have been focused on the players' risk preference and their expectation on what their counterpart would do in such an interactive game. There is a third implication of the withdraw decisions we have been intentionally ignoring so far: the niceness norm. In the 3-option SPD game, withdrawing signals distrust toward your counterpart and eliminates any chance for mutual cooperation, which is clearly not consistent with the niceness norm. The fact that groups trusted their counterparts no more than individuals did might imply the invalidity of the niceness norm explanation. Clearly, more investigation is needed before we can draw a definite conclusion.

Study 4: A Survey on the SPD game

Study 4 is a survey study that is designed in an attempt to answer the following questions: 1) What factors drive the group-individual risk preference difference? Specifically, do guilt aversion and blame avoidance push groups to be more risk averse and invest more frequently to reduce the risk? 2) Does group

membership or group process put social pressure on group members to conform to certain norms? If yes, what are they? Especially, are group members under social pressure from other members to conform to the niceness norm?

Participants and Design.

There were three conditions in Study 4, Individual Survey (IS), Group Private Survey (GPS), and Group Shared Survey (GSS). There were 32 participants in the IS condition, 72 participants (24 groups) in the GPS condition, and 78 participants (26 groups) in the GSS condition. The total number of participants in Study 4 was 182.

In the IS condition, all participants first read the same instructions as the one in Study 1 for the SPD game, finished the quiz, then completed a survey that contains a series questions on their strategy choice, expectation of their counterpart, social preferences, and risk preferences. In the two group conditions (GPS and GSS), participates were assigned to 3-person groups, briefly met their group members, then were led to relatively private locations to read the instructions, finish the quiz, and complete the survey independently. The survey in the group condition includes similar questions as the ones in the individual survey, plus a set of group process related questions. In the GPS condition, the participants were told that, upon the completion of the survey, the experimenter would collect the survey sheets before they rejoined their group to discuss the strategies and play the game. That is, their survey results would remain private and other members in their groups would not see their answers. In the GSS condition, the participants were told that they would bring their surveys and share them with their group members later when they rejoined the group to play the game. Note that all participants answered the survey questions *before* they actually

participated in group discussion or played the game.

The main motivation to have a private and shared group survey was to distinguish between "group membership alone" and "group membership plus peer pressure." The disparity between the GPS and GSS conditions, if any, was supposed to be caused by whether the participants' answers to the survey would be scrutinized by other members. Note that even in the GPS condition, the social pressure to conform to certain norms was not completely removed because group members would foresee intragroup discussion even though their survey would remain private. Such anticipation might put their mind in a group-like setup. Probably for that reason, we did not observe statistically significant differences between the GPS and GSS conditions. Hence two group survey data were pooled for the analysis on group-individual differences.

Results and Discussion

There were two possible paths through which the group cooperativeness over individuals emerged. The first path was through influencing group members' individual strategy. That is, group identity or anticipation of interacting with another group changed group members' real preferences so that it was less likely that group members thought of Not Invest as a preferable strategy than individuals did. One possible reason for the preference switch to Invest is the higher level of trust towards the other group. Recall that Study 3 rejected the group trust hypothesis for the risk averse or neutral players, but was unable to reject it on the general group level.

For the second path, we assume that it was equally likely that group members and individual thought of Not Invest as a preferable strategy, but group processes discouraged members from suggesting Not Invest, refuting Invest, or

encouraged members to suggest Invest. Possible group process candidates include, but are not exclusive to, guilt aversion, blame avoidance, niceness norm pressure, etc.

Group Identity, Inter-group Anticipation, and Group Trust. To test whether the group identity changed group members' strategy preference, both group members and individuals were asked how likely they would invest in the game at the 1st, 5th, and last round. Reponses were on a 100-point scale ranging from 0 (I will never invest) to 100 (I will always invest). There was no significant difference between group members and individuals ($\chi^2(3)=0.815$, $p>0.10$), indicating that group membership alone did not change group member's strategy preference.

As discussed before, anticipating interacting with a group instead of an individual may change players' preference too. To test whether this was true in the SPD game, all group members were asked how likely they were to invest if they were playing against an individual. There was no evidence that interacting with an individual or a group had an influence on the group members' choices ($t(885)=0.60$, $p>0.10$).

To test the group trust hypothesis on a more general level than in Study 3, we asked all players to estimate how likely they thought their counterpart would invest at the 1st, 5th, and 10th round. Consistent with the trust results in Study 3, in general there was no significant group-individual difference on the cooperation expectation of the three rounds in the SPD game ($\chi^2(3)=4.719$, $p>0.10$). Interestingly, groups did show significantly higher expectation of counterpart investing in the first round than individuals did ($z=2.12$, $p<0.05$). Considering that the expectation of the first round was probably most pertinent to the general strategy because the interaction of the two players in the first round had significant influence on later interactions, and

the expectations of the 5th and 10th round might have changed as the game progressed, we believe that the significant difference in cooperation expectation between groups and individuals at the first round should at least be regarded as partial evidence that groups might show more trust than individuals. That is, Study 3 and 4 showed mixed evidence on the group trust hypothesis.

To summarize, in the SPD game, group members' strategy preferences were not significantly affected by group membership, or anticipation of interacting with another group. Groups and individuals had the same strategy preferences before group discussion and game playing. But there was mixed evidence on group trust hypothesis, indicating that groups might have a high cooperation expectation of the other group than individuals had of the other individual.

Guilt Aversion, Blame Avoidance, and Social Norm. Next, we will look in to the second path that group processes discouraged members from suggesting Not Invest, refuting Invest, or encouraged members to suggest Invest.

Reasons for Not suggesting defection were assessed with a series of close-ending ratings, followed by one open-ended question for any reasons that might had been missing in the close-ending ratings. Several participants answered the open-ended question, but their answers were actually in line with the close-ending ratings and were transformed into close-ending answers.

45% of the group members indicated that they did not believe that Not Invest was a good strategy, 20% said they would not hesitate to suggest Not Invest. Of particular interest is why those who believed in Not Invest hesitated to suggest it to the group. Table 13 shows the percentage of 5 reasons participants had for not suggesting defections, although they believed that defection was a good strategy. Note

that the percentages do not add up to 100 because participants were asked to identify all applicable reasons instead one major reason.

Table 13: Reasons for Not Suggesting Defection

Niceness Norm	4%
Guilt Aversion	47%
Blame Avoidance	55%
Persuasion Concern	29%
Does Not Care Enough	23%

As shown in Table 13, guilt aversion (47%) and blame avoidance (55%), turned out to be two major motivations. This is consistent with the discussion in the last chapter that previous research (Baumeister et al. 1994; Charness and Dufwenberg, 2006) indicated that guilt aversion and blame avoidance might be underlying the group risk concern, which drove groups to choose the risk-reduction strategy, cooperation, more frequently than individuals. Note that among those who hesitated to suggested Not Invest, 29% of them also indicated that "hard to convince others" (persuasion concern) was a reason. This supports the reduced persuasion argument we gave when trying to explain why uncertainty reduced the discontinuity effect in the last chapter.

Inconsistent with the niceness norm mechanism we proposed in the last chapter, there was little evidence that group members did not suggest Not Invest because of the niceness norm (4%). Study 4 also investigated whether being in a group imposed extra social pressure to conform to other social norms. Participants were asked to rate two set of norms on a 0-100 scale where 0 represents "it does not describe me in any situation" and 100 represents "it describes me in all situations." The first set was four positive or "To Do" norms: being smart, being team player, working hard, and caring about others. The second set was four negative or "Not To Do" norms: being selfish, being gullible, being incompetent, and being lazy. No

significant difference between group members and individuals were found ($\chi^2(8)=11.29$, $p>0.10$), which indicated that at least before group discussion, there was not much social pressure for social norms.

Conclusions and the Generality Issue

The current paper extends the research on group cooperation under uncertainty from reporting an innovative phenomenon to investigating underlying group mechanisms. Three studies were conducted to examine a variety of possible reasons for the group-individual cooperation difference under uncertainty, including risk preference difference, cooperation expectation difference, social pressure to conform to social norms, etc.

Jointly, the three studies reported in this paper have shown that guilt aversion and blame avoidance drove group members to be more cautious and less risk seeking than individuals. Hence it was more likely for groups to invest to reduce their risk than individuals. There was mixed evidence on whether groups had higher cooperation expectation level on the other group than individuals did on the other individual, after groups observing their own high investing tendency. Groups probably expected their counterpart groups to invest more frequently than individuals did to their counterpart individuals at the first round, but how this expectation may have affected the success of mutual cooperation in later rounds remains unclear. As for the social norm hypothesis, the current studies show no evidence of social pressure pushing groups to be nicer and more cooperative than individuals, at least not before the group discussion. Whether the social pressure to conform to certain norms exists during the group discussion is still an open question.

As discussed before, uncertainty actually has two functions that jointly cause

the reversed continuity effect (groups being more cooperative than individuals). On the one hand, uncertainty reduces greed, fear, and persuasion power, hence reduces the usual inter-group competitiveness. On the other hand, uncertainty encourages inter-group cooperativeness. How are the group processes underlying the reversed discontinuity effect related to the reduced greed, fear, and persuasion power, that are responsible for the disappearance of the discontinuity effect? In other words, how are those mechanisms that encourage inter-group cooperation similar to and different from those that reduce inter-group competitiveness? The simple answer is that they are of similar nature, but may have different magnitudes.

For instance, guilt aversion and blame avoidance reduces social support for greed (defection), hence reduces inter-group competition. The same guilt aversion and blame avoidance also push groups to be more risk cautious, thus increases cooperation to lower the risk.

How uncertainty influences trust level is an example of similar mechanisms with different magnitudes. Study 3 shows clearly that uncertainty reduces inter-group distrust so that groups are no longer more distrustful than individuals, as usually reported in inter-group interactions, but provides no definite evidence that uncertainty encourages groups to be more trustful than individuals. That is, in Study 3, uncertainty increases the group trust level to the same level of the individuals, but not higher. That is why reduced distrust (fear) is a reason for the disappearance of the discontinuity effect, but may not be a reason for the reversed discontinuity effect, although we later find partial evidence in Study 4 that uncertainty might encourage inter-group trust at the beginning of the game.

One question that naturally follows the research on “why groups cooperate

more than individuals under uncertainty" is "when do groups cooperate more than individuals", or the generality question. In this paper, we briefly discussed the possibility that individual risk seeking behavior in the loss domain might change when the game is played in the gain domain. Loss domain is, of course, not the only factor that may interferes with the group cooperation under uncertainty phenomenon, but has not been studied yet. Although the discovery on the group process underlying the phenomenon in Chapter 2 and 3 can help form hypotheses on the existence of the phenomenon under various contexts, the validity and overall generality of the finding remain an open question. This will be the focus of my last chapter of this dissertation: to conclude the current study and discuss future directions.

Chapter 4

Conclusions and Future Research

Major Findings and Implications

Previous research has shown that groups are usually less cooperative than individuals in prisoner's dilemmas. This well-replicated phenomenon is termed the "discontinuity effect". But none of the previous research study group cooperation with the presence of uncertainty. In this dissertation, I conducted a series of studies to examine group cooperation with uncertain outcomes, an important but largely ignored topic in both psychology and economics.

In Study 1 (Chapter 2), 202 subjects play in either a deterministic or a stochastic prisoner's dilemma (DPD or SPD hereafter), either as members of three-person groups or as individuals. That is, the study is a 2X2 between-subject design (2 game types X 2 player types). In the DPD game, players cooperate to reduce magnitudes of losses. In the SPD game, players cooperate to reduce risks of suffering a loss. Mutual cooperation eliminates the uncertainty. The expected values in the stochastic game are the same values as in the deterministic game.

There is a significant interaction between game type and player type. The discontinuity effect is replicated in the DPD game(groups are less cooperative than individuals), but is reversed in the SPD game(groups are more cooperative than individuals). The reversed discontinuity effect is not only highly significant but also big in magnitude. Data analysis on subjects' strategies, survey questionnaires, and recorded discussions reveals that, three major factors (greed, fear, and persuasion power) that underlie the usual discontinuity effect are reduced in the stochastic

environment, which explains why groups were no more 'less cooperative' than individuals in SPD, but not why groups are MORE cooperative.

Study 2 – 4 (Chapter 3) investigated the underlying group mechanisms for the group cooperativeness under uncertainty. A variety of possible reasons for the group-individual cooperation difference under uncertainty were examined, including risk preference difference, cooperation expectation difference, social pressure to conform to social norms, etc.

Jointly, Study 2 - 4 show that guilt aversion and blame avoidance drove group members to be more cautious and less risk seeking than individuals. Hence it was more likely for groups to invest to reduce their risk than individuals. There was mixed evidence on whether groups had higher cooperation expectation level on the other group than individuals did on the other individual, after groups observing their own high investing tendency. Groups probably expected their counterpart groups to invest more frequently than individuals did their counterpart individuals in the first round, but how this expectation may have affected the success of mutual cooperation in later rounds remains unclear. As for the social norm hypothesis, the current studies show no evidence of social pressure pushing groups to be nicer and more cooperative than individuals, at least not before the group discussion. Whether the social pressure to conform to certain norms exists during the group discussion is still an open question.

The discontinuity effect appears to cast doubt on the efficiency of groups with respect to cooperation in social dilemma games with deterministic outcomes. However, the reverse discontinuity effect under uncertainty rekindles hope of groups making cooperative decisions in the interest of social welfare since most scenarios in

the real world are probabilistic ones. This finding has implications for many social dilemma problems. We may actually be able to use uncertainty to improve inter-group cooperation. For example, when two groups face a social dilemma problem, a regulator or a mediator can emphasize the probabilistic nature of the outcomes as a means of reducing group greed and fear associated with defection, while at the same time activating guilt-aversion and blame-avoidance to encourage cooperation. In another scenario where the uncertainty is obvious and people make individual decisions, one may be able to encourage cooperation by categorizing people into groups with common interests.

Before carrying out any application of the group cooperation under uncertainty in the field, there are questions that warrant further investigation. Specifically, the generality of the reversed discontinuity effect in the SPD game remains open to discussion. As mentioned before, uncertainty reduces inter-group competitiveness as well as encourages inter-group cooperativeness. Do these two functions always occur hand in hand? Are there any necessary or sufficient conditions for either of them? In other words, how general this phenomenon is? When does uncertainty reduce inter-group competitiveness, and when does it encourage cooperation?

Generality Discussion and Future Research

The major finding on the interaction between Player type and Uncertainty is new and curious. Although Chapters 2 and 3 jointly provide a clearer picture on why the phenomenon exists, the generality of the findings remain to be explored. Note the game we have been using is very specific and involving multiple important factors that have not been tested upon, but may have significant influence on the decisions.

Study 1 was a 2X2 design that manipulates two factors (Player type and Uncertainty), and keep other factors constant through the four conditions. Considering the complex nature of group process and decision under uncertainty, I would not be surprised that there may exist some triple interaction when a third kind of manipulation is added to the picture. For example, in Chapter 3, I briefly discussed the possibility that individual risk seeking behavior in the loss domain might change when the game is played in the gain domain. The current study uses a security game with negative outcomes to mimic real-world scenario in which players invest to reduce risks of suffering a loss. What if it is an investment game with positive outcomes? Researchers have found that people encode losses and gains differently (Seymour et al., 2007) and typically show greater sensitivity to loss than to gain (Kahneman and Tversky, 1979). The guilt-aversion and blame-avoidance motivations underlying the reversed discontinuity effect may be stronger in a loss-domain game than in a gain-domain game because, if a loss occurred, the regret from not investing in risk-reducing measures is likely to be larger than if additional revenue could have been earned from investing in a profit-enhancing measure in a gain-domain game. It will be interesting to test whether there is a triple interaction between the loss/gain domain, the group/individual player type, and the DPD/SPD game type.

Loss domain is, of course, not the only factor that may interfere with the group cooperation under uncertainty phenomenon, but has not been studied yet. To conclude this dissertation, I will present a few directions for future research on the generality of the group cooperation under uncertainty phenomenon. Some of these experiments have been conducted in the past two months, but the data process is not completed yet and will not be reported in this dissertation. That said, some

preliminary findings are available upon the request of the committee members.

There are numerous factors that could serve as the third factor to interfere with the group player-uncertainty interaction. Based on previous research and my observations during the data collection process, I will identify two categories of factors: factors that change group structure or the decision rules, and factors that alter the game context or structure.

Group Factors

All studies reported in this dissertation utilize unitary groups. Will the group cooperativeness under uncertainty generalize to other groups, such as groups with within-group interest conflicts as well as between-group interaction (Borstein et al., 2002)? As mentioned in Chapter 2, the majority of the groups reached unanimous decisions. Is the decision rule relevant in this phenomenon? If group members have a chance to vote anonymously and the decision is to be made by majority rule, will that change their behavior? Considering that anonymous voting may reduce blame avoidance, hence group risk concern, groups may cooperate less when using majority voting than unanimous decisions.

Another group factor that may interfere with the group cooperation is leadership. Previous research in the discontinuity effect has shown that independent leadership can reduce the discontinuity effect in the deterministic PD game (Pinter et al., 2007). With uncertainty in the picture, the leader's decision is more complicated than in the deterministic PD game. Besides being pro-group, guilt aversion and blame avoidance may become more salient to the leader than to ordinary group members, thus pushing group leaders to lead the group to be even more cautious than before.

Game Factors

Besides group factors, there are several factors that alter the game context or structure and may interfere with group cooperation under uncertainty. I mentioned earlier how loss verse gain domain may change players' behavior. Another game context factor is the length of the game. All studies in this dissertation use a 10-round supergame design. What happens if the game is played only once or to be randomly terminated to mimic infinite games? The discontinuity effect was reported in both one-shot and repeated games in the deterministic PD game (Wildschut and Insko, 2007). It is unclear how or whether players, especially group players, respond to one-shot risk and repeated risk differently. Future research following that direction will shed light on how group make decisions on intertemporal risk regulation.

Another factor is the communication between the players. It is known that communication encourages cooperation and reduces the discontinuity effect in the deterministic PD game (Insko et al., 1993). With uncertainty, communication as a tool to increase cooperation might not be as effective as before. A related issue is the feedback players get from the game. The current studies provide full feedback to the players, but allow no communication. That is, the players know both her and her counterpart's strategy and outcome in the previous rounds, but cannot communicate during the process. It would be interesting to see how and whether communication affects players' decisions, especially if there is only partial feedback so that the player cannot distinguish nature-caused loss from counterpart-defection loss.

The nature of the uncertainty is another factor that may interact with group cooperation. As shown in Table 1, in the upper left cell, both players investing can completely remove the uncertainty. What if the risk is irremovable instead? Based on

previous discussion, we would expect that the level of guilt aversion and blame avoidance to be lower because there is no longer a certain outcome to compare to. Thus, we may expect to see lower risk-reduction driven cooperative behavior from groups. But irremovable uncertainty should have similar effect as removable uncertainty in terms of reducing greed, fear, and persuasion power so that the discontinuity effect should be still reduced. That is, with irremovable uncertainty, we expect to see reduced inter-group competitiveness compared to no uncertainty, and reduced inter-group cooperativeness compared to removable uncertainty.

So far, all studies, including the proposed future studies above, are PD games. From our earlier discussion on why uncertainty reduces inter-group competitiveness and encourages inter-group cooperativeness, there is no reason to believe that the group cohesiveness under uncertainty phenomenon is constrained to the PD game only. Another interesting interactive game is the coordination game and its stochastic version in the Interdependent Security Game (Kunreuther and Heal, 2003). In a coordination game, there are two Nash equilibria in pure strategies: (Invest, Invest) and (Not Invest, Not Invest). The PD game in Table 1 can be easily changed into a coordination game decreasing the investment cost from 45 to 36. In the light of group behavior found in previous studies, we hypothesize that in a stochastic coordination game, risk preference differentials between groups and individuals will lead groups to opt for the risk-reducing measure more frequently than individuals. That is, groups will reach the equilibrium of (Invest, Invest) more easily than individuals.

Last, but not least I would like to propose future studies on the tipping behavior of groups in multiple-player stochastic games. So far, I have been focused on

2-player games. How does uncertainty change players' tipping behavior in a multi-player game? If the group cooperativeness under uncertainty observed in the 2-player games can be generalized to multiple-player games, we may expect to see groups tip towards (Invest, Invest) while individuals tips toward (Not Invest, Not Invest) in a multiple-player stochastic coordination game. Given the fact that most scenarios in the real world actually involve multiple players (for example, multiple nations to develop new technologies to reduce global warming risk), and may have multiple equilibria (either all nations develop new technologies, or none does), I believe that studying group behavior in this kind of games will further deepen our understanding on how decision are made in the real world and have more practical implications than the two-player PD games.

To conclude, group cooperation under uncertainty is a new phenomenon with many perspectives remaining to be explored. Further investigation of these factors provides possible applications for regulators and organizations to control risks, encourage group cooperation, and improve social welfare. We believe that the findings in the current study will serve as a starting point towards integrating three important factors in many social dilemmas -uncertainty, cooperation, and group decision, and have prescriptive implications in encouraging cooperation to improve social welfare in the real world.

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