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Für meine Eltern

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Introduction

This thesis investigates both, theoretically and empirically, the effects of heterogeneity on cooperation in social dilemma situations. Studying social dilemmas has a long history in economics with the *prisoner's dilemma*, the *public goods problem*, and the *tragedy of the commons* being the most prominent examples. The crucial peculiarity of such social dilemmas is that they are characterized by a conflict of interest between individual and collective benefit. As a result, the socially efficient provision of the common good often does not take place (Samuelson, 1954; Olson, 1965; Hardin, 1968). The reason is that by definition nobody can be excluded from the consumption of a common good even if he or she has not contributed to its provision. As a consequence, everyone has an incentive to hope that others provide the common good leading to the famous free-rider problem. Because cooperation failure may have substantial detrimental effects on social welfare, "understanding the proximate and ultimate sources of human cooperation is a fundamental issue in all behavioral sciences"(Gächter and Herrmann, 2009).

Typical applications of social dilemmas in the social and economic life are manifold ranging from important challenges such as environmental protection, national defense, depletion of natural resources, participation in collective action, tax compliance, and charity donations to social interactions at the workplace or at home such as teamwork. Naturally, such situations concern many people who generally differ with respect to a variety of characteristics such as culture, convictions, preferences, resources, qualifications, attitudes, and motivation. As such, the existence and formation of homogeneous group environments can be regarded as an exception, rather than the rule. Studying to what degree collective action is affected by inequality among group members is therefore crucial to understand and predict human behavior in heterogeneous societies. Yet, most studies on collective action have focused on situations where agents with identical characteristics interact with each other. While abstracting from heterogeneity is often legitimate to investigate the underlying logic of collective action problems, this may also be problematic if it neglects important characteristics that influence cooperative behavior.

In general, far less is known about cooperation in heterogeneous than in homogeneous environments, and the evidence that exists for the former is not clear-cut and discussed controversially. While some studies argue that heterogeneity within groups facilitates collective action (cf. Olson, 1965; Hardin, 1982; Oliver et al., 1985), some other studies find rather negative effects of group diversity on cooperation (cf. Ostrom et al., 1994; Bardhan and Dayton-Johnson, 2002; Reuben and Riedl, 2013). Overall, the results show that "the social role of within-group heterogeneity is complex" and that "depending on context, heterogeneity can increase or reduce social cooperation" (Heckathorn, 1993).

Following this, using concepts and instruments from behavioral and experimental economics, all chapters of this thesis aim at shedding light on different aspects of this topic by investigating how different sources of heterogeneity affect people's willingness to cooperate in social dilemma problems. In particular, we are interested in whether the knowledge and insights from cooperative behavior in homogeneous groups can be transferred or extrapolated to heterogeneous environments, or whether there are important interaction effects which influence people's willingness to cooperate in non-trivial ways. In Chapter 1, we therefore analyze the interaction of heterogeneous abilities and inequality in wealth on public goods provision. Chapter 2 studies heterogeneity in agents' capabilities and preferences and compares their influence on cooperative behavior when informal sanctions are available or not. In Chapter 3, we investigate how people's willingness to cooperate depends on the information they receive about heterogeneous public goods contributions of others. Finally, in Chapter 4 we examine whether differences in the framing of a decision situation affect the level of cooperation in a two-person social dilemma game.[1] Based on our findings, we derive practical implications for the development of institutions that help to increase efficiency by fostering cooperation. In the following paragraphs I will briefly introduce the field of behavioral and experimental economics, motivate the research questions of each chapter, summarize the main findings, and explain how they relate to each other.

Although all of economics is meant to be about human behavior, there is a fairly young but growing sub-field called behavioral economics whose objection is to incorporate insights from related disciplines such as sociology and psychology to increase the explanatory power of economic analysis by providing it with a more realistic foundation of human decision making. Usually, studies in behavioral economics relax one or more of the simplifying assumptions of the neoclassical model describing

[1] Chapter 1 has been developed in collaboration with Dirk Sliwka and Nannan Zhou and is based upon Kölle et al. (2011). An earlier version of Chapter 2 can be found in Kölle (2012). Chapter 3 is joint work with Björn Hartig and Bernd Irlenbusch.

mankind as a fully rational and completely self-interested utility maximizer. Especially over the last three decades, research in this area has spawned a substantial literature covering a variety of topics such as intertemporal choice (cf. Frederick et al., 2002), decisions under risk (cf. Kahneman and Tversky, 1979; Köszegi and Rabin, 2007), reference-dependence and loss aversion (cf. Kahneman et al., 1990; Köszegi and Rabin, 2006), and behavioral game theory (cf. Camerer, 2011). A topic that is most relevant for this thesis addresses the nature of social preferences such as altruism (Andreoni and Miller, 2002), inequity aversion (Fehr and Schmidt, 1999; Bolton and Ockenfels, 2000), and reciprocity (Rabin, 1993; Dufwenberg and Kirchsteiger, 2004; Falk and Fischbacher, 2006) which all have been found to be important drivers of economic behavior. Insights from this research have been applied to many different domains such as finance (cf. Barberis and Thaler, 2003), macroeconomics (cf. Shefrin and Thaler, 1992; Shafir et al., 1997), labor and personnel economics (cf. Akerlof and Yellen, 1990; Fehr and Gächter, 2000), and law (cf. Jolls et al., 1998).

One widely applied methodology within behavioral economics are laboratory experiments which allow for a tight control of the decision environment, a fact that is hard to obtain in natural occurring settings. This is important because together with the exogenous assignment to treatment and control conditions, it allows for a precise testing of theoretical predictions and for a clean method to draw inference about the causal relationship of interest. Because of that, experiments can be regarded as a major source of knowledge in the social sciences that complements other methods such as theory or field data (Falk and Heckman, 2009). With regard to the research question of this thesis, laboratory experiments constitute a well suited workhorse as they circumvent the problem that in everyday life, heterogeneity usually emerges endogenously and is often hard to measure. In three out of four chapters we therefore use laboratory experiments as a common element which allows us to induce heterogeneity exogenously and in a controlled way.

In Chapter 1, within a theoretical model we analyze the effects of wealth inequality on the incentives to contribute to a public good when agents are inequity averse and may differ with respect to their abilities. Because an individual's ability determines the marginal effect of her contributions, heterogeneous abilities typically lead to different individual contributions. When all agents benefit to the same extent from the public good, equality in initial wealth may then lead to inequality ex-post as more able agents provide higher inputs and, in turn, incur higher costs. In a first step, we compare optimal contribution behavior of purely selfish agents with those who do not only care about absolute but also about relative payoffs as modeled by Fehr and Schmidt (1999). In a second step, we analyze the welfare consequences arising from the redistribution of a fixed amount of initial wealth among both agents.

Situations like this are highly relevant as, undoubtedly, wealth is often distributed unequally among members of a society and many people care about that distribution (cf. Sobel, 2005; Cooper and Kagel, 2009). Furthermore, while benefits from a common good are typically the same for everyone, people often differ in their ability to contribute to a common good. For example, members of a team working on a joint project often have different task-specific capabilities determining the productivity of their chosen effort.[2] Similarly, in the context of environmental protection countries may have different qualifications in fighting global climate change, e.g. different opportunities to preserve the rainforest or different technological competencies to avoid carbon dioxide emissions.

Our analysis shows that if agents are inequity averse, this leads to an increased incentive to adapt contributions according to the distribution of initial wealth such that potential inequalities are endogenously offset to some degree. Furthermore, we find that while treating agents of different abilities equally may have detrimental effects for the provision of the public good, allocating higher wealth to the more able agent may motivate the latter to increase her contributions which, in turn, can increase social efficiency. The reason is that if initial wealth is distributed unequally, the wealthier agent can reduce this inequality by contributing more than her counterpart. If agents are inequity averse they have an incentive to do that as this reduces their psychological costs due to inequity. If the wealthier agent is also the more able one, this may enhance overall efficiency because increasing her contributions is more valuable than a similar-sized increase in the contributions of less able agents. As a consequence, less able agents may even benefit from initial wealth inequality to their disadvantage because the increased incentive of the more able agents to contribute can outweigh their lower initial wealth. The novel results of this study are that not although but because agents care for fairness it might be optimal to introduce wealth inequality and that the stronger the agents' inequity aversion, the stronger is the incentive effect of inequality and the larger should be the optimal difference in initial wealth.

In line with equity theory (Adams, 1965) and recent empirical evidence (Abeler et al., 2010), our results suggest that (in)equality does not necessarily imply (in)equity and vice versa. Applied to a team context within a firm, this means that simple statements sometimes heard in practice claiming that inequality among the members of a group is demotivating when people care for fairness may be misleading.

[2] In the following, we use the terms of ability and capability interchangeably.

The reason is that when people differ in ability, equality in wealth may actually crowd-out the motivation to contribute, but introducing inequality in favor of the more able agent may have positive effects on people's willingness to cooperate.

Besides heterogeneity in capabilities, another reason for why incentives to contribute to a collective good may differ between individuals is that they have different valuations or preferences for the common good. For example, parks, swimming pools, dams, or other public facilities provide very different benefits to individuals, depending on how far away they live from the site or how often they enjoy the consumption of the public good. In Chapter 2, we experimentally investigate both types of heterogeneity, capabilities and preferences, and compare their effects on contribution behavior in a repeated linear public goods game when the possibility to punish other group members is possible or not. Importantly, in some treatments group members differ with regard to the benefit they receive from their own and their group members' contributions, either because of having different valuations for the public good, or because of having different capabilities determining the marginal effect of contributions. While both types of heterogeneity are closely related and often referred to as changes in the *marginal per capita rate of return* (MPCR), they differ with respect to the externality contributions have on the other group members' payoffs. When individuals have asymmetric preferences, benefits from the public good differ between group members, but are independent of who makes a contribution. In contrast, if individuals have asymmetric capabilities, benefits are the same for everyone but depend on which group member contributes. While in the first case group members always benefit asymmetrically causing inequalities in payoffs, in the case of heterogeneous capabilities, equal contributions also lead to equal payoffs. Because this difference influences the distribution of wealth, given that people are not purely selfish this creates different incentives to contribute.

In contrast to previous studies, this feature allows us to disentangle the effects of heterogeneous characteristics and an asymmetric payoff structure. In general, we find that the nature of group heterogeneity crucially affects cooperation and coordination within groups. Compared to a control group of homogeneous agents, asymmetric preferences for the public good have detrimental effects on voluntary contributions, and different capabilities in providing the public good have a positive and stabilizing effect on contribution behavior. As such, we provide evidence that abstracting from heterogeneity in social dilemma situations can be a serious shortcoming as inequality among group members can have opposing effects on cooperation. Furthermore, our results imply that it is not the asymmetric nature of groups per se that facilitates or impedes collective action, but that it is the specific type of heterogeneity that determines people's willingness to cooperate within groups.

Insights from this research can have important policy implications, for instance by assisting organizations and policy-makers in developing institutions that effectively alleviate cooperation and coordination failure in social dilemma situations. For example, in a firm context our results suggest that the formation of teams in which members have different interests in the success of a joint project, or paying different team-performance related bonuses to otherwise identical agents may have detrimental effects on the group output. In contrast, forming groups of heterogeneous abilities may have positive effects on cooperation.

In Chapter 3, we shift our focus from differences in people's characteristics, to the effects of observing unequal contribution behavior of otherwise identical agents. As has been shown in the first two chapters, heterogeneous characteristics often induce contributions to differ among group members. Yet, the reasons for such diverse behavior may sometimes remain sealed to individuals, for instance when people's characteristics are not common knowledge but private information. Alternatively, differences in individuals' contribution behavior may result from differences in their preferences for cooperation. The question we address in this chapter is how individuals decide about their own contributions when being confronted with cooperative and uncooperative agents at the same time.

Many previous studies have shown that a considerable fraction of people condition their contributions on the behavior of others, i.e., they tend to cooperate if others do so as well, and curtail their contributions if others are not pulling their weight (cf. Chaudhuri, 2011). While evidence for this behavioral regularity called conditional cooperation is extensive, almost all studies have analyzed how conditional contributions depend on the *average* contributions of others. Yet, relatively little is known about how people react when having information about the *exact* composition of others' individual contributions. In many real-life situations observing individual rather than aggregate behavior is the more realistic case, for instance when working in a team within a company or when being member of a football team. In such a situation, however, it is not clear which, if any, contribution is most influential in determining behavior. Are people more inclined to follow the bad example of an uncooperative group member or do they tend to match the good example of a high contributor?

In our experiment, by varying the information subjects receive about others' contributions to a public good, we find that observing uniform individual behavior of others elicits higher contribution levels than receiving only the corresponding aggregate information. Furthermore, when providing full information about others' individual contributions, we find that the higher the variation in others' contributions, the lower, on average, subjects' willingness to contribute. This is in line with the presence of a *bad apple effect* implying that people are more likely to follow the bad example of an uncooperative group member rather than the good example of a high contributor. This may explain why people usually fall short of matching others' contributions perfectly when only aggregate information is provided. The reason is that in this case, people face uncertainty about others' individual behavior. Believing that a "rotten apple" in the group contributes little may then be a sufficient reason to justify low own contributions (i.e., less than the average). In fact, the lack of information about individual behavior may additionally provide individuals with moral "wiggle room" to self-servingly "form" pessimistic beliefs about others' contributions, i.e., as an excuse for contributing little.

Our results may have several interesting implications. For example, our results provide hints on what kind of feedback mechanism is best suited to increase cooperation in the case of fund-raising or sequential public good provision when the organization has some discretion about which information to make public. In particular, policy makers striving to facilitate voluntary public goods provision should reveal previous individual behavior only if it is relatively uniform and instead give information about aggregate behavior if it varies a lot. In a team context within a firm, our results suggest that forming groups of equal performers is generally preferable because in diverse teams, it is more likely that the negative effect of low performers outweighs any positive effects of the high performers. This, for example, highlights why firing shirking workers can have additional positive effects on the productivity of others.

In the last chapter, we experimentally investigate to what degree people's willingness to cooperate is affected by the way how a social dilemma situation is represented.[3] This might be relevant because very often seemingly different decision situations inhere similar strategic circumstances or, likewise, similar decision problems are represented in more than one way. While according to rational choice theory, different formulations of a logically equivalent problem should not affect behavior, evidence from experiments in psychology and economics suggest that many people are prone to *framing effects*. Such framing effect is said to be present when different representations of the same decision situation lead individuals to change behavior, even though the underlying information and decision options remain essentially the same (Cookson, 2000).

[3] In a sense, one could think of this as the effects of heterogeneity in terms of representation.

In this study, we use framing to investigate the interplay of (frame-induced) loss aversion and cooperation, i.e., we want to examine whether people are more or less likely to cooperate when this leads to the achievement of something good compared to when it leads to the prevention of something bad. For instance, while cooperation within a team that is striving for the completion of a project can be seen as an example for achieving something good, the original description of the prisoner's dilemma in which two prisoners who have to remain silent to avoid being imprisoned for long can be seen as an example for preventing something bad. Using a one-shot prisoner's dilemma game, by gradually shifting subjects' payoffs from a positive into a negative domain, we either induce a gain- or a loss-framing (or a combination of both), and subsequently study whether behavior is sensitive to such frame manipulation.

In line with evidence from related studies, we find framing to significantly affect the frequency of cooperation across treatments. Yet, because subjects in our experiment had to choose actions simultaneously, we are not able to disentangle the effects of beliefs and actions. As a consequence, we cannot conclusively answer the question of how loss aversion and the willingness to cooperate interact with each other. To test this more precisely, it is planned to conduct a follow-up experiment in which subjects have to choose actions sequentially. For the second mover, this would rule out the effects of beliefs on behavior by design and thus provide a clean test of the effects of losses on cooperation. Nevertheless, if anything, the results of our experiment indicate that the involvement of losses tends to make people less cooperative.

In general, we think that the question of how the concepts of loss aversion and social preferences interrelate with each other might be an interesting topic that could complement the findings of studies investigating the connection between social preferences and risk taking (cf. Bohnet et al., 2008; Bolton and Ockenfels, 2010). Evidence from this research may have interesting fields of application such as in financial services where advisors sell products to advisees that often not only include high risks but also may entail the danger of incurring losses.

Chapter 1

Inequality, Inequity Aversion, and the Provision of Public Goods

> *The doctrine of equality! There is no more poisonous poison anywhere: for it seems to be preached by justice itself, whereas it really is the termination of justice. "Equal to the equal, unequal to the unequal" - that would be the true slogan of justice; and also its corollary: "Never make equal what is unequal."*
>
> *(Friedrich Nietzsche)*

1.1 Introduction

While most studies on collective action so far have focussed on situations in which agents with identical characteristics interact with each other, in social and economic life homogeneous-group environments are the exception rather than the rule. People often differ with respect to important attributes such as preferences, resources, wealth, ability or motivation. In this study we therefore investigate the effects of the interplay between two sources of heterogeneity: wealth and ability. Undoubtedly, wealth is often distributed unequally among members of a society or an organization. Likewise, people often differ in their skills affecting their ability to contribute to a common good. For example, members of a team that work on a joint project might have different task-specific abilities determining the productivity of their chosen effort. In the context of environmental protection, countries have different qualifications in fighting climate change, for instance different capabilities to resist deforesting the rainforest or different technological competencies to avoid carbon dioxide emissions. Similarly, in the case of charitable donations and volunteer work, ability heterogeneity arises when contributors have heterogeneous capabilities to provide these public services.

The heterogeneity in abilities typically should lead to a heterogeneity in optimal contributions. And this, in turn, naturally leads to inequality when the involved actors benefit to the same extent from the quality of the public good but have different costs. However, there is now a broad number of studies indicating that many people tend to dislike inequity. Formal models of inequity aversion such as those by Fehr and Schmidt (1999) or Bolton and Ockenfels (2000) have been quite successful in explaining several patterns of behavior observed in laboratory experiments and in the field.[1] Inequity aversion should thus affect the willingness to accept heterogeneity in payoffs from public good provision, and, in turn, be an important factor affecting the incentives to contribute.

In this paper we therefore analyze the effect of ex-ante inequality in wealth and ability on the motivation of inequity averse agents to contribute to a public good or a team outcome. While a straightforward conjecture would be that inequity aversion should lead to the optimality of a more egalitarian wealth distribution, we show that the optimal degree of wealth inequality may actually increase with the importance of inequity aversion in the agents' preferences.

In order to address the interaction of wealth and ability heterogeneity, we consider a simple setting in which two agents who are inequity averse simultaneously decide on their contributions to a public good or a team outcome. The joined output is increasing in each agent's contribution but both agents may have different abilities which determine the marginal effect of their contributions. When both agents benefit to the same extent from the public good, equality in initial wealth may then lead to inequity as the more able agent provides higher inputs and, in turn, has higher costs.[2] We show that this inequity is endogenously offset to some degree as the agents adapt their contributions. Treating agents of different abilities equally may then have detrimental effects for the provision of the public good. But allocating a higher wealth to the more able agent may motivate the latter to increase her contribution. When the distribution of initial wealth is aligned to the difference in the agents' abilities, there will be multiple equilibria in which the agents attain the same utility even though their initial wealth differs. In these equilibria, both

[1] For experimental evidence see for example Roth and Kagel (1995), Camerer (2003) and Engelmann and Strobel (2004). Using a more general notion of fairness, field evidence is given by e.g. Blinder and Choi (1990), Agell and Lundborg (1995), Campbell and Kamlani (1997), Bewley (1999) and Carpenter and Seki (2006). For a summary of the empirical evidence on social preferences see for instance Fehr and Schmidt (2002) and Sobel (2005).

[2] In the following we use the term inequality describing inequality in initial wealth, and the term inequity describing inequality in wealth after agents have contributed and received their benefits from the public good.

agents have an incentive to match their group members' contribution and, in turn, the free-rider problem can be substantially reduced when the agents coordinate on the Pareto-dominant equilibrium. In particular, for intermediate levels of wealth inequality both agents exert higher efforts relative to the efforts maximizing their material payoffs.

We further analyze the optimal degree of initial inequality for two simple settings. In the first setting, we analyze the agents' individual preferences for redistribution of a given amount of total initial wealth. Here, we show that the less able agent may even benefit from initial wealth inequality to her *disadvantage*. The reason is that the increased incentives of the more able agent to contribute to the public good can outweigh the loss in initial wealth. In the second setting, we show that not only a utilitarian but also an egalitarian social planner will choose an unequal wealth distribution favoring the more productive agent. Most strikingly, the stronger the agents' inequity aversion, the *larger* should be the difference in initial wealth. Moreover, we show that an egalitarian wealth distribution can only be optimal when all agents have the same ability. On the contrary, in the case of heterogeneous agents such a policy always leads to a stronger underprovision of the public good causing welfare losses. Finally, we demonstrate that under the optimal distribution of wealth, total contributions are independent of the group composition, i.e. homogeneous and heterogeneous groups provide the same amount of the public good and identical levels of social welfare are attained.

In the existing public good literature, a well established result is that the private provision of a public good is unaffected by any reallocation of income amongst contributing agents. This result has first been shown by Warr (1983) and later been extended by Bergstrom et al. (1986). However, the latter also shows that an income redistribution which increases inequality by transferring wealth from non-contributing individuals to contributing individuals can have positive welfare effects (see also Itaya et al. (1997)). In a similar vein, Andreoni (1990) argues that public good provision can be enhanced by redistributing wealth from less altruistic to more altruistic people. We add to this literature by showing that redistribution can be beneficial even for the case of symmetric preferences and even if the set of contributors is left unchanged. While the reason for inequality in our model stems from the heterogeneity in the agents' characteristics, the agents' fairness concerns appear to be an important factor influencing the optimal degree of inequality.

In recent years, there also has been a couple of (predominantly experimental) studies investigating the effects of wealth heterogeneity on public good provision. However, empirical results from these studies are not clear-cut. While some papers find that inequality leads to lower contributions (e.g. Ostrom et al. (1994), Van Dijk et al. (2002), Cherry et al. (2005) and Anderson et al. (2008)), other studies report a neutral or even positive effect of wealth inequality (e.g. Chan et al. (1999), Buckley and Croson (2006)).[3] One reason for the non-conclusive evidence might be that these studies investigated inequality only in the income dimension. Yet, the claim of our study is that there is an interplay of inequality in wealth and heterogeneity in the agents' characteristics that affect "psychological" inequity costs which might hamper the cooperation in social dilemmas.[4]

In this regard, our paper also contributes to the literature on the interplay of equity and equality in social exchanges (e.g. Homans (1958), Adams (1965), Konow (2000), Cappelen et al. (2007) or Konow et al. (2009)). Psychological equity theory (Adams (1965)) for instance argues that individuals do not strive to receive equal benefits or make equal contributions as long as the ratio between benefits and contributions is similar. Analogously, we show that if agents are sufficiently heterogeneous, i.e., if the difference in abilities (and hence their inputs) is large, equity between agents is only feasible when initial wealth levels are unequal suggesting that (in)equality does not necessarily imply (in)equity and vice versa.

Applied to a team context within firms, our study provides insights on the question whether equal wages are always the best wage policy. While it has often been argued that unequal reward schemes provoke morale problems among co-workers leading to lower performances (e.g. Akerlof and Yellen (1990), Bewley (1999)), some other studies questioned whether equal payment, realized by wage compression, does eliminate all these problems.[5] Winter (2004), for instance, shows that it might be even optimal to reward identical agents differently as coordination can be improved which has recently be confirmed in an experiment by Goerg et al. (2010). In another experiment, Abeler et al. (2010) find that paying equal wages after an unequal performance may lead to inequity and, in turn, to substantially lower efforts and a decline in efficiency over time. But while these papers argue for inequality in ex-post performance rewards, our paper shows that it may even be optimal to introduce ex-ante inequality in the non-performance contingent wage components. Furthermore, our paper also adds to the literature on behavioral contract theory

[3]Chan et al. (1996) find evidence which is in line with the model of Bergstrom et al. (1986) on an aggregate level but not an individual level. Studies from sociology and development economics that focus on different types of group heterogeneity also report mixed results (see e.g. Heckathorn (1993), Vedeld (2000), Poteete and Ostrom (2004), Margreiter et al. (2005)).

[4]For recent experimental evidence of ability heterogeneity on public good provision see Noussair and Tan (2011) and Fellner et al. (2011).

[5]See e.g. Lazear (1989) who argues that "... it is far from obvious that pay equality has these effects".

studying the effects of inequity aversion on incentives.[6] However, while in most of the studies inequity aversion leads to more equal payment structures, our model shows that inequity aversion may be a reason to introduce ex-ante inequality.

The remainder of this paper is structured as follows. The model is described in Section 2. Section 3 presents the equilibrium analysis. In Section 4, we compare the effort levels chosen by inequity averse and purely selfish agents. Section 5 analyzes preferences for redistribution and examines the effects of distribution policies and group composition on the public good provision and social welfare. Section 6 concludes.

1.2 The Model

Two agents i and j can both contribute to a public good or a team outcome. An agent's contribution depends on her effort e_i and her ability a_i. Individual effort costs are linear in the exerted effort and equal to $c \cdot e_i$, $c \in \mathbb{R}^+$. The group output is determined by the sum of both agents' contribution:[7]

$$a_i\sqrt{e_i} + a_j\sqrt{e_j}.$$

The agents directly benefit from a higher group output. Each agent receives a share η of the group output indicating her individual valuation of the public good (marginal per capital return). Furthermore, each agent i is provided with an initial endowment w_i.[8] Let $\Delta w_i = w_i - w_j$ be the difference in initial endowments. Both agents are inequity averse with a Fehr and Schmidt (1999) type utility function. An agent's utility is[9]

$$U_i = w_i - c \cdot e_i + \eta \cdot \left(a_i\sqrt{e_i} + a_j\sqrt{e_j}\right) - v\left(w_i - c \cdot e_i - w_j + c \cdot e_j\right)$$

with

$$v(\Delta) = \begin{cases} -\alpha \cdot \Delta & if \quad \Delta < 0 \\ \beta \cdot \Delta & if \quad \Delta > 0 \end{cases}$$

[6] For a theoretical investigation of this topic see for instance Fershtman et al. (2003), Itoh (2004), Grund and Sliwka (2005), Huck and Rey-Biel (2006), Demougin et al. (2006), Fehr et al. (2007), Rey-Biel (2008), Dur and Glazer (2008), Mohnen et al. (2008), Kragl and Schmid (2009), Neilson and Stowe (2010), Bartling and von Siemens (2010) and Englmaier and Wambach (2010).

[7] The concavity of the production functions guarantees internal solutions. Note that this framework can be equivalently transformed to a setting with linear production functions and quadratic costs. The chosen transformation just simplifies the exposition.

[8] In a team context, η represents e.g. the degree of team identification or the intrinsic benefit of the work output and w_i represents the wage.

[9] Hence, we allow that the disutility from inequity $v(\Delta)$ depends on the difference of the agents' net-wealth (rewards minus costs of effort).

where α measures the "psychological costs" of disadvantageous inequity and β that of advantageous inequity. Following Fehr and Schmidt (1999) we assume that $\alpha \geq \beta \geq 0$. Additionally, we assume that $\beta \leq \frac{1}{2}$.[10]

1.3 Equilibrium Analysis

Each agent i maximizes

$$\max_{e_i} w_i + \eta \cdot \left(a_i\sqrt{e_i} + a_j\sqrt{e_j}\right) - c \cdot e_i - v\left(w_i - c \cdot e_i - w_j + c \cdot e_j\right).$$

The function is continuous but not continuously differentiable as it has a kink at $e_i = \frac{\Delta w_i}{c} + e_j$ where i attains the same utility as j. Off the kink, the second derivative with respect to e_i is $-\frac{\eta a_i \sqrt{e_i}}{4e_i^2} < 0$. As the right-sided derivative at the kink is strictly smaller than the left-sided derivative, the function is strictly concave.

We have to consider two possible equilibrium types depending on whether there is inequity in equilibrium or whether both agents are equally well off. In an *inequitable equilibrium* one agent i is better off given the chosen effort levels, i.e. $w_i - ce_i > w_j - ce_j$. Suppose that such an equilibrium exists. When agent i is better off, the following two conditions must hold in equilibrium

$$\begin{aligned} \frac{\partial U_i}{\partial e_i} &= -c + \frac{\eta a_i}{2\sqrt{e_i}} + \beta c = 0, \\ \frac{\partial U_j}{\partial e_j} &= -c + \frac{\eta a_j}{2\sqrt{e_j}} - \alpha c = 0. \end{aligned}$$

The respective equilibrium efforts are therefore

$$e_i^* = \frac{\eta^2 a_i^2}{4\left(1-\beta\right)^2 c^2} \text{ and } e_j^* = \frac{\eta^2 a_j^2}{4\left(1+\alpha\right)^2 c^2}. \tag{1.1}$$

Such an equilibrium exists if at these effort levels we indeed have that $w_i - ce_i > w_j - ce_j$ or

$$w_i - c \cdot \left(\frac{\eta^2 a_i^2}{4\left(1-\beta\right)^2 c^2}\right) > w_j - c \cdot \left(\frac{\eta^2 a_j^2}{4\left(1+\alpha\right)^2 c^2}\right).$$

Substituting $\Delta w_i \equiv w_i - w_j$, this directly leads to the following result:

[10] Note that $\beta > \frac{1}{2}$ connotes a very strong form of inequity aversion implying that ex-post, agents would be willing to donate parts of their wealth to less wealthy group members up to the point where wealth levels are completely equalized (compare Rey-Biel (2008)). We discuss implications of this assumption at the end of Section 3.

Proposition 1 *If the difference in initial wealth* $\Delta w_i > \frac{\eta^2}{4c}\left(\frac{a_i^2}{(1-\beta)^2} - \frac{a_j^2}{(1+\alpha)^2}\right)$, *there exists a unique inequitable equilibrium. In this equilibrium, agent i is strictly better off than agent j; the equilibrium effort levels satisfy:*

$$e_i^* = \frac{\eta^2 a_i^2}{4(1-\beta)^2 c^2} \text{ and } e_j^* = \frac{\eta^2 a_j^2}{4(1+\alpha)^2 c^2}.$$

Note that both agents adapt their efforts as the contribution of the favored agent i increases in the degree of "compassion" β and that of her disadvantaged counterpart j decreases in the degree of "envy" α. Still, they here end up in a situation which is inequitable ex-post. But as the result shows this is only the case when the initial inequality in wealth is sufficiently large.

We now have to check whether there are also *equitable equilibria* in which both agents attain the same payoff. In that case $w_i - ce_i = w_j - ce_j$ and both agents choose their effort levels at the kink of the respective utility function. An effort tuple $\left(\overline{e}_i^*, \overline{e}_j^*\right)$ can be sustained in such an equitable Nash equilibrium if no agent has an incentive to deviate. As the function is strictly concave, necessary and sufficient conditions for the existence of the equilibrium are that for both agents the left hand side derivative of the utility function must be positive at $\left(\overline{e}_i^*, \overline{e}_j^*\right)$, the right hand side derivative negative and $w_i - c\overline{e}_i^* = w_j - c\overline{e}_j^*$. Hence, in an *equitable equilibrium*, the following five conditions must be met:

$$\left.\frac{\partial_- U_i}{\partial e_i}\right|_{e_i=\overline{e}_i^*} = -c + \frac{\eta a_i}{2\sqrt{\overline{e}_i^*}} + \beta c \geq 0 \Leftrightarrow \overline{e}_i^* \leq \frac{\eta^2 a_i^2}{4(1-\beta)^2 c^2} \tag{1.2}$$

$$\left.\frac{\partial_+ U_i}{\partial e_i}\right|_{e_i=\overline{e}_i^*} = -c + \frac{\eta a_i}{2\sqrt{\overline{e}_i^*}} - \alpha c \leq 0 \Leftrightarrow \overline{e}_i^* \geq \frac{\eta^2 a_i^2}{4(1+\alpha)^2 c^2} \tag{1.3}$$

$$\left.\frac{\partial_- U_j}{\partial e_j}\right|_{e_j=\overline{e}_j^*} = -c + \frac{\eta a_j}{2\sqrt{\overline{e}_j^*}} + \beta c \geq 0 \Leftrightarrow \overline{e}_j^* \leq \frac{\eta^2 a_j^2}{4(1-\beta)^2 c^2} \tag{1.4}$$

$$\left.\frac{\partial_+ U_j}{\partial e_j}\right|_{e_j=\overline{e}_j^*} = -c + \frac{\eta a_j}{2\sqrt{\overline{e}_j^*}} - \alpha c \leq 0 \Leftrightarrow \overline{e}_j^* \geq \frac{\eta^2 a_j^2}{4(1+\alpha)^2 c^2} \tag{1.5}$$

$$\overline{e}_j^* = \overline{e}_i^* - \frac{\Delta w_i}{c} \tag{1.6}$$

From these conditions the following result can be derived:

Proposition 2 *If* $\frac{\eta^2}{4c}\left(\frac{a_i^2}{(1+\alpha)^2} - \frac{a_j^2}{(1-\beta)^2}\right) \leq \Delta w_i \leq \frac{\eta^2}{4c}\left(\frac{a_i^2}{(1-\beta)^2} - \frac{a_j^2}{(1+\alpha)^2}\right)$, *there exists a continuum of equitable equilibria. Specifically, any pair* $\left(\overline{e}_i^*, \overline{e}_j^*\right)$ *of effort levels such* *that*

$$\max\left\{\tfrac{\eta^2 a_i^2}{4(1+\alpha)^2c^2};\tfrac{\eta^2 a_j^2}{4(1+\alpha)^2c^2}+\tfrac{\Delta w_i}{c}\right\}\leq \overline{e}_i^*\leq \min\left\{\tfrac{\eta^2 a_i^2}{4(1-\beta)^2c^2};\tfrac{\eta^2 a_j^2}{4(1-\beta)^2c^2}+\tfrac{\Delta w_i}{c}\right\} \quad (1.7)$$

and $\overline{e}_j^*=\overline{e}_i^*-\frac{\Delta w_i}{c}$ *is an equitable equilibrium.*

Proof: Inserting the equity condition (1.6) in conditions (1.4) and (1.5), we can conclude that an effort level $\overline{e}_i^*$ can be sustained if and only if

$$\max\left\{\tfrac{\eta^2 a_i^2}{4(1+\alpha)^2c^2};\tfrac{\eta^2 a_j^2}{4(1+\alpha)^2c^2}+\tfrac{\Delta w_i}{c}\right\}\leq \overline{e}_i^*\leq \min\left\{\tfrac{\eta^2 a_i^2}{4(1-\beta)^2c^2};\tfrac{\eta^2 a_j^2}{4(1-\beta)^2c^2}+\tfrac{\Delta w_i}{c}\right\}.$$

Note that $\frac{\eta^2 a_i^2}{4(1+\alpha)^2c^2}<\frac{\eta^2 a_i^2}{4(1-\beta)^2c^2}$ and $\frac{\eta^2 a_j^2}{4(1+\alpha)^2c^2}+\frac{\Delta w_i}{c}<\frac{\eta^2 a_j^2}{4(1-\beta)^2c^2}+\frac{\Delta w_i}{c}$. Hence, the set is non-empty for certain values of Δw_i if

$$\frac{\eta^2 a_i^2}{4(1-\beta)^2c^2}\geq\frac{\eta^2 a_j^2}{4(1+\alpha)^2c^2}+\frac{\Delta w_i}{c}$$

and

$$\frac{\eta^2 a_j^2}{4(1-\beta)^2c^2}+\frac{\Delta w_i}{c}\geq\frac{\eta^2 a_i^2}{4(1+\alpha)^2c^2}$$

which is the case when

$$\frac{\eta^2 a_i^2}{4(1+\alpha)^2c}-\frac{\eta^2 a_j^2}{4(1-\beta)^2c}\leq\Delta w_i\leq\frac{\eta^2 a_i^2}{4(1-\beta)^2c}-\frac{\eta^2 a_j^2}{4(1+\alpha)^2c}. \quad (1.8)$$

■

This result has several interesting implications. First, note that there are always multiple equitable equilibria. The reason is that inequity averse agents have some interest to adapt their own effort according to the group member's effort in order to avoid the disutility from inequity. This leads to a coordination problem as the reaction functions are upward sloping.

Second, the set of equitable equilibria defined by (1.7) is the larger, the higher the agents' degree of inequity aversion: The more the agents care for equity, the larger is their willingness to adapt their efforts to reduce inequity which may either be triggered by inequality in initial wealth or the group member's effort level. The lower boundary of the equilibrium set is decreasing in α as more "envious" agents are willing to reduce their efforts to avoid being worse off than their group member. Analogously, the upper boundary is increasing in β as more "compassionate" agents are more willing to raise their efforts to reduce a group member's disadvantage. Likewise, the set defined by (1.8) is also increasing in the agents' inequity aversion implying that the stronger the agents' aversion against inequity, the larger may be the maximal initial wealth inequality the agents are willing to offset by adapting their contributions ending up in an equitable equilibrium.

Finally, note that the lower boundary for Δw_i as defined by condition (1.8) exceeds zero (or the upper boundary is smaller than zero) when the abilities differ strongly and inequity aversion is not too strong. In these cases, equitable equilibria never exist when $\Delta w_i = 0$ and, hence, equity cannot be attained when wealth is distributed equally. The reason is that due to the higher marginal productivity of effort, the more productive agent will have a higher incentive to exert more effort than her less productive fellow agent and, in turn, bears higher costs. But as both agents benefit equally from the public good the more able agent is worse off when both have the same initial wealth.[11]

Figure 1 shows the sustainable equilibrium effort levels of both agents i and j as a correspondence of Δw_i.[12] There are two cut-off values for Δw_i. For small values of Δw_i $(= -\Delta w_j)$ below $\frac{\eta^2}{4c}\left(\frac{a_i^2}{(1+\alpha)^2} - \frac{a_j^2}{(1-\beta)^2}\right)$ there is a unique inequitable equilibrium with $e_i^* = \frac{\eta^2 a_i^2}{4(1+\alpha)^2 c^2}$ and $e_j^* = \frac{\eta^2 a_j^2}{4(1-\beta)^2 c^2}$. For large values of Δw_i above $\frac{\eta^2}{4c}\left(\frac{a_i^2}{(1-\beta)^2} - \frac{a_j^2}{(1+\alpha)^2}\right)$ there is a unique inequitable equilibrium with $e_i^* = \frac{\eta^2 a_i^2}{4(1-\beta)^2 c^2}$ and $e_j^* = \frac{\eta^2 a_j^2}{4(1+\alpha)^2 c^2}$. For intermediate values of Δw_i equitable equilibria exist.

Note that as both agents attain identical payoffs in an equitable equilibrium, they prefer the same one. Consequently, it is important to compare the different feasible equitable equilibria with respect to the agents' utility which leads to the following result:

Corollary 1 *As long as $\beta \leq \frac{1}{2}$ the equitable equilibrium in which the agents' utility is highest is always Pareto optimal within the set of Nash equilibria.*

Proof: See the appendix.

To understand this result note that there is a free-rider problem which is particularly strong when agents are selfish. Inequity aversion helps to overcome this free-rider problem as it allows agents to coordinate on higher effort levels which come closer to the first best. As long as β does not exceed $\frac{1}{2}$ the highest feasible equilibrium is still lower than the first-best and therefore is preferred by the agents.[13] With a β larger than $\frac{1}{2}$, however, inequity aversion becomes so strong that an agent

[11] Note that this is always the case when the agents are purely selfish (i.e. $\alpha = \beta = 0$).

[12] The figure shows a setting in which $a_i = 12$, $a_j = 10$, $\alpha = 0.4$, $\beta = 0.2$, $\eta = 0.2$, and $c = 1$.

[13] The agents' first-best efforts can be derived by maximizing $w_i + w_j - c \cdot e_i - c \cdot e_j + 2\eta \cdot \left(a_i\sqrt{e_i} + a_j\sqrt{e_j}\right)$ and are given by $e_i^{FB} = \frac{\eta^2 a_i^2}{c^2}$ and $e_j^{FB} = \frac{\eta^2 a_j^2}{c^2}$.

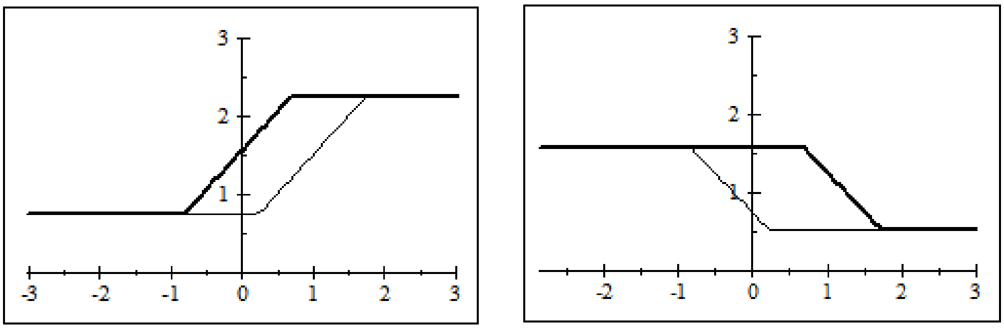


Figure 1.1: Effort choice of agent i (left) and agent j (right) depending on Δw_i.

even would have an incentive to match an inefficiently high effort level chosen by her group member even though both would be better off with a lower effort.

Hence, both agents benefit from playing the equitable equilibrium with the highest sustainable effort level when they are not extremely "compassionate". This effort level is equal to $\min\left\{\frac{\eta^2 a_i^2}{4(1-\beta)^2 c^2}; \frac{\eta^2 a_j^2}{4(1-\beta)^2 c^2} + \frac{\Delta w_i}{c}\right\}$ and, hence, strictly increasing in the degree of advantageous inequity aversion β.

1.4 Do Inequity Averse Agents Contribute More?

We now compare the attained effort levels with those chosen by purely selfish agents to study the effects of inequity aversion on the motivation to contribute to the public good. From Propositions 1 and 2 as well as Corollary 1 (assuming that the agents play the Pareto best equitable equilibrium)[14] we know that the equilibrium effort levels of inequity averse agents $\left(e_i^*, e_j^*\right)$ are given by

$$\begin{cases} \left(\frac{\eta^2 a_i^2}{4(1+\alpha)^2 c^2}, \frac{\eta^2 a_j^2}{4(1-\beta)^2 c^2}\right) & if\ \Delta w_i < \frac{\eta^2}{4c}\left(\frac{a_i^2}{(1+\alpha)^2} - \frac{a_j^2}{(1-\beta)^2}\right) \\ \left(\frac{\eta^2 a_j^2}{4(1-\beta)^2 c^2} + \frac{\Delta w_i}{c}, \frac{\eta^2 a_j^2}{4(1-\beta)^2 c^2}\right) & if\ \Delta w_i \in \left[\frac{\eta^2}{4c}\left(\frac{a_i^2}{(1+\alpha)^2} - \frac{a_j^2}{(1-\beta)^2}\right), \frac{\eta^2}{4c}\left(\frac{a_i^2 - a_j^2}{(1-\beta)^2}\right)\right] \\ \left(\frac{\eta^2 a_i^2}{4(1-\beta)^2 c^2}, \frac{\eta^2 a_i^2}{4(1-\beta)^2 c^2} - \frac{\Delta w_i}{c}\right) & if\ \Delta w_i \in \left[\frac{\eta^2}{4c}\left(\frac{a_i^2 - a_j^2}{(1-\beta)^2}\right), \frac{\eta^2}{4c}\left(\frac{a_i^2}{(1-\beta)^2} - \frac{a_j^2}{(1+\alpha)^2}\right)\right] \\ \left(\frac{\eta^2 a_i^2}{4(1-\beta)^2 c^2}, \frac{\eta^2 a_j^2}{4(1+\alpha)^2 c^2}\right) & if\ \Delta w_i > \frac{\eta^2}{4c}\left(\frac{a_i^2}{(1-\beta)^2} - \frac{a_j^2}{(1+\alpha)^2}\right) \end{cases} \tag{1.9}$$

as depicted by the solid upper boundary of the graphs in Figure 1. Note that both functions are continuous and weakly monotonic.

Suppose, w.l.o.g., that i is the more able agent, i.e., $a_i \geq a_j$. Purely selfish

[14] Cooper et al. (1992), Blume and Ortmann (2007) for instance find experimentally that simple ex-ante cheap talk communication indeed very frequently leads to the choice of the Pareto efficient Nash equilibrium in coordination games. See Demichelis and Weibull (2008) for a theoretical argument based on lexicographic preferences for honesty.

agents' effort choices are not affected by initial wealth inequality as they consider only their marginal returns when choosing their efforts. Hence, efforts are given by[15]

$$e_i^{selfish} = \frac{\eta^2 a_i^2}{4c^2} \text{ and } e_j^{selfish} = \frac{\eta^2 a_j^2}{4c^2}. \tag{1.10}$$

By comparing these effort levels of selfish agents with those of inequity averse agents as given by (1.9) we obtain the following result:

Proposition 3 *If* $\frac{\eta^2 a_i^2}{4c} - \frac{\eta^2 a_j^2}{4(1-\beta)^2 c} < \Delta w_i < \frac{\eta^2 a_i^2}{4(1-\beta)^2 c} - \frac{\eta^2 a_j^2}{4c}$*, both agents contribute more when they are inequity averse (i.e.* $e_i^* > e_i^{selfish}$ *and* $e_j^* > e_j^{selfish}$*). If* $\Delta w_i \geq \frac{\eta^2 a_i^2}{4(1-\beta)^2 c} - \frac{\eta^2 a_j^2}{4c}$*, inequity aversion motivates agent i to exert higher efforts but demotivates agent j (i.e.* $e_i^* > e_i^{selfish}$ *and* $e_j^* < e_j^{selfish}$*). The opposite holds if* $\Delta w_i \leq \frac{\eta^2 a_i^2}{4c} - \frac{\eta^2 a_j^2}{4(1-\beta)^2 c}$.

Proof: By comparing (1.9) with (1.10) it is straightforward to see that $e_i^* > e_i^{selfish}$ if $\Delta w_i \geq \frac{\eta^2}{4c}\left(\frac{a_i^2 - a_j^2}{(1-\beta)^2}\right)$ and $e_i^* < e_i^{selfish}$ if $\Delta w_i \leq \frac{\eta^2}{4c}\left(\frac{a_i^2}{(1+\alpha)^2} - \frac{a_j^2}{(1-\beta)^2}\right)$. We only have to check the case in which $\Delta w_i \in \left(\frac{\eta^2}{4c}\left(\frac{a_i^2}{(1+\alpha)^2} - \frac{a_j^2}{(1-\beta)^2}\right), \frac{\eta^2}{4c}\left(\frac{a_i^2 - a_j^2}{(1-\beta)^2}\right)\right)$. In this case $e_i^* > e_i^{selfish}$ if

$$\frac{\eta^2 a_j^2}{4(1-\beta)^2 c^2} + \frac{\Delta w_i}{c} > \frac{\eta^2 a_i^2}{4c^2} \Leftrightarrow \Delta w_i > \frac{\eta^2 a_i^2}{4c} - \frac{\eta^2 a_j^2}{4(1-\beta)^2 c}.$$

Hence, we can conclude that $e_i^* > e_i^{selfish}$ if Δw_i exceeds this cut-off.[16] Analogously, $e_j^* > e_j^{selfish}$ if $\Delta w_j = -\Delta w_i > \frac{\eta^2 a_j^2}{4c} - \frac{\eta^2 a_i^2}{4(1-\beta)^2 c}$ which gives us the upper boundary. It is straightforward to check that the interval in which both $e_i^* > e_i^{selfish}$ and $e_j^* > e_j^{selfish}$ is non-empty. ■

Hence, the initial wealth differential Δw_i is crucial to determine how inequity averse agents adapt their effort choices relative to the efforts maximizing their material payoffs. For intermediate levels of initial wealth inequality, inequity aversion indeed helps to reduce the free-rider problem as both agents contribute more when coordinating on the Pareto-superior equilibrium.

But if initial wealth inequality becomes stronger, inequity aversion leads to an asymmetric reaction as the favored agent chooses a higher effort than the level maximizing her material payoff and the disadvantaged contributes less than would be optimal from a payoff maximizing perspective.

[15] To see that, just replace $\alpha = \beta = 0$ in the equilibrium efforts given by (1.1).

[16] Note that this cut-off is indeed always in the interior of the relevant interval.

But it is important to note that the latter demotivating effect may arise for the more able agent even when she is richer than her less able colleague: The lower boundary for Δw_i in Proposition 3 is larger than zero if

$$\tfrac{\eta^2 a_i^2}{4c} - \tfrac{\eta^2 a_j^2}{4(1-\beta)^2 c} > 0 \Leftrightarrow a_i > \frac{a_j}{1-\beta}.$$

Hence, when a_i is much larger than a_j or when β is sufficiently small, the more able agent reduces her effort below $e_i^{selfish}$ unless Δw_i exceeds a *strictly positive* cut-off value. Or, in other words, she has to be paid sufficiently more than her colleague or otherwise will reduce her effort below the selfishly optimal level. To understand the reason for this effect, note again that the payoff maximizing effort is always larger for the more able agent as her marginal returns to effort are higher. As both equally benefit from the public good, she is worse off than her less able colleague when both have the same initial wealth. But when being inequity averse she suffers from this disadvantage which is the higher the larger a_i relative to a_j. If β is high, the more able agent will still choose an equilibrium effort level above $e_i^{selfish}$ as also her less able but "compassionate" counterpart puts in a sufficiently high effort and they can coordinate to a superior equilibrium. But when β is small, she can only reduce inequity by lowering her effort. Hence, not awarding the more able agent more money up front leads to an unfair distribution of payoffs and, in turn, to lower efforts.

1.5 Social Welfare, Redistribution, and Group Composition

We proceed by analyzing redistribution preferences of a) the agents and b) a social planner who can allocate a fixed budget. We further investigate the welfare consequences of a policy implementing an egalitarian wealth distribution irrespective of the distribution of the agents' abilities. Finally, we examine the effect of group composition under the optimal distribution of the initial wealth.

1.5.1 Individual Preferences for Redistribution

We first study the agents' ex-ante preferences on the initial wealth differential Δw_i when they take into account their equilibrium effort choices. These considerations will be a useful starting point for welfare analysis. To do that, it is instructive to consider a situation in which a certain budget $W = w_i + w_j$ can be distributed between the two agents. By inserting the equilibrium effort choices (1.9) into the agents' utility functions we can describe their utility as a function of the initial wealth differential Δw_i. Analyzing the shape of the indirect utility functions we obtain the following result:

Proposition 4 *The agents' utility function is continuous in Δw_i. If $\Delta w_i < \frac{\eta^2}{4c}\left(\frac{a_i^2-a_j^2}{(1-\beta)^2}\right)$ or $\Delta w_i > \frac{\eta^2}{4c}\left(\frac{a_i^2}{(1-\beta)^2}-\frac{a_j^2}{(1+\alpha)^2}\right)$ an agent i's utility is strictly increasing in Δw_i. But between these two cut-off values it is strictly decreasing. Both agents' utility functions attain a local maximum at $\Delta w_i^* = \frac{\eta^2}{4c}\left(\frac{a_i^2-a_j^2}{(1-\beta)^2}\right)$.*

Proof: See the appendix.

This result is illustrated in Figure 2. The solid line shows agent i's utility and the dashed line agent j's utility both as a function of Δw_i.[17] For extreme values of Δw_i each agent benefits from a redistribution in her favor and there is a straightforward conflict of interest between both agents. But in the interval between $\frac{\eta^2}{4c}\left(\frac{a_j^2}{(1-\beta)^2}-\frac{a_i^2}{(1+\alpha)^2}\right)$ and $\frac{\eta^2}{4c}\left(\frac{a_i^2}{(1-\beta)^2}-\frac{a_j^2}{(1+\alpha)^2}\right)$ both agents' interests are fully aligned. The reason is that within this interval only equitable equilibria exist, and hence, any ex-ante inequality in wealth will be offset by adapted effort levels. Moreover, all values of Δw_i within this interval are Pareto-dominated by a initial wealth differential of $\Delta w_i^* = \frac{\eta^2}{4c}\left(\frac{a_i^2-a_j^2}{(1-\beta)^2}\right)$ as at this point, agents can coordinate on an equilibrium leading to the highest contributions.

Proposition 4 has several interesting implications. Consider the situation of an individual agent who can (re-)distribute a given wealth allocation. Interestingly, an individual may benefit from ex-ante redistribution at her own expense as the following result shows:

Corollary 2 *If both agents receive the same initial wealth (i.e. $\Delta w_i = 0$) the less able agent j can be made better off by reducing her own initial wealth by $\frac{\eta^2}{8c}\left(\frac{a_i^2-a_j^2}{(1-\beta)^2}\right)$ and transferring this money to the more able colleague i if*

$$\alpha > \frac{1-\beta}{3-4\beta}\sqrt{\left(2\left(6\beta^2-7\beta+2\right)\right)}+\frac{2(1-\beta)^2}{(3-4\beta)}-1.$$

If α is smaller than this cut-off, such a transfer is still beneficial for agent j when her ability is not to small, i.e. if

$$\frac{a_j}{a_i} > \min\left\{\frac{1-\beta}{1+\alpha}, \sqrt{\frac{1}{(1-2\beta)}\left(\frac{4(1-\beta)^2}{(1+\alpha)}+1-4\left(1-\beta\right)-\frac{2\beta(1-\beta)^2}{(1+\alpha)^2}\right)}\right\}.$$

[17] The figure shows a setting in which $a_i = 12$, $a_j = 10$, $\alpha = 0.4$, $\beta = 0.2$, $\eta = 0.2$, and $c = 1$.

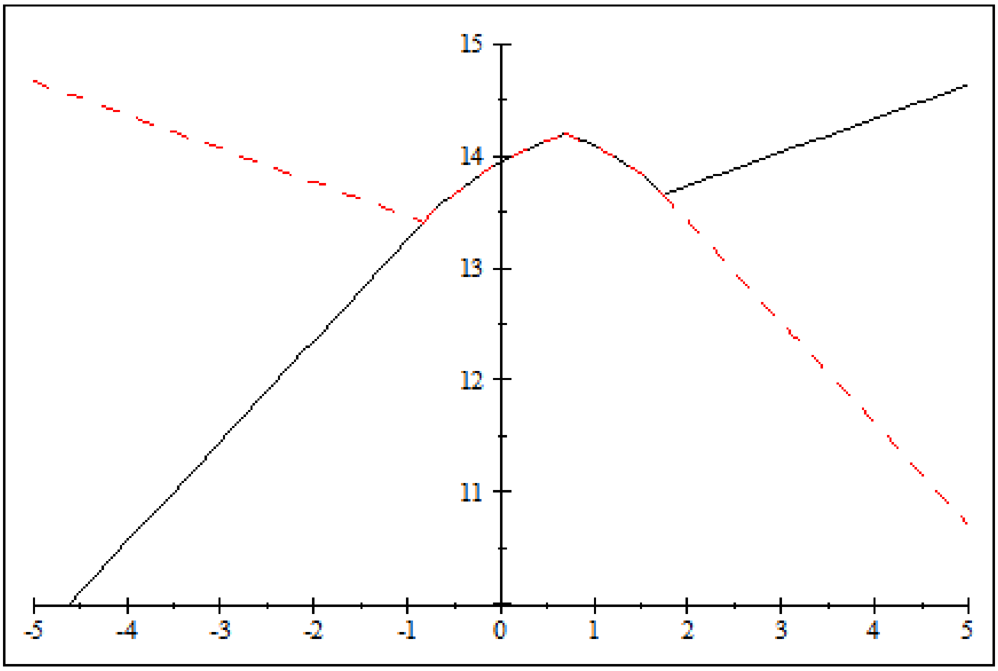


Figure 1.2: Agent i's and agent j's utilities in equilibrium depending on Δw_i.

Proof: See the appendix.

Hence, a less able agent can be better off ex-post when sacrificing parts of her initial wealth which are then transferred to a more able individual. She then benefits from this colleague's higher willingness to contribute to the public good and this helps to reduce the free-rider problem. Interestingly, this is always the case irrespective of the difference in abilities if α is sufficiently large. Moreover, note that the cut-off value for α is equal to $\frac{1}{3}$ when $\beta = 0$ and strictly decreasing in β. Hence, this condition holds for moderate values of α even when the agents only suffer from disadvantageous inequity. The reason is that a more able agent resents being worse off than her less able colleague when exerting a higher effort due to her higher productivity. But she is willing to exert higher efforts when she earns more. Therefore, a less able agent may benefit when her colleague's income is increased because, in turn, this colleague is willing to contribute more.

If α is rather small, the result still holds if the less able agent's productivity is not too small relative to her more able colleague's productivity. If, however, her ability is much smaller the transfer necessary to implement a performance maximizing equitable equilibrium is too large such that agent j prefers to stick with the case in which both receive the same initial wealth although this leads to a lower group output.

1.5.2 Social Welfare

We now study a situation in which an external authority can decide on the distribution of wealth. To do so, we consider, a social planner who has a social welfare function which is either egalitarian (i.e. who wants to maximize the utility of the least well-off) or utilitarian (i.e. wants to maximize the sum of both agents' utility). It directly follows from Proposition 4 that such a social planner always has a dominant choice:

Corollary 3 *A social planner who is either utilitarian or egalitarian will set* $\Delta w_i^* = \frac{\eta^2}{4c}\left(\frac{a_i^2 - a_j^2}{(1-\beta)^2}\right)$.

Proof: It is straightforward to see that within the set of initial wealth differentials inducing equitable equilibria both egalitarian and utilitarian planners will always choose $\Delta w_i^* = \frac{\eta^2}{4c}\left(\frac{a_i^2 - a_j^2}{(1-\beta)^2}\right)$ as at this spread, both the sum and the minimum of the agents' utilities are maximized. Moreover, for an egalitarian social planner any wealth differential which is not inducing an equitable equilibrium is always dominated by this choice as the utility of the least well off agent is always lower in an inequitable equilibrium. To see this formally note that when, w.l.o.g., j is favored $\frac{\partial u_i}{\partial \Delta w_i} = \frac{1}{2} + \alpha > 0$ for all Δw_i inducing an inequitable equilibrium (see (1.12) in the proof of Proposition 4) and as the utility function is continuous, i's utility is always larger in an equitable equilibrium.

A utilitarian social planner will neither choose a wealth distribution inducing an inequitable equilibrium, as in an inequitable equilibrium which, w.l.o.g., favors agent j, the marginal gain from transferring money to agent i $\frac{\partial u_i}{\partial \Delta w_i} = \frac{1}{2} + \alpha$ is always larger than j's marginal loss which is equal to $\frac{1}{2} - \beta$ (see again (1.12)). ■

Hence, even an egalitarian social planner who only considers the utility of the least well off individual should allow for inequality in initial wealth. The reason is that it is precisely this inequality in initial wealth that induces an equilibrium in which equity is attained ex-post and in which the more able agent is willing to contribute more. This observation bears some resemblance to the result by Andreoni (1990) who argues that redistribution of income will increase the total contribution if it benefits the more altruistic individuals.[18] It directly follows that the implementation of an egalitarian wealth distribution policy has detrimental effects if the group considered is not entirely homogeneous in terms of abilities.

[18] Similarly, with respect to social welfare, Thurow (1971) argues that some redistribution of income is necessary in order to achieve a Pareto optimum.

1.5.3 The Optimal Group Composition

So far, we only considered how wealth should be distributed treating the composition of agents within a group as exogenously given. However,it is also interesting to study the case in which the formation of groups can be determined as well. This might be the case either if a principal or social planner has the power to dictate group composition, or if agents have the opportunity to self-select into different groups or incentive systems (see e.g. Hamilton et al. (2003), Kocher et al. (2006), Dohmen and Falk (2011)). A straightforward conjecture is that group composition matters for the willingness to contribute if the agents are inequity averse towards their fellow group members. To investigate this, we consider a simple situation in which there are four agents, two of high ability and two of low ability, that can be assigned into two groups of two.[19] By comparing total contributions, we can derive the following result:

Proposition 5 *If all agents have the same initial wealth, total contributions are always higher with homogeneous than with heterogeneous groups. But when wealth can be adapted optimally, total contributions are independent of the group composition.*

Proof: Let $a_H > a_L$ be the ability of the high and low productive agent and let w_H and w_L denote the initial wealth levels of the two agents, respectively. Given the same initial wealth ($\Delta w = w_H - w_L = 0$) the total contribution with two homogeneous groups is equal to

$$\frac{2\eta^2 a_H^2}{4(1-\beta)^2 c^2} + \frac{2\eta^2 a_L^2}{4(1-\beta)^2 c^2} = \frac{\eta^2\left(a_H^2 + a_L^2\right)}{2(1-\beta)^2 c^2}. \tag{1.11}$$

With heterogeneous groups it is given by

$$\begin{array}{ll} \frac{\eta^2 a_H^2}{2(1+\alpha)^2 c^2} + \frac{\eta^2 a_L^2}{2(1-\beta)^2 c^2} \quad if & \Delta w < \frac{\eta^2}{4c}\left(\frac{a_H^2}{(1+\alpha)^2} - \frac{a_L^2}{(1-\beta)^2}\right) \\ \frac{\eta^2\left(a_L^2 + a_L^2\right)}{2(1-\beta)^2 c^2} \quad if & \Delta w \in \left[\frac{\eta^2}{4c}\left(\frac{a_H^2}{(1+\alpha)^2} - \frac{a_L^2}{(1-\beta)^2}\right), \frac{\eta^2}{4c}\left(\frac{a_H^2 - a_L^2}{(1-\beta)^2}\right)\right] \end{array}.$$

In both cases, the expression is strictly smaller than (1.11). If, however, the distribution of the initial wealth can be optimally adapted, i.e. $\Delta w^* = \frac{\eta^2}{4c}\left(\frac{a_H^2 - a_L^2}{(1-\beta)^2}\right)$, the

[19] Note that in this regard, heterogeneity refers to the difference in agents' abilities. For studies analyzing optimal team composition with heterogeneity in agents' preferences see for instance Fershtman et al. (2006) and Brunner and Sandner (2012). Bartling (2012) analyzes how agents' (social) preferences can be endogenously affected by the internal design of organizations.

total contribution of two heterogeneous groups is

$$
\begin{aligned}
2\left(\frac{\eta^2 a_H^2}{4(1-\beta)^2 c^2}+\frac{\eta^2 a_H^2}{4(1-\beta)^2 c^2}-\frac{\Delta w^*}{c}\right) &= \frac{2\eta^2 a_H^2}{4(1-\beta)^2 c^2}+\frac{2\eta^2 a_H^2}{4(1-\beta)^2 c^2}-\frac{2\eta^2}{4c^2}\left(\frac{a_H^2-a_L^2}{(1-\beta)^2}\right) \\
&= \frac{2\eta^2\left(a_H^2+a_L^2\right)}{4(1-\beta)^2 c^2}.
\end{aligned}
$$

But this is equal to the total contribution of the homogeneous groups which is again given by (1.11) as $\Delta w^* = 0$ is optimal in this case. ■

Hence, when the wealth level is fixed and equally distributed it is beneficial to have homogeneous groups. The reason is straightforward from the analysis above: Heterogeneity in abilities leads to a de-motivation of the more qualified agent when wealth is equally distributed. By matching agents into homogeneous teams, this de-motivational effect can be avoided and group homogeneity helps the agents to coordinate on more favorable equilibria.

It is, however, interesting to note that group composition is irrelevant for total contributions when the wealth level can be optimally adapted. In this case, the disadvantage of the more able agent can be entirely offset and, in turn, motivation to contribute is restored to the levels attainable in homogeneous groups. Besides of that, there might be other channels through which performance can be affected by group composition. For example, as argued by Hamilton et al. (2003), "worker heterogeneity could shape team productivity by facilitating mutual learning or by influencing the group production norm." Using a large dataset, the authors indeed find that teams with a greater spread in ability are more productive than teams of homogeneous agents.

1.6 Conclusion

This paper contributes to the literature investigating the effects of group heterogeneity on collective action. In particular, we analyzed the effects of wealth inequality on the incentives to contribute to a public good when agents are inequity averse. We have shown that it is optimal to introduce ex-ante inequality in wealth if agents differ in their abilities. The reason is that inequality in favor of a more able agent can motivate this agent to exert higher efforts. In particular, the stronger the agents' inequity aversion, the stronger is also this incentive effect of inequality and the larger should be the difference in initial wealth. Furthermore, we have shown that compared to the case when agents are purely self-interested, contributions are higher when agents are inequity averse as inequity aversion helps to reduce the free-rider problem and agents can coordinate on higher efforts.

Our results have several interesting implications. First of all, they cast doubt on simple statements sometimes heard in practice claiming that inequality among the members of a group is demotivating when people care for fairness. While this is indeed true for very large wealth differentials in our model, the opposite can also be the case, when wealth differentials are too small. Allocating agents of different abilities the same initial wealth can lead to highly inequitable situations. The reason is that in a public good setting, all agents equally benefit from the group output, but more able agents exert higher efforts as their marginal returns to effort are higher and, in turn, they incur higher costs. When agents are inequity averse this can demotivate the more able agents which is bad for the overall performance as their contributions are more valuable.

The results also may cast some light on the discussion about distributional politics (Alesina and Angeletos (2005), Durante and Putterman (2009)) and the effects on citizens' willingness to voluntary donate to a common good. Some previous studies (e.g. Warr (1983) and Bergstrom et al. (1986)) have argued that the total provision of a public good is independent of the distribution of wealth. In contrast, our results indicate that equality in wealth may crowd-out the motivation to contribute. But introducing inequality may have positive effects on the citizens' willingness to work for the common good. However, our model also shows that this is the case only if the higher wealth is in the hands of those who can provide the most valuable contributions.

1.7 Appendix to Chapter 1

Proof of Corollary 1:

The value of $e_i^{\max}$ directly follows from the upper boundary given by (1.7). Let

$$v_i^E(e_i) = w_i - ce_i + \eta\left(a_i\sqrt{e_i} + a_j\sqrt{e_i - \frac{\Delta w_i}{c}}\right)$$

be agent i's utility which is equal to agent j's utility in any equitable equilibrium. To compare the equilibria in the set defined by (1.7) we have to check which value of e_i maximizes this utility. Note that

$$\begin{aligned}\frac{\partial v_i^E(e_i)}{\partial e_i} &= -c + \eta\left(\frac{a_i}{2\sqrt{e_i}} + \frac{a_j}{2\sqrt{e_i - \frac{\Delta w_i}{c}}}\right) \quad \text{and} \\ \frac{\partial^2 v_i^E(e_i)}{\partial e_i^2} &= \eta\left(-\frac{a_i}{4}e_i^{-\frac{3}{2}} - \frac{a_j}{4}\left(e_i - \frac{\Delta w_i}{c}\right)^{-\frac{3}{2}}\right) < 0.\end{aligned}$$

As $v_i^E(e_i)$ is strictly concave, $\left.\frac{\partial v_i^E(e_i)}{\partial e_i}\right|_{e_i = e_i^{\max}} \geq 0$ is a necessary and sufficient condition for $e_i^{\max}$ to be Pareto optimal. If $\Delta w_i < \frac{\eta^2}{4c}\left(\frac{a_i^2}{(1-\beta)^2} - \frac{a_j^2}{(1-\beta)^2}\right)$, $e_i^{\max}$ is equal to $\frac{\eta^2 a_j^2}{4(1-\beta)^2c^2} + \frac{\Delta w_i}{c}$ and the condition is equivalent to

$$-c + \eta\left(a_i\frac{1}{2\sqrt{\frac{\eta^2 a_j^2}{4(1-\beta)^2c^2} + \frac{\Delta w_i}{c}}} + a_j\frac{1}{2\sqrt{\frac{\eta^2 a_j^2}{4(1-\beta)^2c^2} + \frac{\Delta w_i}{c} - \frac{\Delta w_i}{c}}}\right) \geq 0 \Leftrightarrow$$

$$\Delta w_i \leq \frac{\eta^2}{4c}\left(\frac{a_i^2}{\beta^2} - \frac{a_j^2}{(1-\beta)^2}\right).$$

But $\frac{\eta^2}{4c}\left(\frac{a_i^2}{\beta^2} - \frac{a_j^2}{(1-\beta)^2}\right) \geq \frac{\eta^2}{4c}\left(\frac{a_i^2}{(1-\beta)^2} - \frac{a_j^2}{(1-\beta)^2}\right)$ as long as $\beta \leq \frac{1}{2}$. Hence, both agent's utility is maximal at $e_i^{\max}$ in this case. If, however, $\Delta w_i \geq \frac{\eta^2}{4c}\left(\frac{a_i^2}{(1-\beta)^2} - \frac{a_j^2}{(1-\beta)^2}\right)$, $e_i^{\max}$ is equal to $\frac{\eta^2 a_i^2}{4(1-\beta)^2c^2}$ and the condition is equivalent to

$$-c + \eta\left(a_i\frac{1}{2\sqrt{\frac{\eta^2 a_i^2}{4(1-\beta)^2c^2}}} + a_j\frac{1}{2\sqrt{\frac{\eta^2 a_i^2}{4(1-\beta)^2c^2} - \frac{\Delta w_i}{c}}}\right) \geq 0 \Leftrightarrow$$

$$\Delta w_i \geq \frac{\eta^2}{4c}\left(\frac{a_i^2}{(1-\beta)^2} - \frac{a_j^2}{\beta^2}\right)$$

But $\frac{\eta^2}{4c}\left(\frac{a_i^2}{(1-\beta)^2} - \frac{a_j^2}{\beta^2}\right) \leq \frac{\eta^2}{4c}\left(\frac{a_i^2}{(1-\beta)^2} - \frac{a_j^2}{(1-\beta)^2}\right)$ is again equivalent to $\beta \leq \frac{1}{2}$. ■

Proof of Proposition 4:

By substituting the equilibrium efforts (1.9) into agent i's utility function we obtain:

$$u_i = \begin{cases} \frac{W+\Delta w_i}{2} + \eta\left(a_i\sqrt{\frac{\eta^2 a_i^2}{4(1+\alpha)^2c^2}} + a_j\sqrt{\frac{\eta^2 a_j^2}{4(1-\beta)^2c^2}}\right) - \frac{\eta^2 a_i^2}{4(1+\alpha)^2 c} + \alpha\left(\Delta w_i - \frac{\eta^2 a_i^2}{4(1+\alpha)^2 c} + \frac{\eta^2 a_j^2}{4(1-\beta)^2 c}\right) \\ if\ \Delta w_i < \frac{\eta^2}{4c}\left(\frac{a_i^2}{(1+\alpha)^2} - \frac{a_j^2}{(1-\beta)^2}\right) \\ \frac{W+\Delta w_i}{2} + \eta\left(a_i\sqrt{\frac{\eta^2 a_j^2}{4(1-\beta)^2c^2} + \frac{\Delta w_i}{c}} + a_j\sqrt{\frac{\eta^2 a_j^2}{4(1-\beta)^2c^2}}\right) - \left(\frac{\eta^2 a_j^2}{4(1-\beta)^2 c} + \Delta w_i\right) \\ if\ \Delta w_i \in \left[\frac{\eta^2}{4c}\left(\frac{a_i^2}{(1+\alpha)^2} - \frac{a_j^2}{(1-\beta)^2}\right), \frac{\eta^2}{4c}\left(\frac{a_i^2 - a_j^2}{(1-\beta)^2}\right)\right] \\ \frac{W+\Delta w_i}{2} + \eta\left(a_i\sqrt{\frac{\eta^2 a_i^2}{4(1-\beta)^2c^2}} + a_j\sqrt{\frac{\eta^2 a_i^2}{4(1-\beta)^2c^2} - \frac{\Delta w_i}{c}}\right) - \frac{\eta^2 a_i^2}{4(1-\beta)^2 c} \\ if\ \Delta w_i \in \left[\frac{\eta^2}{4c}\left(\frac{a_i^2 - a_j^2}{(1-\beta)^2}\right), \frac{\eta^2}{4c}\left(\frac{a_i^2}{(1-\beta)^2} - \frac{a_j^2}{(1+\alpha)^2}\right)\right] \\ \frac{W+\Delta w_i}{2} + \eta\left(a_i\sqrt{\frac{\eta^2 a_i^2}{4(1-\beta)^2c^2}} + a_j\sqrt{\frac{\eta^2 a_j^2}{4(1+\alpha)^2c^2}}\right) - \frac{\eta^2 a_i^2}{4(1-\beta)^2 c} - \beta\left(\Delta w_i - \frac{\eta^2 a_i^2}{4(1-\beta)^2 c} + \frac{\eta^2 a_j^2}{4(1+\alpha)^2 c}\right) \\ if\ \Delta w_i > \frac{\eta^2}{4c}\left(\frac{a_i^2}{(1-\beta)^2} - \frac{a_j^2}{(1+\alpha)^2}\right) \end{cases}$$

The first derivative of this function is

$$\frac{\partial u_i}{\partial \Delta w_i} = \begin{cases} \frac{1}{2} + \alpha & if\ \Delta w_i < \frac{\eta^2}{4c}\left(\frac{a_i^2}{(1+\alpha)^2} - \frac{a_j^2}{(1-\beta)^2}\right) \\ -\frac{1}{2} + \frac{\eta \cdot a_i}{2c\sqrt{\frac{\eta^2 a_j^2}{4(1-\beta)^2c^2} + \frac{\Delta w_i}{c}}} & if\ \Delta w_i \in \left[\frac{\eta^2}{4c}\left(\frac{a_i^2}{(1+\alpha)^2} - \frac{a_j^2}{(1-\beta)^2}\right), \frac{\eta^2}{4c}\left(\frac{a_i^2 - a_j^2}{(1-\beta)^2}\right)\right] \\ \frac{1}{2} - \frac{\eta \cdot a_j}{2c\sqrt{\frac{\eta^2 a_i^2}{4(1-\beta)^2c^2} - \frac{\Delta w_i}{c}}} & if\ \Delta w_i \in \left[\frac{\eta^2}{4c}\left(\frac{a_i^2 - a_j^2}{(1-\beta)^2}\right), \frac{\eta^2}{4c}\left(\frac{a_i^2}{(1-\beta)^2} - \frac{a_j^2}{(1+\alpha)^2}\right)\right] \\ \frac{1}{2} - \beta & if\ \Delta w_i > \frac{\eta^2}{4c}\left(\frac{a_i^2}{(1-\beta)^2} - \frac{a_j^2}{(1+\alpha)^2}\right) \end{cases} \tag{1.12}$$

Note that the slope in the second interval is *strictly* positive if

$$\begin{aligned} -\frac{1}{2} + \frac{\eta \cdot a_i}{2c\sqrt{\frac{\eta^2 a_j^2}{4(1-\beta)^2c^2} + \frac{\Delta w_i}{c}}} &> 0 \Leftrightarrow \\ \frac{\eta^2}{4c}\left(4a_i^2 - \frac{a_j^2}{(1-\beta)^2}\right) &> \Delta w_i \end{aligned}$$

which is always true for any $\Delta w_i \in \left[\frac{\eta^2}{4c}\left(\frac{a_i^2}{(1+\alpha)^2} - \frac{a_j^2}{(1-\beta)^2}\right), \frac{\eta^2}{4c}\left(\frac{a_i^2 - a_j^2}{(1-\beta)^2}\right)\right]$ and $\beta \leq \frac{1}{2}$. Furthermore, it is always positive at $\Delta w_i = \frac{\eta^2}{4c}\left(\frac{a_i^2 - a_j^2}{(1-\beta)^2}\right)$ for any $\beta \leq \frac{1}{2}$ and equal to zero if and only if $\beta = \frac{1}{2}$.

Similarly, the slope in third interval is *strictly* negative if

$$\begin{aligned}\frac{1}{2}+\eta\cdot a_j\frac{-\frac{1}{c}}{2\sqrt{\frac{\eta^2a_i^2}{4(1-\beta)^2c^2}-\frac{\Delta w_i}{c}}} &< 0\Leftrightarrow\\ \frac{\eta^2}{4c}\left(\frac{a_i^2}{(1-\beta)^2}-4a_j^2\right) &< \Delta w_i\end{aligned}$$

which is always true as well for any $\Delta w_i\in\left[\frac{\eta^2}{4c}\left(\frac{a_i^2-a_j^2}{(1-\beta)^2}\right),\frac{\eta^2}{4c}\left(\frac{a_i^2}{(1-\beta)^2}-\frac{a_j^2}{(1+\alpha)^2}\right)\right]$ and $\beta\leq\frac{1}{2}$. Furthermore, it is always negative at $\Delta w_i=\frac{\eta^2}{4c}\left(\frac{a_i^2-a_j^2}{(1-\beta)^2}\right)$ for any $\beta\leq\frac{1}{2}$ and equal to zero if and only if $\beta=\frac{1}{2}$.

■

Proof of Corollary 2:

The utility of agent j at $\Delta w_i=0$ is always smaller as compared to $\Delta w_i=\frac{\eta^2}{4c}\left(\frac{a_i^2-a_j^2}{(1-\beta)^2}\right)$ if agent j's utility function is increasing at $\Delta w_i=0$ which is the case when

$$0>\frac{\eta^2}{4c}\left(\frac{a_i^2}{(1+\alpha)^2}-\frac{a_j^2}{(1-\beta)^2}\right)\Leftrightarrow\frac{a_j}{a_i}>\frac{1-\beta}{1+\alpha}.$$

If this is not the case we have to compare the utility of the less able agent j at the local maximum of both agents' utility function

$$\frac{W}{2}-\frac{\eta^2\left(a_i^2+a_j^2\right)}{8(1-\beta)^2c}+\frac{\eta^2\left(a_i^2+a_j^2\right)}{2\left(1-\beta\right)c}$$

with her utility at $\Delta w_i=0$, which for $\frac{a_j}{a_i}<\frac{1-\beta}{1+\alpha}$ is given by

$$\frac{W}{2}+\frac{\eta^2a_j^2}{2\left(1-\beta\right)c}+\frac{\eta^2a_i^2}{2\left(1+\alpha\right)c}-\frac{\eta^2a_j^2}{4\left(1-\beta\right)^2c}+\beta\left(\frac{\eta^2a_j^2}{4\left(1-\beta\right)^2c}-\frac{\eta^2a_i^2}{4\left(1+\alpha\right)^2c}\right).$$

Hence, agent j is better off with an unequal income when

$$\frac{a_j^2}{a_i^2}>\frac{1}{(1-2\beta)}\left(\frac{4\left(1-\beta\right)^2}{(1+\alpha)}+1-4\left(1-\beta\right)-\frac{2\beta\left(1-\beta\right)^2}{\left(1+\alpha\right)^2}\right).$$

Note that if $\left(\frac{4(1-\beta)^2}{(1+\alpha)}+1-4\left(1-\beta\right)-\frac{2\beta(1-\beta)^2}{(1+\alpha)^2}\right)<0$ this holds for all values of a_j. As $4\beta-3<0$ this condition is equivalent to

$$\left((1+\alpha)-\frac{2\left(1-\beta\right)^2}{(3-4\beta)}\right)^2>\frac{2\left(1-\beta\right)^2}{\left(3-4\beta\right)^2}\left(6\beta^2-7\beta+2\right).$$

Note that $6\beta^2 - 7\beta + 2 > 0$ as this function is $= 0$ at $\beta = \frac{1}{2}$ and decreasing for $0 < \beta < \frac{1}{2}$. Rearranging the equation gives

$$\alpha > \frac{1-\beta}{3-4\beta}\sqrt{2\left(6\beta^2 - 7\beta + 2\right)} + \frac{2\left(1-\beta\right)^2}{\left(3-4\beta\right)} - 1$$

which proves the first claim. If, however, $\left(\frac{4(1-\beta)^2}{(1+\alpha)} + 1 - 4\left(1-\beta\right) - \frac{2\beta(1-\beta)^2}{(1+\alpha)^2}\right) > 0$, the condition is equivalent to

$$\frac{a_j}{a_i} > \sqrt{\frac{1}{\left(1-2\beta\right)}\left(\frac{4\left(1-\beta\right)^2}{\left(1+\alpha\right)} + 1 - 4\left(1-\beta\right) - \frac{2\beta\left(1-\beta\right)^2}{\left(1+\alpha\right)^2}\right)}$$

which establishes the second claim. ■

Chapter 2

Heterogeneity and Cooperation in Privileged Groups: The Role of Capability and Valuation on Public Goods Provision

2.1 Introduction

Most studies on collective action have focused on situations where agents with identical characteristics interact with each other. When considering the social and economic life, however, people generally differ with respect to a variety of characteristics, such as preferences, resources, qualifications, and attitudes. As such, the existence and formation of homogeneous group environments can be regarded as an exception, rather than the rule. Yet, the when, how, and to which degree collective action is affected by inequality among group members is still a question that is discussed controversially.[1] In this paper, we therefore experimentally investigate the effects of two different sources of heterogeneity, valuations and capabilities, on the willingness to cooperate in social dilemmas.

While it is often legitimate to abstract from heterogeneity to study the underlying logic of collective action problems, we illustrate that this abstraction can sometimes be problematic as it neglects important characteristics of cooperation. Our results indicate that heterogeneity can affect the principle of reciprocity in non-trivial ways by fundamentally altering individuals' willingness to cooperate within groups. More importantly, however, we find that it is not the asymmetric nature of groups per

[1] While some studies argue for a positive effect of heterogeneity (e.g. by increasing the likelihood of attaining motivated contributors that initiate collective action (Olson, 1965; Hardin, 1982; Oliver et al., 1985)), others find negative effects on cooperation levels, arguing that diversity makes the emergence and enforcement of social norms more difficult (Bardhan and Dayton-Johnson, 2002; Reuben and Riedl, 2013).

se that facilitates or impedes collective action, but that it is the specific type of heterogeneity that determines the degree of cooperative behavior and the level of public good provision. In particular, our results imply that when heterogeneity is associated with group members benefiting differently from the collective action, then this has negative effects on contribution behavior. In contrast, we find that if heterogeneity does not destroy the symmetric nature of public good benefits, then inequality among group members can have positive effects on cooperation and coordination.

Undoubtedly, members of a society or an organization often differ with respect to their incentives to contribute to a collective good. On the one hand, this might be the case if they have different *valuations / preferences*[2] for the public good. For example, parks, swimming pools, dams, or other public facilities provide very different benefits to individuals, depending on how far away they live from the site or how often they enjoy the consumption of the public good. Similarly, on an international level, countries commonly are differently affected by global warming, the exploitation of natural resources such as fish populations, or conventions about international defense alliances. On the other hand, incentives to contribute may differ because individuals have different *capabilities* in providing the public good.[3] For example, members of a team working on a joint project often have different task-specific capabilities determining the productivity of their chosen effort. In the context of environmental protection, countries may have different qualifications in fighting global climate change, e.g. different opportunities to preserve the rainforest or different technological competencies to avoid carbon dioxide emissions. Likewise, in the case of charitable donations and volunteer work, capability heterogeneity arises when individual donors have asymmetric information about fundraising organizations with varying levels of qualifications (Vesterlund, 2003).

While both types of heterogeneity (preferences and capabilities) are closely related and often referred to as changes in the *marginal per capita rate of return* (MPCR), they differ with respect to one important characteristic, namely the externality contributions have on the other group members' payoffs. When individuals have asymmetric preferences, benefits from the public good differ between group members, but are independent of who makes a contribution. In contrast, if individuals have asymmetric capabilities, benefits are the same for everyone but depend on which group member contributes. While in the first case group members always benefit asymmetrically causing inequalities in payoffs, in the case of heterogeneous

[2]In the following, we use both terms interchangeably.

[3]See e.g. Sugden (1984) who argued that "... equal efforts [to the public good] on the part of different individuals need not be equally productive."

capabilities, equal contributions also lead to equal payoffs. This difference influences the distribution of wealth and, given that people are not purely selfish, creates different incentives to contribute which, in turn, can also affect allocation. By comparing these two sources of heterogeneity, we are able to disentangle the effects of heterogeneous characteristics and an asymmetric payoff structure.

In particular, we investigate these types of heterogeneity within privileged groups which according to Olson (1965) are groups in which at least one group member "has an incentive to see that the collective good is provided, even if he has to bear the full burden of providing it himself".[4] While the main argument of our paper is not exclusive to privileged groups but also applies to heterogeneous non-privileged groups, there are several reasons why these groups are of special interest. First, many groups facing the problem of providing public goods can be regarded as being privileged, e.g. in the case of commons-based peer productions such as Linux (Benkler, 2002), attempts to stop overexploitation of natural resources, or the fight against international terrorism.[5] Second, especially in privileged groups peoples' willingness to (conditionally) cooperate is affected in important ways. The reason is that contributions by others are not necessarily reciprocated if they do not entail an individual sacrifice, making it hard to unequivocally identify them as nice acts (Glöckner et al., 2011). Third, although the free-rider problem is mitigated in privileged groups as at least some amount of the public good is voluntarily provided, there will still be underprovision as long as some members find it optimal not to contribute. Finally, privileged groups are especially suited for studying heterogeneity as they are asymmetric in their nature per se.

Because in collective action problems private and social marginal benefits diverge, relying on voluntary provisions typically leads to an inefficient underprovision of the public good (Samuelson, 1954; Olson, 1965; Hardin, 1968). Different institutional solutions have been proposed to overcome this problem (see Chen, 2008, for a survey). In the experimental literature, the most commonly used institution to improve collective action is decentralized peer punishment. However, while punishment has

[4]A different environment in which positive public goods contributions can be sustained in equilibrium are so called step-level or threshold public good games (see e.g. Van de Kragt et al., 1983; Suleiman and Rapoport, 1992; Marks and Croson, 1998; Cadsby and Maynes, 1999; Croson and Marks, 2000; Spencer et al., 2009). Introducing provision points eliminates dominance from the free-riding strategy and creates multiple equilibria by embedding a coordination game into the social dilemma. This can lead to an efficient supply of the public good when agents manage to coordinate, so that the provision point is exactly met.

[5]For example, the implementation of fishing quotas might be seen as individually optimal or not, depending on how much a country's economy depend on fishing. Likewise, in the case of the fight against international terrorism, depending on the likelihood of being a target, countries may perceive the benefits of contributing as being larger or lower than the costs (compare Reuben and Riedl, 2009).

shown to be very effective in promoting public good contributions in homogeneous settings (Gächter and Herrmann, 2009; Chaudhuri, 2011), evidence from heterogeneous groups is rather sparse and inconclusive.[6] In such environments, it is not clear whether punishment and related mechanisms work similarly effective. As argued by Reuben and Riedl (2013), one reason for this is that in asymmetric settings, different fairness concepts can imply different contribution norms which, in turn, can have detrimental effects on voluntary contributions and enforcement of cooperation. In contrast, in homogeneous environments, different fairness norms such as efficiency, equality, and equity all lead to one "coinciding focal norm" facilitating cooperation and coordination and its enforcement. To study these effects in our context, we compare our experimental treatments under two complementary situations: one in which punishing other group members is possible and one in which informal sanctions are absent.

Closest related to our work is a study by Reuben and Riedl (2009). In their experiment, they also compare privileged groups of *heterogeneous valuations* to normal groups when punishment is possible or not. They find that without punishment privileged groups contribute more, but once punishment is possible they lose their privileged status contributing less than normal groups. They conclude that the asymmetric nature of groups makes the enforcement of cooperation through informal sanctions harder to accomplish. In contrast to them, we additionally study privileged groups of *heterogeneous capabilities*. This enables us to demonstrate that it is not the asymmetric nature of groups per se that facilitates or impedes collective action, but that it is the specific type of heterogeneity that determines peoples' willingness to cooperate within groups. In particular, our results imply that heterogeneity only has detrimental effects on voluntary contributions if it is accompanied by an asymmetric payoff structure, highlighting the importance of payoff equality on cooperation and coordination within groups.

So far, most previous studies that investigate the effects of heterogeneity on public good provision also have made the payoff structure asymmetric by analyzing

[6]To our knowledge, the only experimental studies that analyze the interaction of heterogeneity and punishment are Burns and Visser (2006), Reuben and Riedl (2009; 2013), and Noussair and Tan (2011). While the first study finds positive effects of punishment on cooperation, the latter find that punishment is relatively ineffective in increasing contributions in heterogeneous environments.

inequality in endowments[7] or preferences[8]. The crucial point of studying capability differences is that it allows us to investigate the effects of heterogeneity on public goods provision without destroying the symmetry of the payoff structure. In the experimental literature, we are only aware of two studies (Noussair and Tan, 2011; Fellner et al., 2011) that implement capability heterogeneity in a similar manner as in our study. However, none of them investigate privileged groups and none of them analyze the mere effect of capability heterogeneity as they do not compare behavior to groups of homogeneous capability. Furthermore, we are not aware of any study that directly compares differences in capabilities and preferences. Shedding light on the differences between these two related types of heterogeneity is the major goal of this study.

The remainder of this paper is organized as follows. In Section 2, the experimental design and the behavioral predictions are described. Section 3 presents the results of the experiment. Section 4 concludes.

2.2 The Experiment

2.2.1 Experimental Design

The underlying decision situation behind our experiment is a standard linear public goods game. Subjects are randomly assigned to one of three experimental treatments, which differ with respect to the group members' characteristics (see below). In each treatment, participants are matched into groups of three, playing the public goods game for twenty consecutive periods with a surprise restart after ten periods

[7]Experiments investigating the effects of wealth heterogeneity in social dilemmas report mixed results. While most studies find that endowment inequality leads to lower contributions (Ostrom et al., 1994; Zelmer, 2003; Cherry et al., 2005; Anderson et al., 2008), a few studies report neutral or even positive effects (Chan et al., 1996; 1999). Buckley and Croson (2006) find that individuals with low incomes contribute the same absolute amount and a higher percentage of their income to a common good than individuals with a high income. Levati et al. (2007) report a negative effect of endowment heterogeneity on leading by example situations, especially in the case of incomplete information. Cardenas (2003) finds a negative effect of inequality in real-life wealth on cooperation levels when group members can communicate with each other.

[8]Several studies investigate the effects of different material incentives to contribute. Without altering the Nash prediction of full free-riding, Isaac et al. (1984) and Isaac and Walker (1988) find that higher marginal benefits from the public good also lead to higher contributions (see also Ledyard (1995) and Zelmer (2003) for an overview). While these studies implement heterogeneity only between groups, other studies analyze the effects of within-group inequality by manipulating the opportunity costs of contributing (Fisher et al., 1995; Palfrey and Prisbrey, 1996; 1997). Relatedly, Goeree et al. (2002) investigate the effects of different internal and external returns on public good provision. Similar to our experiment, a few articles study the case of full cooperation being the dominant strategy. They find that even then, underprovision of the public good occurs (Saijo and Nakamura, 1995; Reuben and Riedl, 2009; Glöckner et al., 2011).

(compare Andreoni, 1988; Croson, 1996). Group composition is kept constant across all twenty periods (partner-matching design). At the beginning of each period, all group members $i \in \{1, 2, 3\}$ receive an endowment of twenty tokens.[9] During the first ten periods of the experiment, the game only consists of a contribution stage in which participants simultaneously decide how many tokens of their endowment they want to contribute to the public good and how many tokens they want to keep for themselves. In the last ten periods, the contribution stage is followed by a decentralized punishment stage.[10]

Importantly, in addition to one benchmark treatment in which all subjects have completely identical characteristics, in the other two treatments group members differ with regard to the benefit they receive from their own and their group members' contributions. In one treatment, they differ with respect to their valuation of the public good δ_i, and in the other treatment, they differ with respect to their capability a_i determining the marginal effect of their contributions. As such, a subject's *effective contribution* to the public good depends on two factors: (1) the individual's *nominal contribution* $c_i \in [0, 20]$, and (2) the individual's capability a_i. Hence, every token contributed to the public good by subject j increases the earnings of each group member by $\delta_i \cdot a_j$ tokens. Any token not contributed to the public good increases the own payoff by one token(leaving the other group member's payoff unchanged). Without punishment, subjects' monetary payoff at the end of each period is given by

$$\pi_i = 20 - c_i + \delta_i \cdot \sum_{j=1}^{N} a_j \cdot c_j \tag{2.1}$$

where the amount of public good provision is given by the sum of effective contributions. If subjects are only interested in maximizing their monetary payoffs, if $\delta_i \cdot a_i < 1$, then in the stage game, the dominant strategy for subject i is to completely free-ride and contribute nothing to the public good. If, however, $\delta_i \cdot a_i > 1$, then full contribution becomes the dominant strategy. Furthermore, social efficiency is max-

[9] In each period, subjects receive an additional lump sum payment of five tokens. These tokens, however, do not alter contribution possibilities to the public good. This was done because of some additional treatments unrelated to the research question in this paper. As the lump-sum payment does not alter any of our predictions and results, we discard it from our analyses.

[10] In this study, we abstain from controlling for order effects. However, as has been shown previously (see e.g. Fehr and Gächter, 2000), the sequence of play, i.e. whether the punishment condition is played first or last, does not affect the effectiveness of punishment. Therefore, in the results section, we assume that contribution differences between conditions are mainly driven by the introduction of punishment, rather than other explanations such as learning. Furthermore, as our results from the punishment condition are very similar to Reuben and Riedl (2009) who analyze the effects of punishment in a between-subject design, we provide evidence that they are robust to this variation in the experimental design.

imized if everyone contributes their entire endowment to the public good. Hence, we have a typical social dilemma situation in which, except for privileged players, individual and group interests are at odds.

In the punishment stage, each participant i simultaneously decides how many punishment points $p_{ij} \in [0, 10]$ she wants to assign to each other group member j. Each punishment point assigned reduces the earnings of the punished group member by three tokens and costs the punisher one token. At the end of each period, group members are informed about the total number of punishment points received by other group members and their earnings from this period.[11] With punishment, in each period, earnings are given by

$$\pi_i = 20 - c_i + \delta_i \cdot \sum_{j=1}^{N} a_j \cdot c_j - 3 \sum_{j \neq i} p_{ji} - \sum_{j \neq i} p_{ij} \qquad (2.2)$$

The parameterization of our experiment is very similar to other public good experiments. In our baseline treatment (BASE), all group members receive the same endowment $y_i = 20$, benefit to the same extent from the public good $\delta_i = 0.5$, and have the same capability of providing the public good $a_i = 1$.[12] In the valuation treatment (VAL), the only difference is that at the beginning of the experiment, in each group one randomly selected member is assigned a valuation of $\delta_H = 1.5$ leaving her capability of $a_H = 1$ unchanged. In the capability treatment (CAP), the randomly selected member receives an capability of $a_H = 3$ keeping constant her valuation of $\delta_H = 0.5$. The two non-selected group members have the same characteristics as subjects in the baseline treatment ($\delta_L = 0.5$; $a_L = 1$). In both treatments we refer to the randomly selected members as *h-types* and to the other members as *l-types*. The assignment of types is kept constant throughout all 20 periods. All of this information is common knowledge to all participants in the experiment. Additionally, at the end of each period subjects receive exact feedback about each group members' contribution and payoff. For a summary of the three treatments, see Table 2.1.

The difference between VAL and CAP arises from the different externalities contributions have on the group members' payoffs, i.e. *l-* and *h-players* in VAL and CAP benefit differently from contributions made by *h-* and *l-players*, respectively. In Table 2.1, Column 5 shows public good benefits subjects receive from contribu-

[11]Subjects do not receive any information about individual punishment behavior of the other group members. Additionally, subjects are informed that they are protected against severe losses as they cannot be punished by other group members below zero (compare Fehr and Gächter, 2002).

[12]Note then when $a_i = 1$, the game boils down to the standard case without an explicit modeling of capability.

Table 2.1: Experimental Treatments

Treatment	Type	Valuation δ_i	Capability a_i	$\frac{\partial \pi_i^{PG}}{\partial c_L} = \delta_i \cdot a_L$	$\frac{\partial \pi_i^{PG}}{\partial c_H} = \delta_i \cdot a_H$	# Groups
Base	*3 x l-player*	0.5	1	0.5	-	15
Val	*2 x l-player* *1 x h-player*	0.5 1.5	1 1	0.5 1.5	0.5 1.5	16
Cap	*2 x l-player* *1 x h-player*	0.5 0.5	1 3	0.5 0.5	1.5 1.5	15

Note: The endowment for all player types in all treatments is 20 tokens per period.

tions of *l-types*, and Column 6 displays public good benefits subjects receive from contributions of *h-types*. In Val, only *h-players* directly benefit from the "gift" of having a higher evaluation, irrespective of which type contributes. *L-players* only indirectly benefit from the increased material incentives of the *h-player* but not from her higher valuation per se. In contrast, in Cap, all group members benefit equally from the "gift" of one player having a higher capability. Both types of player receive 1.5 points from the public good when *h-types* contribute, and 0.5 points when *l-types* contribute. Hence, *l-players* not only benefit from the increased material incentives of the *h-player* but also from the fact that her contributions are more valuable. In the next section, we investigate how this difference between both types of privileged groups affects behavior.

In summary, the only difference across treatments is the absence or presence of an *h-player* and, in the latter case, whether the *h-player* has a higher valuation or a higher capability than the *l-players*. Thus, by comparing our three treatment conditions, we can investigate the effect of different types of *h-players* on contribution behavior depending on whether the possibility to punish is available or not.

2.2.2 Behavioral Predictions

Without the possibility to punish, under the assumption that individuals are fully rational, focusing only on the maximization of their own monetary payoff, nobody is predicted to contribute a positive amount to the public good in Base. The same prediction can be made for *l-types* in Val and Cap. However, in these treatments, it is strictly dominant for *h-types* to contribute their entire endowment as their individual return of contributing strictly outweighs the corresponding costs, and therefore, also increases their own material payoff. In contrast to *normal groups* in Base, groups in these two treatments can be characterized as being *privileged* in the sense of Olson (1965), as one member in each group has an individual material incentive to provide the public good. Importantly, monetary incentives for *h-players* in VAL and CAP are completely identical, as their marginal benefit from contributing one token to the public good is given by $\delta_H^{VAL} \cdot a_H^{VAL} = 1.5 \cdot 1 = 1.5$ and $\delta_H^{CAP} \cdot a_H^{CAP} = 0.5 \cdot 3 = 1.5$, respectively. Certainly, they differ with respect to the externality they have on other group members and other group members have on them. Yet, these external effects only matter if people also care about the well-being of others (see below). Introducing punishment does not change the standard predictions made previously. Since punishment is costly, selfish individuals are predicted to not assign any punishment points in the second stage. By the logic of backward induction, this is anticipated by group members in the first stage and, thus, they do not change their contribution behavior, as punishment is not credible.

However, there are now a broad number of studies indicating that many people are not solely motivated by monetary incentives, but also exhibit some form of other-regarding preferences. For example, even when nobody is predicted to contribute anything, evidence from previous public good experiments suggest that there is some positive amount of voluntary cooperation (Dawes and Thaler, 1988; Ledyard, 1995; Chaudhuri, 2011). A variety of models of other-regarding-preferences (Rabin, 1993; Fehr and Schmidt, 1999; Bolton and Ockenfels, 2000; Charness and Rabin, 2002; Dufwenberg and Kirchsteiger, 2004; Falk and Fischbacher, 2006) have been established that are quite successful in explaining such patterns of behavior observed in the laboratory and in the field.[13] In the following, we discuss the implications such other-regarding preferences have on contribution behavior in our experimental setting.

First of all note that when the endowment and the valuation of the public good is the same for all group members, differences in contributions translate one-to-one into differences in final payoffs, i.e. irrespective of the subjects' capabilities, equal contributions lead to equal payoffs and unequal contributions lead to unequal payoffs. In BASE, given that people are motivated by inequity aversion or reciprocity, the public goods problem turns into a coordination problem with multiple Pareto ranked equilibria (Rabin, 1993; 1998; Fehr and Schmidt, 1999; Gächter and Fehr, 1999). Given the right beliefs about other peoples' contribution, individuals act as conditional cooperators (Fischbacher et al., 2001) and any amount of cooperation can be sustained in equilibrium. Yet, as argued by Fehr and Schmidt (1999), coordination on high contribution levels is more likely when the possibility to punish

[13] For a summary of the empirical evidence on social preferences, see Sobel (2005) and Fehr and Schmidt (2006).

free-riders is available. The reason is that reducing income differences by punishing low contributing group members becomes a credible motivation when people also care about relative incomes.

In Cap, basically the same logic applies. Yet, in contrast to Base, if both types of players follow their payoff-maximizing strategy, they end up with very unequal payoffs. The reason is that all group members benefit equally from the public good but only *h-players* have to bear the costs of providing it. If subjects are inequity averse, they have an incentive to match their group members' contributions. While *l-players* would like to increase their contributions to reduce their disutility from being better off, *h-players* would like to decrease their contributions to reduce their disutility from earning less than their group members. Ex-ante, however, it is not straightforward on which equilibrium subjects may coordinate on (see Kölle et al., 2011, for an theoretical analysis of capability heterogeneity on public goods provision). Fehr and Schmidt (1999) argue that full contribution can be a focal point serving as a coordination device. Applying their utility function to this context, however, reveals that the condition for *h-players* to decrease their contributions is much easier to fulfill than the condition for *l-players* to increase their contributions, making equilibria with low cooperation levels more likely.[14] However, when subjects are given the possibility to punish each other, like in Base, coordination on equilibria with high cooperation levels may work as well, as using punishment to reduce income differences is a credible motivation.

When people have asymmetric valuations for the public good, predictions are different. While contributions made by *h-players* increase their own payoff without changing income differences within a group, contributions made by *l-players* decrease their own income and additionally increase unfavorable income inequality compared to the *h-player*. Therefore, inequity aversion does not change the predictions made by the standard model of purely selfish agents. *H-players* have no incentive to deviate from full contributions, and *l-players* have no incentive to deviate from free-riding. Furthermore, introducing punishment is not predicted to increase contributions in this kind of groups. Contrary to the other two treatments, the motivational effect of punishment has less bite here. The reason is that even when getting punished, *l-types* might be reluctant to increase contributions as *h-types*

[14]Given the parameterization of this experiment, for sustaining an equilibrium in which all players contribute positive amounts, both *l-players* must suffer sufficiently strong from being better off ($\beta \geq 0.5$). In contrast, *h-players* have an incentive to deviate and free-ride when their disutility from being worse off is sufficiently strong ($\alpha > 0.5$). Note that because disadvantageous inequity aversion is usually much more pronounced than advantageous inequity aversion (see Blanco et al. (2011) for an empirical study eliciting the distribution of α and β parameters), the first condition is more demanding than the latter making deviations of *h-players* more likely.

would benefit disproportionately from that leading to an increase in inequality.[15]

Intention-based theories of social preferences may also lead to different predictions between treatments. While in normal groups, low and high contributions may have an unambiguous interpretation of being kind or unkind, in privileged groups, this judgment is more difficult. In these groups, contributions of *h-players* cannot unequivocally be identified as being a nice act, as they also maximize their individual payoffs. As a consequence, *l-types* might be unsure whether to reciprocate these contributions or not which, in turn, might hamper cooperation (Glöckner et al., 2011). While this is true in both types of privileged groups, contributions of *h-players* might also be evaluated more kindly in Cap than in Val. The reason is that due to the different externalities, by contributing *h-types* in Cap have to fear the risk of being worse off which is not the case for their counterparts in Val. Likewise, when comparing free-riding by *l-players* between Val and Cap, in the latter such behavior might be judged being more unkind as, compared to the *h-types*, this also gives them a monetary advantage in relative terms.[16]

In summary, standard preferences do not predict any differences in voluntary contributions between both types of privileged groups. While models of other-regarding preferences can explain such differences, ex-ante it is not clear in which treatment underprovision of the public good will be more pronounced. When the opportunity to punish is introduced, however, we expect that it has a much weaker effect on increasing cooperation in Val than in the other two treatments.

2.2.3 Experimental Procedure

The experiment was conducted in 2011 at the Cologne Laboratory for Economic Research (Germany). Subjects were students from the University of Cologne and were recruited using the online recruiting software ORSEE (Greiner, 2004). Experimental sessions were computerized using the software z-Tree (Fischbacher, 2007). In total, 138 subjects participated in the experiment, 45 in Base and Cap, and 48 in Val, leading to 15, 15, and 16 independent observations, respectively. About half of the subjects were female and about half studied economics. Upon arriving

[15] Of course, if contributing would prevent *l-types* of getting punished, this would pay off. However, *h-types* may not punish *l-types* in the first place, because this would further increase inequality. Furthermore, another strategy for *l-types* to avoid inequality is to punish *h-types* as a response to expected punishment.

[16] Another motivation for contributing to the public good are efficiency concerns (see e.g. Engelmann and Strobel, 2004). In this case, we would expect less underprovision in privileged groups than in normal groups. When comparing privileged groups, we observe that the maximum social efficiency achievable is the same in Val and Cap. While contributions made by *h-types* are more efficient in Cap, contributions made by *l-types* are more efficient in Val. Ex-ante, however, it is difficult to predict which, if any, of the two effects dominates.

in the laboratory, each subject drew a card which randomly assigned them a seat in the lab. Subjects were also randomly assigned to a treatment, a type (*l* or *h*), and a group. At the beginning of the experiment, subjects read the instructions explaining the public goods problem, the incentives, and the rules of the game. To ensure their understanding of the experiment, participants had to answer several control questions about the comparative statics of the game. Only after all participants answered all questions correctly, the experiment started. At the end of the experiment, subjects had to fill out a short questionnaire, after which they were confidentially paid out their earnings in cash. A typical experimental session took about 1.5 hours and subjects earned, on average, 17.02 Euros (approx. 22.81 USD).

2.3 Results

We start our analysis by investigating contribution behavior in the first ten periods without punishment. After that, we analyze how contributions change when subjects are given the possibility to punish other group members. In both cases, we first analyze behavior on an aggregated group level and then zoom into individual behavior of *l*- and *h-types*. We then study punishment behavior and how subjects react to received punishment.

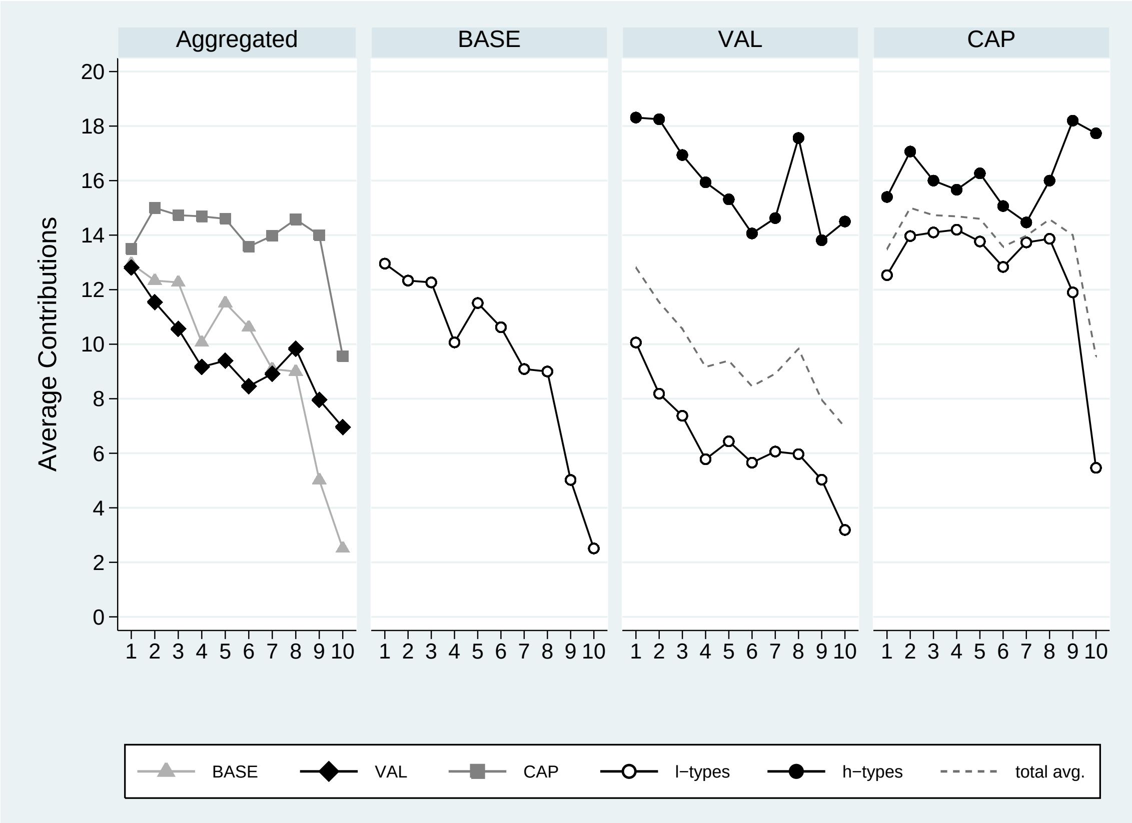
2.3.1 Voluntary Contributions without Punishment

Figure 2.1 illustrates average contributions for all three treatments in periods 1-10 at an aggregated group level (Column 1), as well as separated by *l*- and *h-types* (Columns 2-4). Comparably to similar public good experiments, in Base we find the commonly observed pattern of positive but decreasing contributions over time. While in the first round, participants contribute around 60% of the social optimum, contributions nearly drop to full free-riding in the last period. A Spearman's rank-order correlation of contributions on periods corroborates this negative time trend ($\rho = -0.531, p = 0.007$).[17]

Very similar contribution dynamics can be observed in Val. Contributions start at high but decrease to very low levels in the final period ($\rho = -0.513, p < 0.001$). As a result, average contributions are basically identical in both treatments (Base: 9.54 and Val: 9.56 tokens, see Table 2.2). In fact, a non-parametric Mann-Whitney

[17] Throughout this paper, when using Spearman's rank-order correlation we calculate a correlation coefficient for each independent observation (group) and report the average. For the p-value we apply a Binomial test with the null hypothesis that a positive and a negative trend are equally likely.

Figure 2.1: Average contributions over time without punishment



U test[18] cannot reject the hypothesis that distributions are drawn from the same population ($p = 0.812$). The reason is that in VAL, increased contributions of *h-types* are accompanied by decreased contributions of *l-types* (see Column 3 in Figure 2.1). Compared to BASE, both effects are statistically significant (MWU, *l-types*, $p < 0.044$; *h-types*, $p < 0.002$). While both types start at different levels, they exhibit a similar decline in cooperation over time until a small endgame effect sets in. On average, *h-types* contribute 15.93 tokens and *l-types* contribute 6.38 tokens (Wilcoxon signed-rank test, $p < 0.001$). Strikingly, *h-types* do not stick to their dominant strategy of full contribution although contributing their entire endowment would not only maximize their material payoff, but would also maximize social efficiency, leaving relative incomes unchanged (Sign test, $p < 0.001$ one-sided).[19] Altogether, we find that privileged groups whose asymmetry stems from differences in the preferences for the common good do not contribute more

[18]If not otherwise indicated, we use a non-parametric Mann-Whitney U test (henceforth MWU) for comparisons between treatments and a non-parametric Wilcoxon signed-rank test (henceforth WSR) for within-treatment comparisons. We always apply two-sided test statistics and use group averages based on data from all relevant periods (either 1-10 or 11-20) as the unit of observation.

[19]By applying a one-sided test, we account for the fact that deviations from full contribution can only either be zero or negative.

Table 2.2: Descriptive Statistics

	Contributions					
	WITHOUT PUNISHMENT			WITH PUNISHMENT		
	l-player	*h-player*	*total*	*l-player*	*h-player*	*total*
BASE	9.54	-	9.54	16.53	-	16.53
	(4.56)	-	(4.56)	(3.68)	-	(3.68)
VAL	6.38	15.93	9.56	10.27	17.96	12.83
	(5.24)	(4.32)	(4.11)	(6.85)	(5.40)	(5.53)
CAP	12.64	16.19	13.82	18.41	19.83	18.88
	(6.01)	(4.16)	(5.03)	(3.02)	(0.41)	(2.02)

Note: Average contributions depending on treatment, subjects' type and whether the opportunity to punish other group member is available or not. Standard deviations using group averages as the unit of observation are in parentheses.

than normal groups.[20]

In contrast, privileged groups of heterogeneous capabilities do much better in sustaining cooperation. While contributions in the first period are at a similar same level than in the other two treatments, they maintain a high level until the final period, when a typical endgame effect sets in. Hence, having one subject with a high capability in the group has a positive and stabilizing effect on voluntary contributions. A Spearman's rank-order correlation of contributions on periods does not indicate a decline of cooperation over time ($\rho = -0.066, p = 1.000$). In total, subjects in CAP contribute, on average, 13.82 tokens compared to 9.56 in VAL. Although standard theory predicts that contributions should be the same in both treatments, a Mann-Whitney test clearly rejects equality of distributions ($p = 0.034$). The difference in contributions is thereby mainly driven by *l-* rather than by *h-types*. While the latter contribute about the same amount in both treatments (VAL: 15.93, CAP: 16.19; MWU, $p = 0.984$), *l-types* in CAP contribute about twice as much as in VAL (12.64 vs. 6.38; MWU, $p = 0.007$). This already indicates that in CAP, *l-types* have a much higher willingness to reciprocate contributions made by *h-types*. The reason is that in CAP, by increasing contributions to the levels provided by *h-types*, *l-types* can decrease payoff inequality within the group. Moreover, this also prevents fairness concerned *h-types* to decrease contributions as a consequence of being worse off. In this case, increasing contributions also materially pays off for *l-types*, as contributions of *h-types* are more valuable. In contrast, in VAL such a behavior would increase inequality to the *l-types*' disadvantage which, in turn, decreases their

[20] While Reuben and Riedl (2009) find the same result only for the case in which informal sanctions are available, in our study this effect is also present in situations in which punishing other group members is not possible.

Table 2.3: OLS Regressions: Contributions to the public good

Dependent variable: $c_{i,\,t}$	BASE	VAL		CAP	
Contributions by i		*l-types*	*h-types*	*l-types*	*h-types*
(Avg.) lagged contrib. *l-types*	0.700***	0.640***	0.339*	0.511***	0.478***
$\bar{c}^{low}_{-i,\,t-1}$	(6.36)	(5.51)	(2.12)	(4.81)	(4.12)
Lagged contrib. *h-types*		0.068		0.244**	
$\bar{c}^{high}_{-i,\,t-1}$		(1.31)		(2.64)	
Period	-0.538***	-0.106	-0.196	-0.664***	0.175
t	(-3.61)	(-0.98)	(-1.01)	(-4.42)	(1.08)
Constant	5.159***	1.202	14.561***	5.862***	8.798***
	(3.02)	(0.71)	(5.91)	(3.51)	(3.92)
# Observations	405	288	144	270	135
Adj. R^2	0.448	0.449	0.102	0.381	0.281

Note: t statistics in parentheses; * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$; Robust Std. Err. (clustered on groups)

willingness to contribute.

Further support for the different incentives in reciprocating the other types' contributions comes from an OLS regression.[21] Results are reported in Table 2.3. Columns 2-6 illustrate the results from separate regressions for each treatment and, in VAL and CAP, additionally separated for *l-* and *h-types*. The dependent variable is the level of public good provision, c_i, made by subject i. As independent variables, we use the lagged contributions of the other group members from the previous period to analyze subjects' willingness to (conditionally) cooperate. To provide a clearer understanding of the dependence of contributions between types, for *l-types* we distinguish between contributions made by *h-* or other *l-types* in the group. In addition, we control for different time trends, intercepts, and the dependency of observations within groups.

In normal groups (Column 2) we find a strong and significant positive relationship between own contributions and the other group members' contributions from the preceding period. Thus, subjects seem to condition their contributions on the other group members' behavior, i.e. the higher (lower) the other group members' contributions in the previous period, the higher (lower) are subject $i's$ contributions in the subsequent period. In VAL, we observe an asymmetry in the willingness to reciprocate between types. Results indicate that *l-players* (Column 3) do condition their contributions on the behavior of the other *l-player*, but contributions by *h-players* do not significantly affect their decisions (F-test, $p < 0.001$), i.e. *l-players*, at least to some extent, are willing to match the other *l-player's* contribution, but are

[21] Applying Tobit regression instead of OLS leads to the same results and conclusions.

reluctant to increase their contributions up to the level of the *h-player* as this would increase inequality to their disadvantage. At the same time, however, *h-players* (Column 4) do take into account the contribution behavior of *l-players*, indicating that they act as conditional cooperators, thereby "punishing" *l-types* by reciprocating their decreasing contributions over time. This behavior basically constitutes a one-to-one punishment strategy, which lowers all group members' payoffs by the same amount, leaving relative incomes unchanged.[22] These results are in line with *l-players* following a norm of equal payoffs, and *h-players* players following a norm of equal contributions. This asymmetry in behavior may also be a reason for the steady decline of cooperation over time in this treatment.[23] In contrast, in Cap we find contribution behavior to be much closer and more symmetrically interrelated. *H-players* reciprocate contributions by *l-players*, and *l-players* reciprocate contributions by *h-* and other *l-players* (Columns 5 and 6). All these effects are positive and statistically significant. This implies that despite the fact of heterogeneous capabilities, the symmetric payoff structure maintains the *l-* and *h-players*' incentives to match each other's contributions. In this case, the norms of equal contributions and equal payoffs coincide, which seems to foster cooperation.

In summary, we find that the nature of asymmetry within a group crucially affects peoples' willingness to cooperate. While ex-ante it was not clear which (if any) type of privileged group performs better, our results indicate that groups of asymmetric capabilities are much better in coordinating on high cooperation levels than groups of asymmetric preferences. The main reason are the different externalities contributions have on the other group members, causing the payoff structure to be symmetric in Cap, but asymmetric in Val. To demonstrate the magnitude of the effect this has on the distribution of outcomes, we calculate the standard deviation of earnings per period within each group as a simple measure of inequality. As expected, we find inequality within groups to be much more pronounced in Val than in Cap. Average payoffs per period for *l-* and *h-types* are 27.97 and 47.09, respectively, in Val, and 44.28 and 40.73, respectively, in Cap. The average standard deviation of earnings sums to 11.40 in Val, and 4.34 in Cap (MWU, $p = 0.016$). Furthermore, not only in terms of equality but also in terms of efficiency, groups in Cap perform better than in Val. In the former they reach 86%, and in the latter

[22]This result is consistent with previous studies which explicitly implement a one-to-one punishment technology (Egas and Riedl, 2008; Nikiforakis and Normann, 2008; Sutter et al., 2010). They find that even when punishment does not affect relative incomes, subjects punish each other although this is not very effective in increasing contributions.

[23]See Fischbacher and Gächter (2010) for a more comprehensive analysis of contribution dynamics in repeated public goods games.

they reach 69% of the social optimum (MWU, $p = 0.002$).[24]

2.3.2 Voluntary Contributions with Punishment

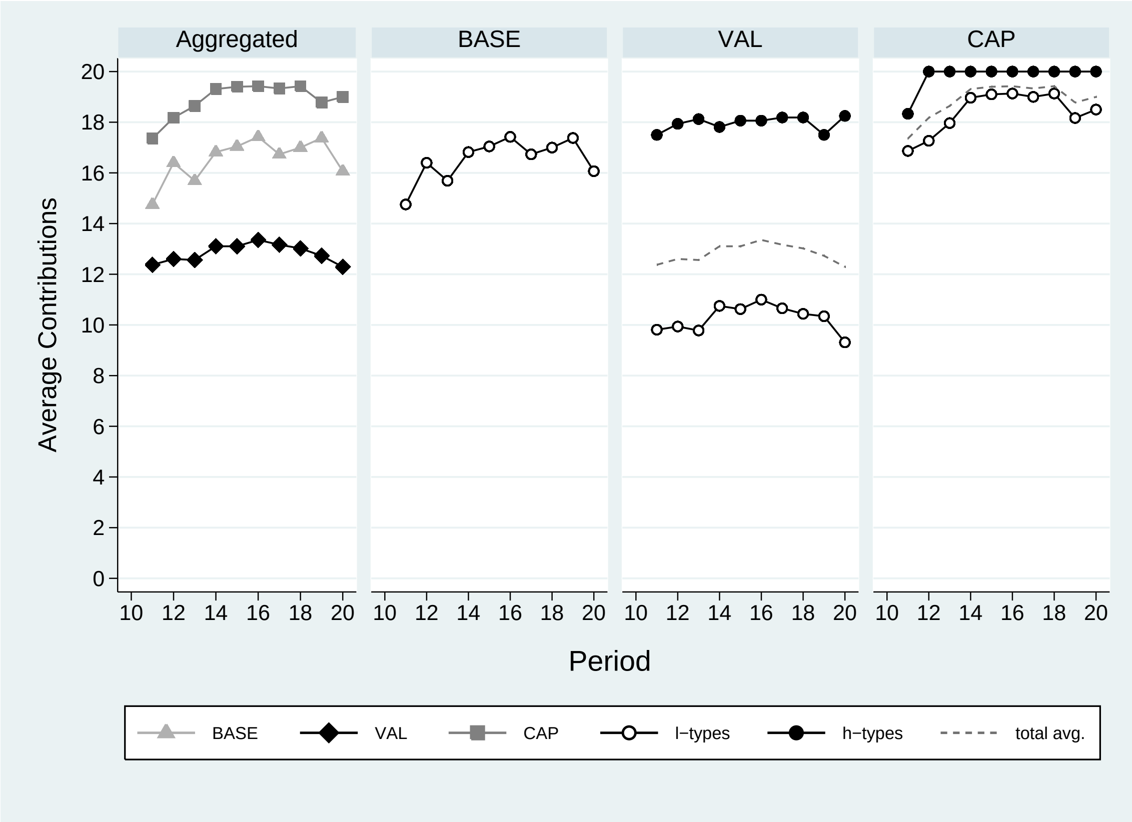
As argued above, heterogeneity can lead to an increased ambiguity or disagreement about the contribution norm which, in turn, can substantially affect the enforcement of cooperation through informal sanctions. In the following, we therefore analyze to which degree the results found so far hold or change when subjects are given the possibility to punish each other.

Figure 2.2 summarizes the results illustrating average contributions over time for all treatments and types when punishment is possible (periods 11-20). We observe that introducing the opportunity to punish increases average contributions in all three treatments. However, the quantitative effect of punishment on contributions strongly differs between treatments. Compared to the first ten periods without punishment, average contributions go up by 6.99 (WSR, $p < 0.001$), 3.27 (WSR, $p = 0.030$), and 5.06 (WSR, $p < 0.001$) tokens, in BASE, VAL, and CAP, respectively. Apparently, especially in the treatments in which all subjects benefit equally from the public good, punishment is effective in increasing contributions. Jointly testing the change in contributions in BASE and CAP compared to VAL reveals that in the latter, punishment is less effective in fostering cooperation (MWU, $p = 0.054$). One reason for this result is that in VAL, the introduction of punishment causes opposing reactions. In 5 out of 16 groups (31%), average contributions are actually lower under the punishment condition, leading to an increased standard deviation of contributions across groups (4.11 vs. 5.53, see Table 2.2). In contrast, in BASE and CAP punishment has a clear and consistent positive effect on cooperation, leading to increased contributions in all groups. Furthermore, implementing punishment also leads to a decreased dispersion across groups within treatments, as the standard deviation of average contributions decreases from 4.56 to 3.68 in BASE, and 5.03 to 2.02 in CAP.

When having a closer look at the contribution dynamics over time, in BASE and CAP we observe a significant upward trend in contributions over time (BASE: $\rho = 0.348, p = 0.035$; CAP: $\rho = 0.515, p < 0.001$). In contrast, contribution dynamics in VAL are rather flat ($\rho = 0.026, p = 0.210$), implying that peer-punishment is largely ineffective in fostering cooperation over time. When treating average contributions from period 11 to 20 as independent observations, we find a clear ranking of cooperation levels. Average contributions in the last ten periods are 16.53, 12.83,

[24] In BASE, subjects earn on average 24.77 tokens per period, corresponding to 83% of the social optimum and to an inequality measure of 3.95.

Figure 2.2: Average contributions over time with punishment



and 18.88 in Base, Val, and Cap, respectively. As in the no punishment condition, average contributions in Cap are highest. Remarkably, contributions in Val now fall short even below the levels provided in Base. All these differences are statistically significant (Base vs. Cap: MWU, $p = 0.024$; Val vs. Cap: MWU, $p = 0.002$; Base vs. Val: MWU, $p = 0.053$).[25] Thus, when introducing the possibility to punish, privileged groups in Val lose their privileged status completely and perform even worse than normal groups. However, as can be seen from the results in Cap, it is not the asymmetric nature of groups per se that hampers cooperation. It is rather the specific type of heterogeneity that undermines peoples' willingness to cooperate and prevent contribution levels coming close to social efficiency.

When zooming into the behavior of *l-* and *h-types*, similar to the first ten periods, we observe that contributions are much more closely interrelated in Cap than in Val (Columns 3 and 4 in Figure 2.2). The difference in contributions between both types amounts to 1.42 and 7.70 tokens (MWU, $p = 0.009$), respectively. Comparing both

[25] When treating group behavior over all twenty periods as independent observations, average contributions are given by: Base: 13.03; Val: 11.20; and Cap: 16.35. Pairwise comparisons reveal that the distribution of contributions in Cap is significantly different from Base (MWU, $p = 0.015$) and Val (MWU, $p = 0.002$), but a comparison between Base and Val does not show any significant differences (MWU, $p = 0.179$).

player types' contributions between treatments, we again find the main difference between both kinds of privileged groups originating from disparities in the behavior of *l-types*. Contribution levels in VAL and CAP are 10.27 and 18.41 (MWU, $p = 0.002$), respectively, for *l-types*, and 17.96 and 19.83 (MWU, $p = 0.382$), respectively, for *h-types*. Hence, while *l-types* in CAP contribute nearly twice as much as in VAL, the difference in the *h-types*' behavior is less pronounced. Nevertheless, in CAP, *h-types* in all groups contribute their entire endowment from the second punishment period onwards, which is never the case in VAL.

In summary, as in the first ten periods we find the specific type of heterogeneity crucially affecting cooperation levels within groups. As predicted, in the case of asymmetric preferences informal sanctions are less effective in enforcing cooperation and coordination within groups. The reason is that the asymmetric payoff structure prevents punishment to foster individuals' willingness to cooperate. In contrast, when the payoff structure is symmetric, punishment successfully deters group members from free-riding. As a consequence, while privileged groups of asymmetric capabilities are very close to full cooperation, in VAL they contribute even less than normal groups. In addition, the introduction of punishment also has different effects on the distribution and total amount of wealth across treatments. While compared to the first ten periods, in BASE, average payoffs slightly decrease by 1.39 to 23.38 tokens, in VAL and CAP, earnings increase by 2.71 and 3.27 to 37.05 and 46.37 tokens, respectively. However, in VAL, these efficiency gains come at costs of a significant increase in payoff inequality. The average standard deviation of earnings within groups increases from 11.40 to 18.64 (WSR, $p = 0.034$). In contrast, in BASE and CAP this dispersion significantly decreases when punishment is introduced (BASE: 3.94 vs. 2.54, WSR, $p < 0.02$; CAP: 4.34 vs. 1.65, WSR, $p < 0.001$). This implies that in these treatments, punishment indeed has a disciplining effect on relative contributions and payoffs. In terms of social efficiency, groups in BASE, VAL, and CAP now reach, on average, 78%, 74%, and 93%, respectively, of the social optimum. As without punishment, the difference between both privileged groups is highly significant (MWU, $p < 0.002$).

2.3.3 Punishment Behavior

To understand the driving forces that cause the strong differences in contribution behavior, we now analyze to which extent they depend on the way group members punish each other and how they adapt contributions after being punished.

The average amount of punishment points spent is similar across treatments (BASE: 1.25; VAL: 0.55; CAP: 0.73). Although subjects in normal groups punish a little bit more than in privileged groups, these differences are not statistically significant (Kruskal-Wallis test, $p = 0.330$). Also when pairwise comparing allocated and received punishment within and between treatments and types, we do not find any statistical significant differences. However, more important than comparing absolute levels of punishment is to analyze how subjects punish group members conditional on their contributions, and how group members react to received punishment.

To investigate the possible determinants of allocating punishment, we apply Tobit regressions, using the amount of punishment points subject i dealt out to subject j, p_{ij}, as the dependent variable.[26] As explanatory variables, we use the deviation of j's contribution from the other two group members' contribution, i and k. This allows us to illustrate the dependence of punishment on relative contributions more clearly than by only using average contributions. Given the opposing monetary incentives of *l-* and *h-types* in privileged groups, deviations from the average group contribution may also not be a very meaningful reference point subjects base their sanctioning decisions on. As negative deviations are usually punished more heavily than positive deviations (Fehr and Gächter, 2002), we allow for different slopes for social and antisocial punishment, when applicable.[27] Furthermore, we control for different time trends, level effects and the dependency of observations within groups. Table 2.4 reports regression results separated by the subjects' type and treatment. For *l-types*, we additionally include an *h-type* dummy to test whether, ceteris paribus, punishment differs depending on whether the target person is a *l-* or a *h-type*.

For *l-types* (Columns 2-4) we observe that negative deviations from their own contributions are strongly and significantly punished in all three treatments. Comparing coefficients between both types of privileged groups reveals that this effect is stronger in Cap than in Val (Wald test, $p < 0.05$). As *h-types* are almost always the highest contributor in each group, negative deviations are found to primarily occur relative to the other *l-type* in the group. Holding the amount of the deviation fixed, this implies that *l-types* in Cap punish each other more severely than their counterparts in Val. This result indicates that in the case of asymmetric preferences, low contributions have a higher likelihood of being tolerated, suggesting that

[26]We use Tobit regressions to account for the fact that the dependent variable exhibits censoring from above and below at 10 and 0 points, respectively.

[27]In Val and Cap, only in 2.5% and 1.33% of the cases, respectively, contributions of *h-types* are lower than contribution made by a *l-type*. Due to the small number of cases, we cannot reliably estimate the effect of antisocial punishment for *h-types* in privileged groups. In this case, we instead use the deviation from i's contribution as the explanatory variable. However, results and significances do not change when we do separate social and antisocial punishment for *h-types* as well.

Table 2.4: Tobit Regressions: Punishment assigned to j by i

Dependent variable: p_{ij}	*l-types*			*h-types*	
Punishment given by i to j	Base	Val	Cap	Val	Cap
Deviation from c_i				-0.145	-0.768***
$c_j - c_i$				(-1.41)	(-3.21)
Positive deviation from c_i	0.242**	0.149**	0.240		
$max\,(c_j - c_i, 0)$	(2.24)	(1.97)	(1.46)		
Negative deviation from c_i	0.719***	0.890***	2.040***		
$max\,(c_i - c_j, 0)$	(4.31)	(6.92)	(3.56)		
Positive deviation from c_k	-0.057	-0.151	-0.203	0.111	-0.167
$max\,(c_j - c_k, 0)$	(-0.44)	(-1.18)	(-1.14)	(0.59)	(-0.74)
Negative deviation from c_k	0.163	-0.029	0.113	0.852***	0.110
$max\,(c_j - c_k, 0)$	(0.76)	(-0.32)	(0.76)	(5.09)	(0.41)
j is a *h-type*		0.410	-1.251		
1 if $\delta_j = 1.5$ or $a_j = 3$		(0.57)	(-1.11)		
Period	-0.315**	0.154	0.554*	0.357*	0.310
t	(-2.10)	(1.50)	(1.67)	(1.67)	(0.90)
Constant	-3.406	-9.609***	-18.04**	-14.32***	-12.56
	(-1.55)	(-4.06)	(-2.57)	(-3.19)	(-1.55)
# Observations	900	640	600	320	300
Log-Likelihood	-591.3	-304.4	-179.4	-156.6	-171.4

Note: t statistics in parentheses; * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$; robust standard errors (clustered on groups)

the norm of equal contributions is enforced less consequently. In line with other studies (see e.g. Herrmann et al., 2008), we also observe some amount of antisocial punishment. This effect turns out to be statistically significant in Base and Val, but not in Cap. Compared to the occurrence of altruistic punishment, however, such "perverse" punishment is much less pronounced (Wald test, $p < 0.01$ in all treatments). Regarding the relative contributions of the targeted person j compared to k, we do not find any significant effects on subject i's punishment behavior. Hence, *l-types* seem to mainly take into account deviations from their own, rather than from the other group members' contributions, when making punishment decisions. Furthermore, in privileged groups we do not observe that, ceteris paribus, *h-types* get punished more severely than *l-types*.

We now turn to the behavior of *h-types* in privileged groups (Columns 5 and 6). In Val, we observe that deviations from own contributions are not punished, but that negative deviations from the third group member's contributions are strongly and significantly punished. In Cap, we find that only deviations from own contributions matter for punishment behavior. The difference of both coefficients between treatments is large and statistically significant (Wald test, $p < 0.02$ in both cases).

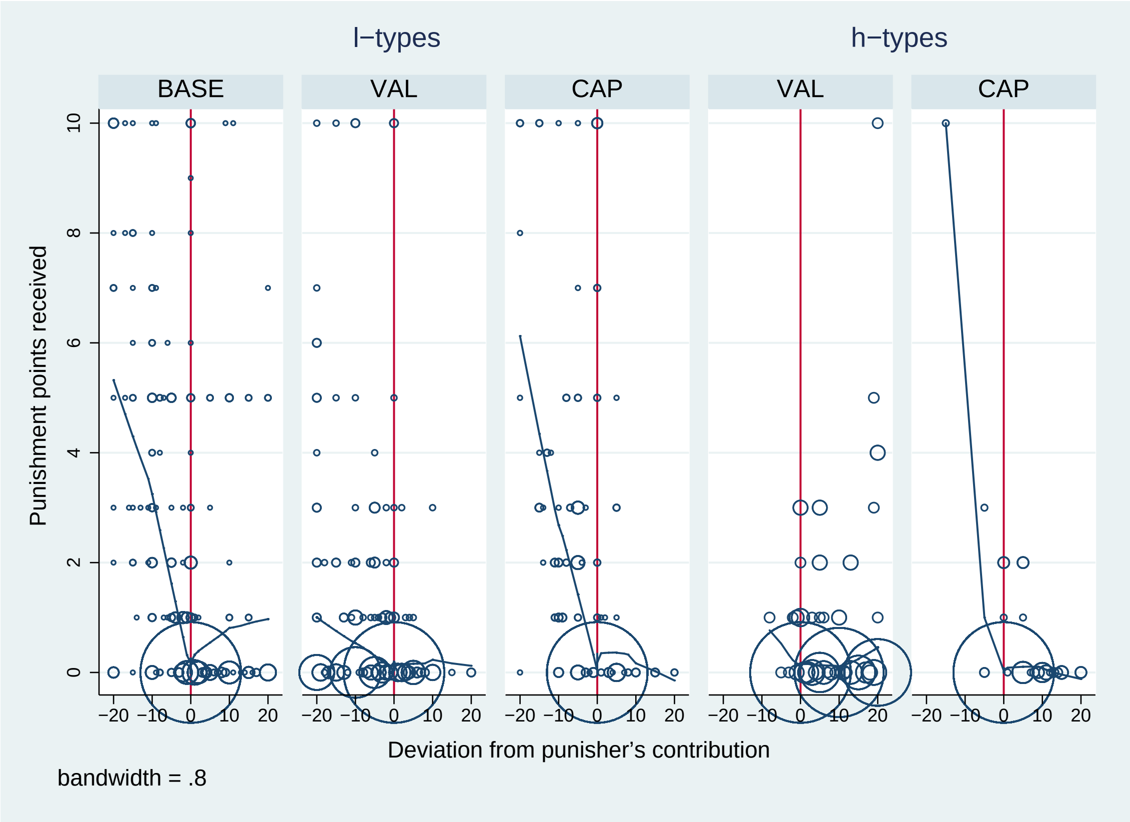
This result implies that in CAP, *h-types* try to enforce a norm of equal nominal contributions, punishing everyone who free-rides on their contributions. In contrast, in VAL *h-types* follow a more modest goal of trying to only increase contributions of the lowest contributor, tolerating the fact that *l-types* contribute less than themselves.

The differences in punishment behavior are neatly summarized in Figure 2.3 which illustrates the number of punishment points received as a function of i's deviation from the punisher's contribution. The size of each circle represents the relative frequencies of a given tuple and the solid line indicates the fitted line of the locally weighted regression of punishment received on the deviation from the punisher's contribution. In line with the regression results, for *l-types*, the punishment function in VAL turns out to be very different compared to the other two treatments (see Columns 1-3). In BASE and CAP, negative deviations are frequently and considerably punished. In contrast, in VAL we observe a much less systematic pattern of punishment behavior. This is indicated by a much flatter slope of the punishment function, implying that negative deviations often get away unpunished. In fact, in BASE, VAL, and CAP negative deviations from a group member's contribution are being punished in 57%, 22%, and 73% of the cases, respectively. Also for *h-types* (Columns 4 and 5) we observe noticeable differences between treatments. While there is hardly any case in which *h-types* contribute less than *l-types*, in the case of positive deviations, *h-types* in VAL are punished more strongly than in CAP. The reason is that in VAL, *l-types* are always worse off than *h-types* as long as they do not free-ride completely. In these cases (80% of the cases), *l-types* can use antisocial punishment with respect to *h-types* to decrease payoff inequalities in their group. In CAP, such perverse punishment is not necessary, as *h-types* are only better off when they contribute less than their group members, which is almost never the case.

The effectiveness of punishment, however, not only depends on the way group members punish each other, but also on the way how they adapt contributions as a response of being punished. Given the different incentives to contribute, we surprisingly find no pronounced differences across treatments. Evidence comes from OLS regressions with the change in contributions as the dependent variable and a binary punishment variable interacted with the relative contributions within groups as independent variables (see Table 2.5 in Appendix A).[28] In all three treatments, we find a negative and statistically significant effect of relative contributions when being punished, i.e. as a response of being punished, subjects increase (decrease) contributions when contributing less (more) than their group members. Most im-

[28]We restrict our analysis to the behavior of *l-types*, as contributions of *h-types* in VAL and CAP are very similar and exhibit very little variance over time.

Figure 2.3: Punishment as a function of deviation from punisher's contribution



portantly, however, when comparing coefficients across treatments, we do not find any statistically significant differences of punishment responses (Wald test, $p > 0.74$ for all pairwise comparisons). Hence, we conclude that when sanctioning group members is possible, it is the different punishment behavior, rather than differences in the reactions to punishment, that induces contributions of *l-types* in both types of privileged groups to further diverge.

2.4 Conclusion

In this article, we investigate the effect of heterogeneity on the provision of public goods. In particular, we compare two kinds of privileged groups vis-a-vis to normal, non-privileged, groups when punishment is possible or not. Under both conditions, we find that the nature of group heterogeneity crucially influences cooperation and coordination within groups. While asymmetric preferences for the public good have detrimental effects on voluntary contributions, different capabilities in providing the public good have a positive and stabilizing effect on contribution behavior. In addition, the type of heterogeneity also affects the usage and effectiveness of informal sanctions in fostering cooperation. The main reason for our results are the different externalities contributions have on the other group members' payoffs, causing the payoff structure to be asymmetric in one case and symmetric in the other. If people are not only concerned by maximizing their own monetary payoff, but also exhibit some form of other-regarding preferences, this can affect the principle of reciprocity and cooperation in non-trivial ways. If group members benefit equally from the public good, they have an incentive to match each other's contributions which, in turn, facilitates the agreement and establishment of a contribution norm that fosters cooperation and coordination. In contrast, when individuals benefit differently from the public good, this decreases their willingness to cooperate which, in turn, has detrimental effects on voluntary contributions.

With regard to Olson's (1965) theory on privileged groups, we find that, depending on the nature of their privilege, they do or do not fulfill their privileged status. Besides that, our study also implies an extension of the findings of Glöckner et al. (2011), as we find that individuals are willing to reciprocate contributions even if they do not constitute a sacrifice, but only if all group members benefit equally from such contributions. All in all, we provide evidence that it is not the asymmetric nature of groups per se that facilitates or impedes collective action, but that it is the specific type of heterogeneity determining the degree of cooperative behavior and the level of public good provision.

Our results highlight the importance of investigating the effects of diversity within societies on collective action problems. We provide evidence that abstracting from heterogeneity in social dilemma situations can be a serious shortcoming, as inequality among group members can have opposing effects on cooperation and coordination. Because in everyday-life, heterogeneous group environments are the rule, rather than the exception, understanding the driving forces of cooperation in these groups is of great importance. In line with previous research (Heckathorn, 1993; Varughese and Ostrom, 2001; Poteete and Ostrom, 2004; Reuben and Riedl, 2009; 2013), our findings stress the importance of a proper understanding of the context dependent interplay of heterogeneity, institutions, social norms, and collective action. In related contexts, other studies already have emphasized the relevance of community heterogeneity on social capital (Alesina and La Ferrara, 2000), civic engagement (La Ferrara, 2002; Costa and Kahn, 2003), or the maintenance of irrigation systems (Bardhan and Dayton-Johnson, 2002).

Insights from this research can have important policy implications, for instance by assisting organizations and policy-makers in developing institutions that effectively alleviate cooperation and coordination failure in social dilemma situations.

For example, in a firm context, our results suggest that the formation of teams in which members have different interests in the success of a joint project, or paying different team-performance related bonuses to otherwise identical agents may have detrimental effects on the group output. On a higher level, e.g. in national or international conflicts, group composition and valuations for a public good are often given and cannot be changed exogenously. In these cases, if valuations are heterogeneous but private information, one possible solution that has been proposed to increase social welfare is the bundling of (excludable) public goods (Hellwig, 2007; Fang and Norman, 2010). In political decision making, something similar can be observed in the guise of vote trading (logrolling). Furthermore, while relying on informal sanctions to foster cooperation has shown to be ineffective in the case of asymmetric valuations, when individuals differ in their capabilities they seem to work quite well in encouraging collective action. In the latter situation, individuals with high capabilities even impersonate potential candidates for leading-by-example that could further increase contributions (Potters et al., 2005; 2007; Güth et al., 2007).

2.5 Appendix to Chapter 2

A Regression on change in contributions

Table 2.5 shows regression results from OLS regressions with the change in contributions as dependent variable, and the difference between i's contribution and the average contribution of the other group members in the previous period as the independent variable. We also include a binary punishment variable and interact it with the deviation in contributions to explore how subjects change contributions depending on whether they got punished or not. We further control for different time trends, intercepts, and the dependency of observations within groups by clustering standard errors on each group. As contribution behavior of *h-types* in VAL and CAP are very similar and exhibit only very little variance over time, we restrict our analysis to the behavior of *l-types*.

Table 2.5: OLS Regressions: Change in Contributions from period t to $t+1$

Dependent variable: Δc_i	*l-types*		
Change in contributions	BASE	VAL	CAP
Received punishment	0.847**	0.870	-0.631
1 if $p_{ji} + p_{ki} > 0$	(2.26)	(1.56)	(-0.71)
Deviation from avg. contrib. others	-0.074	-0.079*	-0.059
$c_i - \bar{c}_{-i}$	(-1.13)	(-1.97)	(-1.29)
Deviation from avg. contrib. others × being punished	-0.253**	-0.288***	-0.304**
$c_i - \bar{c}_{-i} \times 1$ if $p_{ji} + p_{ki} > 0$	(-2.58)	(-4.63)	(-2.47)
Period	-0.117*	-0.026	-0.084
t	(-2.01)	(-0.29)	(-1.44)
Constant	1.602	-0.392	1.297
	(1.58)	(-0.27)	(1.48)
# Observations	405	288	270
Adj. R^2	0.182	0.209	0.172

Note: t statistics in parentheses; * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$; Robust Std. Err. (clustered on groups)

B Experimental Instructions (translated from German)

These are the instructions for *h-types* in the CAP treatment. Instructions for the *l-types* and the other treatments are similar and available upon request.

Introduction

You are now taking part in a scientific experiment. If you read the following instructions carefully, additionally to the €2.50 you receive for your show up for sure, depending on your and the other participants' decisions you can earn a considerable amount of money. How you can earn money is explained in the following instructions.

During the experiment communication with the other participants is prohibited. If you have any questions, please contact us. If you violate this rule, we shall have to exclude you from the experiment and all payments. If you have any questions, please raise your arm. A member of the research team will come to you and answer your question privately.

During the experiment your entire earnings will be calculated in *tokens*. At the end of the experiment the total amount of tokens you have earned will be converted to euro at the following rate:

75 tokens = 1 €

The converted amount will be paid in cash afterwards. The payment is done anonymously, i.e. no participant finds out another participant's payoff. All decisions in the experiment are made anonymously as well, i.e. nobody of the other participants finds out the identity of a person who made a particular decision.

The experiment

The experiment is divided into several periods. There are *10 periods* in total. During all 10 periods the participants are divided into *groups of three*. Hence, you act in a group with two other participants. *Note: The composition of the groups will remain the same during all periods of the experiment.* This means that in all 10 periods you act with the same participants in your group.

The decision situation

You will learn later on how the experiment will be conducted exactly. In this part, we first introduce you to the basic decision situation. The decision situation is the same in all 10 periods. In each period, each group member has to decide on the use of a certain number of tokens. You can decide how many tokens you want to contribute to a *group project* and how many tokens you want to *keep for yourself.* Each token you do not contribute to the group project you automatically keep for yourself.

From each token you or your group members contribute to the group project, each group member will benefit. From each token you or your group members keep for yourself, only you and your group members, respectively, will earn something. After all group members have made a decision on the use of the provided tokens, the period ends.

The initial endowment

At the beginning of each period each participant in your group receives *25 tokens.* We will refer to these tokens as your *initial endowment.*

Contributions to the project

In each period you decide how to use your initial endowment. You have to decide how many tokens you want to contribute to a group project and how many tokens you want to keep for yourself. You can contribute *any amount between 0 and 20 tokens* to the group project. How many tokens you contribute is up to you. Each other group member also makes such a decision. All decisions are made simultaneously. This means that nobody will be informed about the decision of the other group members before everyone else has made his or her own decision.

After all group members have made their contribution decision, an overview screen will be displayed. This screen informs you and your group members about each group members' contribution to the group project and about each group members' payoff in this period. In addition, you and your group members are informed about the total amount of tokens each group member has earned up to this period.

Earnings

Your earnings in tokens, in each period, are the sum of two parts:

1. The number of tokens that you kept for yourself.
2. Your income from the group project. This income is equal to:

Income from the group project $=$ *0.5* $\times$ *sum of outputs of all group members*

We denote 0.5 as the multiplication factor of the group project. The output of each group member is calculated as follows:

Output = productivity × contribution to group project

The output of each group member results from her contribution to the group project multiplied with her productivity. The productivity of a group member is determined as follows: In each group, one of the group members receives a productivity of 3 and the other two group members receive a productivity of 1. Before the experiment started, every seat was assigned productivity equal to either 1 or 3. Therefore, by randomly drawing a seat number, each participant was randomly assigned to one of these values. In all periods, your productivity as well as the productivity of the other group members does not change.

You are the group member who receives a productivity of 3.

Notice that for each token which you keep for yourself you earn exactly 1 token. If instead you contribute this token to the group project, then the total output of the project rises by three tokens. Your income from the group project rises by 1.5 token). Moreover, the other group members' income from the project also rises by 1.5 tokens.

Your contribution to the group project therefore also raises the income of the other group members. For each token contributed to the project the total earnings of the group rise by 4.5 tokens. Note that you also earn tokens for each token contributed to the group project by the other group members. For each token contributed by any member you earn 0.5 tokens. In summary, your earnings in tokens in each period are equal to:

Your total income = 25 - your contribution + 0.5 × sum of outputs of all group members to the project

Announcement

(*The following parts were given to the subject only after the end of period 10.*)

Now we repeat the experiment with *one single modification*. As before, the experiment is divided into 10 periods and in each period you have to make a decision on how many tokens you contribute to the group project and how many tokens you want to keep for yourself.

Note that the composition of the group remains the same. This means that in the next 10 periods, you are playing with exactly the same participants in a group as in the last 10 periods. Furthermore, also the initial endowment, the productivity, and the multiplication factor, which were assigned to you and your group members, remain the same.

Modification

In the following *10 periods*, there will now be a *second stage* in each period. In this second stage, you must decide whether and if yes how many *deduction points* you want to spend to reduce the first stage earnings of the other two group members.

The second stage

At the beginning of the second stage, everyone in the group is informed about how much each of the other group members contributed to the project as well as their earnings from the first stage. The decision each group member has to make in the second stage is to either reduce or leave equal the other group members' earnings. Reducing other group members' earnings can be done by allocating deduction points. The other group members can also reduce your earnings if they wish to. All decisions are made simultaneously. That means that nobody will be informed about the decision of the other group members before everyone has made his or her decision.

More concisely, in this stage you must decide whether and if yes how many deduction points you want to spend to reduce the earnings of the other two group members. If you want to reduce another member's earnings, you do that by allocating deduction points. For each deduction point you allocate to another group member her or his earnings are reduced by 3 tokens and your own earnings are reduced by 1 token. If you do not wish to change the earnings of another group member then you must allocate 0 deduction points to him or her. Note that you will be not allowed to reduce the earnings of a group member to less than zero. Furthermore, remember that for any deduction point you receive from the other members, your earnings will be reduced by 3 points (but never below zero).

Each group member can spend a maximum of 10 deduction points on each group member in each period. After all group members have made their decisions, you will be informed about how many deduction points you received from the other group members and also what your total earnings for that period are. Note that you do not get to know how individual group members spend their deduction points. In other words, you will only be informed of the total amount of deduction points allocated to you by the other group members but you will not know how many deduction points each individual group member allocated to you.

Summary

In summary, your earnings in tokens in each period are equal to:

(Your first stage earnings - 3 × deduction points allocated to you) - deduction*

points you allocated

* If the number between brackets is negative then replace it with zero.

Example for the second stage

Here are some arbitrarily chosen numbers that illustrate how your final earnings are calculated. You, group member 1, and group member 2 are all members of the same group. Suppose that after the first stage your earnings are equal to 30 tokens. In the second stage you decide to allocate 3 deduction points to group member 1 (this reduces the earnings of group member 1 by 9 tokens) and 0 deduction points to group member 2 (this does not change the earnings of group member 2). After all have made their decision, you learn that the others allocated in total 4 deduction points to you. In this case, your total earnings in tokens in this period are equal to: $(30 - 3 \times 4) - 3 = 18 - 3 = 15$ tokens.

Negative earnings

In principal, it is possible that you attain negative earnings in a period. However, you can always avoid this by not spending any tokens in the second stage (that is, by not distributing any deduction points to the other group members). Hence, you can always avoid negative earnings with certainty through your own choices.

Chapter 3

One rotten apple may spoil the barrel - How information about others' individual contributions affects cooperation

3.1 Introduction

Many important challenges in social and economic life such as environmental protection, voluntary provision of public goods, participation in collective action, charity donations, tax compliance, or teamwork share a tragic dilemma: They are all characterized by a discrepancy between individual and collective interest. Because it is individually rational for self-interested agents to free ride on others' contributions, the socially desirable amounts of the public goods are not provided (Samuelson, 1954; Olson, 1965; Hardin, 1968). Yet, there is plenty of evidence that even in anonymous one-shot interactions, people often voluntarily contribute to public goods and achieve higher cooperation levels than can be explained by the free-riding hypothesis (see e.g. Ledyard, 1995; Gächter and Herrmann, 2009, for overviews). While some studies argue that individuals contribute independently of others' contributions - e.g. because of pure and impure altruism (Andreoni, 1989; 1990) or confusion (Anderson et al., 1998)[1] - recent studies find that a considerable fraction of people condition their contributions on the behavior of others (see Chaudhuri, 2011, for an overview). They increase contributions as others make higher donations and curtail their contributions if they believe others are not pulling their weight (Fischbacher

[1]See e.g. (Andreoni, 1995; Keser, 1996; Palfrey and Prisbrey, 1997; Brandts and Schram, 2001) for a test of these motives.

et al., 2001; Frey and Meier, 2004; Kocher et al., 2008; Fischbacher and Gächter, 2010; Rustagi et al., 2010; Carpenter and Seki, 2011).

In this paper we go one step further by investigating how the *exact* composition of others' individual contributions within a group affects conditional cooperation. Think, for instance, of a group in which contributions are heterogeneous. In such a situation it is not clear which, if any, contributions are (most) influential in determining behavior. Are people more inclined to follow the bad example of an uncooperative group member or do they tend to match the good example of a high contributor? Or do they only orientate themselves towards the average of all group members' contributions?

These questions are highly relevant because on the one hand it is well known that people have heterogeneous preferences for cooperation. For example, while some people always free-ride, others are conditional cooperators (Fischbacher et al., 2001, henceforth FGF). On the other hand, there is evidence for the importance of so-called (*social interaction effects*) arguing that the composition of types within a group is crucial in determining the level of voluntary contributions. For instance, as shown by Gächter and Thöni (2005), cooperation is easier to sustain among like-minded people with similar cooperative preferences. We extend this line of research by investigating how people behave when simultaneously being grouped with people who are like-minded and ones who are not. Ex-ante, it is far from clear how conditional cooperators will react to such scenarios as prominent benchmark models of other-regarding preferences (e.g. Fehr and Schmidt, 1999; Bolton and Ockenfels, 2000; Charness and Rabin, 2002) would suggest different behavior.

To shed light on these questions, we report an experiment in which we employ a reduced form of the strategy method to systematically vary the information subjects receive about others' behavior. To avoid confounds due to strategic concerns or beliefs in a repeated environment, we use a one-shot linear public goods game. We apply a variant of the design by FGF which allows to elicit people's preferences for cooperation in an incentive compatible way. While in one treatment subjects are only informed about the average contribution of others, in another set of treatments they learn about the full vector of others' individual contributions.

Our main finding is that compared to the aggregate information treatment, in the full information treatments contributions are significantly higher when others contribute equally. This is not the case when others' contributions are heterogeneous. In addition, in the full information treatments we find contributions to be the lower the higher the variation in the other group members' contributions. The main reason for this result is the presence of a considerable fraction of conditional cooperators who are primarily guided by the minimum contribution of others. While we also observe subjects who primarily condition their behavior on the median or maximum contribution, the distribution of types tends to be skewed towards the minimum. Taken together, we provide evidence that information about individual contributions affects people's willingness to cooperate in systematic ways. But there is a substantial amount of heterogeneity in how individuals react to such information.

Our results have several interesting implications. First of all, they may explain why people usually fall short of matching others' contributions perfectly when only aggregate information is provided. It appears that some people are generally willing to cooperate but prefer not to spend more than the lowest contributor. However, when only receiving aggregate feedback, people face uncertainty about individual behavior and therefore have to form beliefs about the other group members' individual contributions. Believing that a "rotten apple" in the group contributes little may then be a sufficient reason to justify low own contributions (i.e., less than the average). In fact, the lack of information about individual behavior may additionally provide individuals with moral "wiggle room" to self-servingly "form" pessimistic beliefs about others' contributions, i.e., as an excuse for contributing little.[2] Furthermore, our results provide hints on what kind of feedback might facilitate cooperation. This can be relevant, for example, in the case of fund-raising or sequential public good provision when the organization has some discretion about which information to make public. Likewise, in a team context within a firm, our results may be insightful for the design of feedback mechanisms and team composition to help to sustain cooperation.[3]

Closely related to our work are studies by Croson (2007) and Cheung (2011). Using a repeated public goods game, Croson (2007) analyzes the effect of feedback about individual contributions within a group after each period. She is able to distinguish between different types of reciprocity and she finds the median to be a

[2]Our results might also add to the understanding of previous findings that show that peer-punishment typically stabilizes or even increases contributions. While in public goods games without punishment subjects typically only receive information about average contributions, introducing peer-punishment requires revealing individual contributions (see e.g. Fehr and Gächter, 2000). In the light of our results this difference in information could add to the stabilization of contributions in public goods games with punishment. For example, when punishment leads to more equal contribution behavior in subsequent rounds, our results suggest that subjects become inherently more willing to contribute at that level, so that the stabilizing effect is not exclusively due to the threat of punishment.

[3]Our results are thus also related to the literature on seed money (Andreoni, 1998; List and Lucking-Reiley, 2002), leadership (Hermalin, 1998; Potters et al., 2005; 2007; Güth et al., 2007; Levati et al., 2007; Glöckner et al., 2011), and information in social dilemmas (Vesterlund, 2003; Irlenbusch and Rilke, 2012).

better predictor than either minimum or maximum. Because of the repeated nature of her experiment, however, results may be biased by strategic and reputational concerns. Furthermore, because she does not apply the strategy method, results are also influenced by beliefs and she only draws inferences on an aggregate but not on an individual level. In contrast, similar to our design, Cheung (2011) also employs the strategy method to study how individuals respond to a variation in others' contributions. Yet, he does not compare behavior between treatments with aggregate and individual feedback. Furthermore, he uses a different setting with only three players and four possible contribution levels. This naturally precludes subjects conditioning on the median contribution which Croson (2007) identifies as focal, and also does not allow to analyze effects of heterogeneous contribution behavior on an individual level. With our experiment we aim to fill these gaps, helping to understand more precisely the factors that influence preferences for cooperation.

The paper proceeds as follows. The next section describes the experimental design and procedures. In section 3, we discuss behavioral predictions based on different models of other-regarding preferences. The experimental results are presented and discussed in section 4. Section 5 concludes.

3.2 Experimental Design and Procedures

3.2.1 The Basic Setup

The underlying decision situation of our experiment is a standard linear public goods game. Subjects are randomly matched into groups of four and each subject is endowed with 20 tokens which she can either keep or contribute to a joint project. The payoff function for each individual i is given by:

$$\pi_i = 20 - c_i + 0.4 \cdot \sum_{j=1}^{N} c_j$$

where the amount of public good provision is equal to the sum of contributions of all group members. Contributing one token to the public good yields a marginal private benefit of 0.4 and a marginal social benefit of 1.6 tokens. If subjects are only interested in maximizing their own monetary payoff, the dominant strategy for each subject i is to completely free-ride and contribute nothing to the public good, i.e., $c_i = 0$ for all i. However, as marginal social benefits exceed marginal private costs, social welfare is maximized when all group members contribute their whole endowment. Hence, we have a typical social dilemma situation in which individual and group interests are at odds. Within this basic setting, we elicit people's preferences for cooperation using a similar design as FGF which allows subjects to state their contributions conditional on the decisions of others in an incentive compatible way. Specifically, subjects are asked to make two types of decisions: an *unconditional contribution* and a *conditional contribution* to the public good. The unconditional contribution is simply a single decision in which subjects choose how many of their 20 tokens they want to contribute. For the conditional contribution, we apply a variant of the "strategy method" (Selten, 1967). In a series of decisions, subjects have to indicate how much they want to contribute conditional on certain public goods contributions by the other group members.

3.2.2 Treatments

In total, we run four different treatments. In a baseline treatment (Avg), we apply the original design by FGF. Participants are shown a table with the 21 possible values of (rounded) average contributions by the other three group members, i.e., subjects only receive information about aggregate but not individual contribution behavior. Then we ask subjects to state their contributions for each of the 21 values.

In the other three treatments, we enrich the information set subjects receive by showing them the complete vector of individual contributions. This allows us to investigate how subjects choose their contributions depending on the specific composition of individual contributions in the group. Since the number of all possible contribution levels from 0 to 20, amounts to $\left(\!\binom{21}{3}\!\right) = 1771$ possible combinations of other players' contributions, it is not feasible to let subjects make decisions for each single instance. Therefore, we restrict our analysis to a manageable set of selected cases. To ensure incentive compatibility of all decisions, we apply the so called *Conditional Information Lottery* design (CIL) by Bardsley (2000). Similar to a random lottery design and the strategy method, subjects have to solve several tasks of which only one will become payoff relevant. In CIL subjects are told that all but one task are fictitious and that only the single real task will determine payoffs. Of course, participants do not know ex-ante which of the tasks is real, i.e., they have an incentive to treat each task as if it is relevant for their outcome.

In total, subjects are confronted with 36 tasks displayed in a random order on one screen in a contribution table. Among these, there are 35 fictitious tasks which are the same for all subjects and one real task which depends on the actual unconditional contributions of the subject's group members.[4] The fictitious tasks

[4]When the real task is identical to one of the 35 fictitious tasks, we add another fictitious

are chosen such that (*i*) subjects cannot figure out which task contains the actual contributions, and (*ii*) they exhibit sufficient variation to estimate the effects of heterogeneous contribution behavior on the willingness to cooperate. To ensure (*i*) we fit the distribution of contributions used in these tasks to a typical one-shot public good experiment with the same parameters that was run as a pilot. To achieve (*ii*) we implement several cases which can be systematically analyzed. For example, to analyze the effect of heterogeneous contribution behavior, in one case an average of 5 is given by individual contributions of 5/5/5, and in another case the same average is given by individual contributions of 0/5/10 (see Table 3.4 in the appendix for an overview of all 35 fictitious tasks).

In the first of the three individual information treatments (IND-ONLY), subjects only see the (fictitious) contribution vectors representing the three individual contributions of the other group members. In the second treatment (IND-AVG), subjects additionally receive information about the rounded average of the three (fictitious) contributions, combining the elements of IND-ONLY and AVG. In a third treatment (IND-PG), conditions are the same as in IND-ONLY except that subjects play a regular one-shot public goods game before they decide on their conditional and unconditional contributions. This is done because of another research question not related to this paper. For an overview of our experimental treatments, see Table 3.1.

Table 3.1: Experimental Treatments

Treatment	Part I	Part II: Information about individual contributions	Part II: Information about average contributions	# Obs.
AVG	-	No	Yes	64
IND-ONLY	-	Yes	No	64
IND-AVG	-	Yes	Yes	64
IND-PG	one-shot PG	Yes	No	56

3.2.3 Procedures

The experiment was conducted at the Cologne Laboratory for Economic Research (CLER) in February 2011. We used the experimental software z-Tree (Fischbacher,

task so that no task shows up twice. Furthermore, in the questionnaire following the experiment, subjects were asked for their incentivized beliefs about which case they saw contained the actual contributions. Only 6 out of 184 (3.3%) participants guessed this case correctly, which is in line with random luck (1/36 = 2.78%).

2007) and recruited student participants from the University of Cologne with the online recruiting software ORSEE (Greiner, 2004). In total, we conducted eight experimental sessions in which 248 subjects participated. Each session involved 24 to 32 participants who were not allowed to take part in more than one session. About half of the subjects were female and about half studied economics or business administration.

At the beginning of each session, participants were randomly assigned to cubicles in the lab. After taking seats, subjects had to read the instructions explaining the public goods problem, the incentives, and the rules of the game. After that, participants had to answer several control questions to make sure that they understood the game. Only after all participants had answered all questions correctly, the experiment started. Unlike the other three treatments, in Ind-Pg subjects were told that the experiment consisted of two parts and that they would learn about the second part only after finishing the first one. Importantly, to avoid any kind of income-, learning-, or reputational effects, subjects were informed that only one part would be randomly chosen and paid out in the end. Furthermore, subjects received no feedback about the outcome after the first part and groups were rematched so that subjects did not interact with each other twice. At the end of each session, subjects were asked to fill in a short questionnaire on their motivation and demographic data. Afterwards, they were informed about the decisions of their group members and about their payoffs. Finally, participants were privately paid their individual earnings in cash. On average, participants earned €14.23 (including €2.50 show-up fee) and all sessions lasted approximately 1 hour. Since the game was only played once and no information about behavior was given until the very end of the experiment, the decisions of different subject can be treated as independent observations.

3.3 Hypotheses

Evidence from public goods experiments has shown that the amount of public goods provision is typically larger than what can be explained by pure self-interest. Many different explanations have been proposed to explain this phenomenon. One of the most prominent is the approach of conditional cooperation describing the tendency to cooperate if others do so as well. Several papers have shown that there is a considerable fraction of people who exhibit a willingness to contribute more the higher the average contributions of the other group members.[5]

Even though these studies have eliminated strategic concerns from repeated interactions by using the strategy method in a one-shot design, by providing only averages as information about others' contributions in the group, they maintain some uncertainty about individual contributions. If the composition of average behavior is relevant for own contributions, subjects have to form beliefs about the individual contributions of other group members. To eliminate uncertainty and beliefs, we provide full information about individual contributions. In this case, several behavioral reactions are conceivable because different theories of social preferences make different predictions about how the composition of the others' average contribution should influence individual's willingness to cooperate.

For instance, adjusting the own contribution down to the level of the lowest contributor would be in line with the predictions made by the model of Fehr and Schmidt (1999, henceforth FS-model) or Sugden's principle of reciprocity 1984. According to the FS-model, individuals suffer both from advantageous and disadvantageous inequality, with the latter looming larger than the first. Individuals with such preferences are willing to contribute to the public good if others do so as well if the reduction in (advantageous) inequity costs outweighs the monetary benefits of not contributing. Given the payoff structure of our experiment and the assumptions of the FS-model, this condition can only be fulfilled until own contributions match the lowest contributions of others, i.e., no player wants to be worse off than the richest of the other group members. Hence, the FS-model could explain why contributions decrease when information about heterogeneous individual behavior is disclosed. In contrast, in the model of Bolton and Ockenfels (2000, henceforth BO-model) individuals are assumed to suffer from inequity when the own payoff differs from the average payoff implying that when holding the own payoff constant, individuals prefer to receive the average. Because the average does not vary with the specific composition of others' contributions, in our context the BO-model predicts no effect of disclosing others' individual behavior compared to disclosing others' average contributions. Finally, the model by Charness and Rabin (2002, henceforth CR-model) assumes that people are concerned about efficiency and that they care about the group member with the lowest payoff (maximin). Because in the public goods game, the lowest payoff belongs to the group member contributing the most, this model could explain why individuals are willing to contribute up to the

[5](See e.g. Fischbacher et al., 2001; Keser and Van Winden, 2000; Frey and Meier, 2004; Gächter, 2007; Kocher et al., 2008; Herrmann and Thöni, 2009; Fischbacher and Gächter, 2010; Chaudhuri, 2011; Fischbacher et al., 2012)

maximum contribution of others when being provided with this information.[6]

Taken together, when holding constant the average contribution of others, an increased spread of others' individual contributions may have a negative (FS-model), no effect (BO-model), or positive (CR-model) on own willingness to contribute (see the appendix for the proofs). While the intention of our experiment is not to make this yet another contest of the different models (see e.g. Engelmann and Strobel, 2004), we nevertheless use them to provide a rationale for potential reactions to the composition of others' contributions.

3.4 Results

To investigate whether and to what degree information about individual contributions influences people's willingness to (conditionally) cooperate, we first compare contribution behavior in the Avg treatment with behavior from the three Ind-treatments providing feedback on individual contributions. After that, we look more closely at behavior in the Ind-treatments to identify behavioral patterns depending on the composition of others' contributions. As a preliminary remark, it is important to keep in mind that all the following results are based on our 35 selected cases which we have selected because it was not feasible to incorporate all cases (see above). While we have no indications that this selection affects our findings in any systematic way, it should be mentioned that it might not be immediately clear whether our results generalize to the complete set of possible cases.

Table 3.4 (see appendix) depicts all 35 cases that subjects face in the contribution table in Ind-Only, Ind-Avg, and Ind-Pg.[7] Columns 4-7 display average contributions for each treatment and case, and column 8 shows aggregated data over all three Ind-treatments. Since there are no pronounced or systematic differences across the three Ind-treatments, in the following, we pool the data of these treatments and refer to them as Ind.[8] To compare behavior between the Ind-treatments

[6]Efficiency concern suggests people are willing to contribute unconditionally to the public good to increase overall welfare, but there has been virtually no evidence for such behavior in the past.

[7]Note that in Table 3.4 the cases are sorted by their averages (Column 3) while they are presented to the subjects in a random order. To guarantee comparability, for our analysis we disregard the real case from each group and only analyze the 35 fictitious cases which are identical for all subjects in all Ind-treatments.

[8]Irrespective of whether we compare contribution behavior in the three Ind-treatments separately for each case or aggregated over all cases, and irrespective of whether we compare them jointly using a non-parametric Kruskal-Wallis test, or pairwise using a non-parametric Mann-Whitney U test, we do not find any significant differences for any of the comparisons. Hence, we conclude that there are no significant differences between the three Ind-treatments. This means providing information about the average contributions in addition to the individual contributions has no significant effect on contribution behavior. Likewise, letting subjects play a one-shot public

and Avg, for each case in Ind, we take the corresponding case in Avg with the same (rounded) average of the other group members' contributions.

3.4.1 Cooperation in Homogeneous Cases

We first compare behavior between Ind and Avg for cases in which others' contributions are homogeneous, i.e., cases in which all other group members contribute equally. For these four cases (5/5/5, 8/8/8, 10/10/10, and 15/15/15), we find a clear pattern of results: When revealing that contributions of the other group members' are uniform, contributions in Ind are significantly higher than in the corresponding cases in Avg. A non-parametric Mann-Whitney U test rejects equality of distributions for all these four cases ($p < 0.051$ for all pairwise comparisons).[9] Furthermore, also the proportion of players contributing exactly that amount significantly increases. A Fisher's exact test reveals that the proportion of contributions of 5, 8, 10, and 15, respectively, are significantly higher in Ind than in the corresponding case in Avg ($p < 0.046$ for all pairwise comparisons), suggesting the presence of a strong focal point which could be explained by conformity (Carpenter, 2004) or an increased pressure to follow the social norm of contributing (Reuben and Riedl, 2013).[10] Our results can be summarized as follows:

> **Observation 1:** *If individual contributions are the same, providing information about individual contributions of others tends to have a positive effect compared to only providing average contributions.*

This result can be further supported using OLS regressions with own contribution as dependent variable and average contribution of the other group members as independent variable. To allow for differences in slopes between treatments, we include a dummy variable for the Ind-treatments and interact it with the average contribution of others. To ensure comparability, we only include data from the

good game before the FGF design does not affect conditional contributions in any systematic way.

[9]If not indicated otherwise, we use two-sided test statistics.

[10]In principle, there is also uniform behavior in the cases 0/0/0 and 20/20/20. However, as these are border cases, there is no uncertainty about individual contributions in Avg either because it is clear that all other group members must have contributed 0 and 20, respectively. Therefore, we do not expect any differences between Ind and Avg for these cases. And indeed, a MWU-test does not indicate any significant differences (0/0/0: $p = 0.417$; 20/20/20: $p = 0.125$). Likewise, also the focal-point effect is less pronounced for these cases. A FE-test does not reveal any significant differences in the proportions of choosing contributions of 0 or 20 across treatments ($p > 0.290$ for both pairwise comparisons). These results imply that compared to observing only aggregated behavior, receiving feedback about individual behavior has a positive effect on contributions only if the individual feedback provides formerly unavailable information about uniformity of individual contributions.

four no-variance cases in IND and its corresponding cases in AVG. Furthermore, we control for the dependency of observations by clustering standard errors on the individual level. The results of the estimations are given in Table 3.2.

Table 3.2: OLS Regressions: Conditional Contributions depending on contributions of other group members for no-variance cases in IND and AVG

Dependent variable: c_i	ALL	Cond. Coop.
Contributions by i	(1)	(2)
avg. others' contribution	0.401***	0.765***
$\bar{c}_{-i}$	(6.00)	(10.65)
IND × avg. others' contribution	0.159**	0.146*
	(2.02)	(1.79)
IND	-0.035	-0.047
1 if treatment = IND	(-0.06)	(-0.07)
Constant	0.520	-0.310
	(1.05)	(-0.52)
# Observations	992	556
Adj. R^2	0.154	0.495

Note: t statistics using robust standard errors clustered on individuals are in parentheses; * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Using data from all participants (model 1), subjects in AVG contribute on average 0.4 tokens for each token of the others' average contribution. In IND, subjects contribute on average 0.16 tokens more (+40%) for each token of the others' average contribution. This difference is statistically significant and corroborates the results from the non-parametric tests. Importantly, these results are not driven by possible treatment differences in the proportions of different contribution types but persist if we only look at conditional cooperators. To test this, we follow the approach of FGF and, depending on subjects' conditional contributions, classify individuals into *free-riders*, *conditional cooperators*, and *others*.[11] The results from this categorization reveal that the distribution of types is very similar across treatments and also replicate FGF quite closely (see Table 3.5 in the appendix). Furthermore, as shown in model (2) we still find a significant treatment effect between IND and AVG if we only include data from subjects being classified as conditional cooperators. Clearly, for this type the relationship between own and others' contributions is much closer to one. While in AVG, conditional cooperators contribute 0.77 tokens for each token of the average contribution, in IND they contribute an additional 0.15 tokens (+19%), which is still significantly more.

[11] See the appendix for an exact description of our classification strategy in AVG and IND.

3.4.2 Cooperation in Heterogeneous Cases

An additional explanation for the results found above could be that it is not only the uniformity of contributions but rather the revelation of information about individual behavior per se that facilitates contributions. To investigate this hypothesis, we now turn to cases in which contributions differ among group members. While in 28 out of 29 such cases, average contributions in IND are higher than in AVG, Mann-Whitney U tests only yields three weakly significant differences out of the 29 comparisons which, however, may well be random outliers from multiple testing.[12] These may well be random outliers from multiple testing.

Furthermore, also the focal-point effect of the average vanishes if others' contributions differ. For none of the 29 cases a Fisher's exact test reveals that the proportion of players contributing exactly the average is higher in IND than in AVG implying that they condition their contributions on something else than the average. This might not be too surprising as in 24 out of the 29 cases, none of the displayed individual contributions equals the implied average (e.g. 0/11/13; $\varnothing = 8$).

In the following, we investigate more closely how individuals in IND react to the composition of the other group members' average contribution. Because free-riders and others are not expected to react on the composition of the average, in this analysis we focus on conditional cooperators only.[13] As a first indicator, for each individual we (using data from all 35 cases) calculate a Spearman's rank order correlation between the standard deviation in others' individual contributions and the deviation in own contributions from the average. We then use these correlation coefficients and perform a binomial test to check whether a positive or negative relationship between the two variables is equally likely. According to this test, the correlation coefficients are significantly more often negative than positive ($p < 0.001$) indicating that, on average, the more uniform others' contributions are, the higher the willingness to cooperate.

This result is supported by OLS regressions with individual contributions as dependent variable, and different combinations of others' contributions as independent variables. As a benchmark, in model (1) we use the average contribution of others as independent variable. To check whether conditional cooperators react to the composition of the average, in model (2) we additionally include the standard deviation of the other three group members' contributions as a measure of variation.[14] In both specifications, we use data from all 35 cases for subjects being classified as

[12] The three cases are: 0/5/7 ($p = 0.093$), 0/5/10 ($p = 0.087$), and 6/6/10 ($p = 0.059$).

[13] In fact, results do not change qualitatively when including data from all subjects.

[14] Using the range (defined as difference of lowest and highest contribution) instead of the standard deviation yields very similar results.

conditional cooperators, and cluster standard errors on the individual level taking into account the dependency of observations. The results from these regressions are shown in Table 3.3.

Table 3.3: OLS Regressions: Determinants of contributions by conditional cooperators in IND

Dependent variable: c_i	Conditional Cooperators		
Contributions by i	(1)	(2)	(3)
AVG	0.832***	0.835***	
	(27.73)	(27.97)	
STD. DEV.		-0.132***	
		(-4.74)	
MIN			0.353***
			(14.94)
MED			0.269***
			(11.47)
MAX			0.215***
			(12.26)
Constant	-0.402	0.147	0.111
	(-0.43)	(0.52)	(0.40)
# Observations	3640	3640	3640
Adj. R^2	0.424	0.430	0.431

Note: t statistics using robust standard errors clustered on individuals are in parentheses; * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Not surprisingly, evidence from model (1) suggests that the average contribution of others is a strong predictor for contribution behavior of conditional cooperators. Interestingly, however, model (2) indicates that they do not only care about the average contribution of others but also about its composition. While the average still has a strong and significant positive effect, the standard deviation of others' contributions has a significant negative effect on own contribution behavior, implying that the more spread out the others' individual contributions are, the lower is the own willingness to contribute. This constitutes our second result:

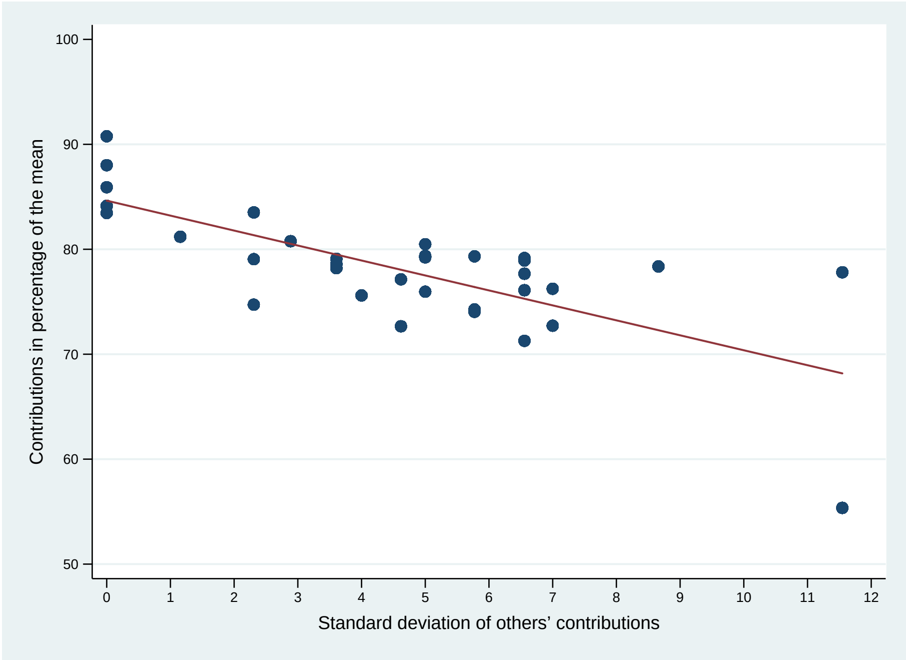
> **Observation 2:** *The higher the variation in others' individual contributions, the lower, on average, the own willingness to contribute.*

This result is nicely summarized by Figure 3.1. For conditional cooperators, it depicts average contributions as a percentage of the others' mean contribution depending on the standard deviation of their individual contributions.[15] As can be

[15]One possible objection of this analysis might be that the standard deviation of others' contri-

seen, relative contributions are highest when the other group members contribute equally, and decrease the higher the variance in others' contributions.

Figure 3.1: Contributions in percentage of the mean depending on the variation in others' contributions



The fact that the variation in others' contributions has a negative effect on cooperation already indicates that individuals are more guided by the lowest rather than the highest contributions of their group members. To investigate this more precisely, in model (3) we analyze which contribution is, on average, best in predicting individual behavior. We use the minimum, median, and maximum contribution of the other three group members as explanatory variables and, consequently, compare the relative importance of each of the factors. Testing the respective coefficients against each other, we find the minimum to be relatively more important than the median (Wald-test, $p = 0.044$) and the maximum (Wald-test, $p < 0.001$), and the median to be more important than the maximum (Wald-test, $p = 0.049$).[16] This means that

butions partly depends on the average. The reason is that by definition, for average contributions in the middle of the choice set higher standard deviations are possible than for averages at the boundaries. Yet, this is not the case for our selected cases. A Spearman's rank order correlation of the standard deviation and the average contribution yields only a very weak and insignificant relationship ($rho = 0.048$, $p = 0.784$).

[16]In an extensive analysis, we also check for individual differences in the reactions to the composition of others' contributions. Unfortunately, it is very difficult to directly test the average contribution against the three individual contributions because of perfect multicollinearity. Generally, when we separately compare correlations with own contributions, more people appear to condition primarily on the average contribution than on any of the individual contributions, but only a handful is perfectly described by the average. Since we are primarily interested in what

conditional cooperators are more likely to follow a bad example of a low contributor rather than a good example of a high contributor. This is a novel result as previous studies, restricted by their experimental design, could not investigate cooperation preferences in this detail.

3.5 Concluding Remarks

Our experiment demonstrates that the type of information people receive about others' public goods contributions affects own willingness to cooperate in systematic ways. In general, the willingness to give is significantly higher when others contribute equally compared to when contributions are more spread out or when only aggregate information is available. Furthermore, when providing full information about individual contributions, higher variation in others' contributions have, on average, a negative effect on the willingness to contribute. On the individual level, we find marked heterogeneity among conditional cooperators in what they condition their contributions on. A sizable fraction of subjects condition their behavior predominantly on the minimum contribution of others and are therefore primarily responsible for the aggregate effect. This is in line with the presence of a *bad apple effect* implying that people are more likely to follow the bad example of an uncooperative group member rather than the good example of a high contributor. While it is important to mention that all our results are based on our selection out of all possible cases and thus are not immediately generalizable, our approach constitutes a first step to investigate more deeply how preferences of cooperation depend on others' individual contributions.

Our study adds to the literature on conditional cooperation and the importance of social interaction effects in social dilemma situations. With regard to policy implications, our results suggest that policy makers striving to facilitate voluntary public goods provision should reveal previous individual behavior only if it is relatively uniform and instead give information about aggregate behavior if it varies a lot. Likewise, when constructing teams, forming groups of equal performers is generally preferable because in diverse teams, it is more likely that the negative effect of low

makes people deviate from the average, we estimate model (3) separately for each conditional cooperator and subsequently classify them according to which factor is best in predicting behavior. Overall, we find pronounced heterogeneity, yet in line with the aggregate results, there are more conditional cooperators who are mainly guided by the minimum rather than by the median or the maximum contribution. Notwithstanding, there is also a considerable fraction of individuals who condition their contributions on each of the three factors equally (indicated by an insignificant F-test between the three coefficients), and thus can be best described as true average types. The results of this analysis are available upon request.

performers outweighs any positive effects of the high performers. This, for example, highlights why firing shirking workers can have additional positive effects on the productivity of others.

3.6 Appendix to Chapter 3

A Descriptive statistics by treatment and case

Table 3.4: Average Contributions by Treatment and Case

Case	Contribution Vector	∅	Ind-Only	Ind-Avg	Ind-Pg	Avg		Ind (combined)
Uncond. Contrib	-	-	6.32	5.77	6.23	5.50		6.10
1	0/0/0	0	0.14	0.34	0.21	0.50		0.23
2	0/5/7	4	2.33	2.13	2.84	1.92	<*	2.41
3	5/5/5	5	3.11	3.00	3.39	2.33	<**	3.16
4	0/5/10	5	2.78	2.84	3.07	2.33	<*	2.89
5	0/5/13	6	3.39	3.34	4.00	2.78		3.56
6	0/0/20	7	2.70	3.30	2.43	3.30		2.83
7	5/5/10	7	4.28	3.83	4.21	3.30		4.10
8	4/4/12	7	3.44	3.77	4.54	3.30		3.89
9	6/6/10	7	4.25	4.22	4.68	3.30	<*	4.37
10	4/8/8	7	3.55	3.95	4.46	3.30		3.97
11	0/8/13	7	3.42	3.84	4.39	3.30		3.86
12	2/4/15	7	4.22	3.63	3.84	3.30		3.90
13	8/8/8	8	4.78	4.73	5.46	3.75	<*	4.97
14	5/5/15	8	4.72	4.33	4.52	3.75		4.52
15	4/8/12	8	4.30	4.33	4.34	3.75		4.32
16	0/11/13	8	4.19	4.27	4.55	3.75		4.33
17	2/7/15	8	4.06	4.23	4.38	3.75		4.22
18	3/8/13	8	4.45	3.95	4.52	3.75		4.30
19	8/8/12	9	5.30	4.75	5.09	4.02		5.04
20	4/12/12	9	4.55	4.59	5.25	4.02		4.78
21	8/10/10	9	5.06	4.81	5.16	4.02		5.01
22	6/8/13	9	5.06	4.75	4.91	4.02		4.91
23	2/10/15	9	4.58	4.84	4.84	4.02		4.75
24	5/10/12	9	5.19	4.64	5.18	4.02		4.99
25	10/10/10	10	6.17	6.36	6.46	4.88	<**	6.33
26	5/5/20	10	5.52	5.92	5.32	4.88		5.60
27	5/10/15	10	5.63	5.88	5.77	4.88		5.76
28	8/10/15	11	6.27	6.03	5.88	5.17		6.07
29	5/10/8	11	6.14	6.11	5.71	5.17		6.00
30	5/15/15	12	5.66	6.09	7.05	5.48		6.23
31	0/20/20	13	5.91	6.81	7.34	5.66		6.66
32	15/15/15	15	8.75	8.14	9.48	6.34	<**	8.76
33	10/15/20	15	7.98	7.28	8.20	6.34		7.80
34	10/20/20	17	7.50	8.16	8.91	7.22		8.16
35	20/20/20	20	10.16	9.39	11.61	8.38		10.33
Total	-	9	4.84	4.82	5.20	4.11		4.94

Note: Stars indicate significant effects on a * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$ level using a MWU-test.

B Classification of types

Following FGF, we categorize subjects in AVG as conditional cooperators if their contributions are monotonically increasing in the average contribution of the other group members, or exhibit a positive and significant (at the 1% level) Spearman's rank-order correlation coefficient between own and others' contributions. In the IND-treatments, we employ the same criteria as before, using the six no variance cases (0/0/0; 5/5/5; 8/8/8; 10/10/10; 15/15/15; 20/20/20) so that the lowest, median, average, and highest contribution all coincide (see Cheung (2012) for a similar approach). If subjects' contributions in these cases yield a positive and significant (on 5% level[17]) Spearman's rank-order correlation coefficient, or are monotonically increasing, we classify them as conditional cooperators. The distribution of types (see Table 3.5) is very similar and not significantly different between IND, AVG, and the original data from FGF (χ^2 - test: $p > 0.33$).

Table 3.5: Distribution of Types by Treatment

Type	FGF	AVG	IND
Conditional Cooperators	50.0% [22]	54.7% [35]	56.5% [104]
Free-rider	29.5% [13]	32.8% [21]	22.3% [41]
Others	20.5% [9]	12.5% [8]	21.2% [39]

Note: Number in brackets display absolute frequencies.

C Predictions Fehr and Schmidt model

In the FS-model, besides getting utility from their own monetary payoff π_i, individuals are assumed to endure envy costs α_i when their own payoff is lower than the payoff of others, and endure compassion costs β_i if it exceeds the payoff of others. In other words, individuals maximize the following utility function:

$$U_i(\pi_i, \pi_j) = \pi_i - \alpha_i \frac{1}{n-1} \sum_{j \neq i} \max[\pi_j - \pi_i, 0] - \beta_i \frac{1}{n-1} \sum_{j \neq i} \max[\pi_i - \pi_j, 0]$$

with $\alpha_i \geq \beta_i$ and $0 \leq \beta_i < 1$, assuring that envy looms larger than compassion and individuals never destroy their own payoff to decrease their costs of compassion.

[17] We lower the threshold to 5% because we only have six cases instead of 21 in AVG. If we would also use this lower threshold in AVG, we would get exactly the same classification because all p-values of the Spearman rank-correlations that are below 5% are also below 1%.

Proposition:

According to the FS-model, in our public goods game a player never contributes more than the minimum of the other group members' contributions.

Proof:

Without loss of generality, assume that player 4 observes contributions $c_1 \leq c_2 \leq c_3$ from her group members 1, 2, and 3, respectively. She then chooses her contribution c_4 to maximize the utility function mentioned above. With $\pi_i = 20 - c_i + 0.4 \cdot (c_1 + c_2 + c_3 + c_4)$ for $i \in 1, 2, 3, 4$, player 4's utility is given by:

$$
\begin{aligned}
U_4\left(c_1, c_2, c_3, c_4\right) = {} & 20 - c_4 + 0.4 \cdot (c_1 + c_2 + c_3 + c_4) \\
& - \frac{\alpha_4}{3}\left(\max\left[c_1 - c_4, 0\right] + \max\left[c_2 - c_4, 0\right] + \max\left[c_3 - c_4, 0\right]\right) \\
& - \frac{\beta_4}{3}\left(\max\left[c_4 - c_1, 0\right] + \max\left[c_4 - c_2, 0\right] + \max\left[c_4 - c_3, 0\right]\right)
\end{aligned}
$$

Note that because of the linearity of the public good game and the symmetry of the group members' payoff function, differences in contributions translate one-to-one into differences in payoffs. Therefore, depending on where c_4 ranks among all contributions, increasing the contribution of player 4 by one unit changes her utility by the following amounts:

$$
\frac{\partial U_4}{\partial c_4} = \begin{cases}
-0.6 + \beta_4 & if \quad c_4 < c_1 \leq c_2 \leq c_3 \\
-0.6 + \frac{2}{3}\beta_4 - \frac{1}{3}\alpha_4 & if \quad c_1 \leq c_4 < c_2 \leq c_3 \\
-0.6 + \frac{1}{3}\beta_4 - \frac{2}{3}\alpha_4 & if \quad c_1 \leq c_2 \leq c_4 < c_3 \\
-0.6 - \alpha_4 & if \quad c_1 \leq c_2 \leq c_3 \leq c_4
\end{cases}
$$

Given the model's assumptions of $\alpha_i \geq \beta_i$ and $0 \leq \beta_i < 1$, only the first expression can be positive, hence the utility maximizing contribution for player 4 is:

$$
c_4^* = \begin{cases}
0 & if \quad \beta_4 < 0.6 \\
c_1 & if \quad \beta_4 \geq 0.6
\end{cases}
$$

i.e., player 4 free-rides if her strength of compassion is lower than a threshold value $\widetilde{\beta} = 0.6$, and matches the lowest contribution of the other group members c_1 exactly if β_4 exceeds that threshold. Although further increasing her contributions would decrease advantageous inequity with regard to the two highest contributors in the group, this would also decrease her own material payoff and increase disadvantageous inequity with regard to the lowest contributor. However, this can never increase her utility because $-0.6 + \frac{2}{3}\beta_4 - \frac{1}{3}\alpha_4 < 0$ for all $\alpha_4 \geq \beta_4$ and $0 \leq \beta_4 < 1$.

Hence, players with FS-preferences will never contribute more than the lowest contribution of the other three group members. ■

D Predictions Bolton and Ockenfels model

The BO-model postulates that individuals maximize their motivation function given by $v_i(y_i, \sigma_i)$ with y_i being the individual's payoff and σ_i the individual's share of the total payoff. By assumption, $v_{i1}(y_i, \sigma_i) \geq 0$, $v_{i11}(y_i, \sigma_i) \leq 0$, $v_{i2}(y_i, \sigma_i) = 0$ if $\sigma_i = \frac{1}{n}$ (where n is the number of players) and $v_{i22}(y_i, \sigma_i) < 0$. In other words, ceteris paribus, individuals prefer more money over less and prefer to receive the equal split.

Proposition:

Individuals with ERC-preferences never contribute more than the average contribution of the other group members. Furthermore, the composition of individual contributions that make up that average does not matter for contribution behavior.

Proof:

Without loss of generality, assume that player 4 observes contributions c_1, c_2, and c_3 from her group members 1, 2, and 3, respectively. Let $C_{123} \equiv c_1 + c_2 + c_3$. It follows that

$$y_4 = 20 - c_4 + 0.4 \cdot (C_{123} + c_4)$$

and

$$\sigma_4 = \frac{20 - c_4 + 0.4 \cdot (C_{123} + c_4)}{80 + 0.6 \cdot (C_{123} + c_4)}.$$

so both the player's material payoff, y_4, and her relative share, σ_4 strictly decreases in c_4, i.e., $\frac{\partial y_4}{\partial c_4} < 0$ and $\frac{\partial \sigma_4}{\partial c_4} < 0$. For any given C_{123}, c_4 determines both, y_4 and σ_4, so we can write $v_4(y_4(c_4), \sigma_4(c_4))$ or $v_4(c_4)$. The first derivative of v_4 with respect to c_4 has two components: The payoff effect

$$\underbrace{v_4^1\left(y_4(c_4), \sigma_4(c_4)\right)}_{\geq 0} \cdot \underbrace{y'(c_4)}_{=-0.6} \leq 0$$

and the relative share effect

$$\underbrace{v_4^2\left(y_4(c_4),\sigma_4(c_4)\right)}_{\substack{<0 \text{ if } c_4 < C_{123}/3 \\ =0 \text{ if } c_4 = C_{123}/3 \\ >0 \text{ if } c_4 > C_{123}/3}} \cdot \underbrace{\sigma'(c_4)}_{<0}$$

which is positive if $c < C_{123}/3$, zero if $c = C_{123}/3$, and negative if $c > C_{123}/3$. When $v_4(y_4(c_4),\sigma_4(c_4))$ is maximized, it follows that $v_4'(y_4(c_4),\sigma_4(c_4)) = 0$, hence

$$v_4^1\left(y_4(c_4),\sigma_4(c_4)\right) \cdot y_4'(c_4) + v_4^2\left(y_4(c_4),\sigma_4(c_4)\right) \cdot \sigma_4'(c_4) = 0$$

which requires $c_4 \leq C_{123}/3$. Therefore, the player never contributes more than the average contribution of the other three group members. Furthermore, since all expressions only depend on the sum C_{123} and not on the individual contributions c_1, c_2, and c_3, changing the composition of C_{123} does not influence own contributions in the BO-model. ■

E Predictions Charness and Rabin model[18]

The CR-model assumes that individuals maximize the following utility function:

$$\begin{aligned} U_i\left(\pi_1,\pi_2,\ldots,\pi_N\right) = (1-\lambda)\pi_i + \lambda\,[\delta \cdot \min\left[\pi_1,\pi_2,\ldots,\pi_N\right] \\ + (1-\delta)(\pi_1+\pi_2+\ldots+\pi_N)] \end{aligned}$$

with π_i being individual i's payoff, $\lambda \in [0,1]$ the strength of social concern compared to material self-interest and $\delta \in [0,1]$ the strength of Rawlsian concern for the individual with the lowest payoff compared to concerns for efficiency.

Proposition:

According to the CR-model, individuals are either willing to contribute irrespective of other group members' contributions to increase overall efficiency, or are willing to contribute up to the maximum contribution of the other group members to increase the lowest overall payoff.

Proof:

Without loss of generality, assume that player 4 observes contributions $c_1 \leq$

[18]For comparability with the other two models, we apply the outcome-based version of the CR-model without reciprocity.

$c_2 \leq c_3$ from her group members 1, 2, and 3, respectively. She then chooses her contribution c_4 to maximize her utility function given by:

$$U_4\left(c_1, c_2, c_3, c_4\right) = (1-\lambda)(20 - c_4 + 0.4 \cdot \sum_{j=1}^{4} c_j)$$
$$+ \lambda \left[\delta \cdot \min \left[20 - c_3 + 0.4 \cdot \sum_{j=1}^{4} c_j, 20 - c_4 + 0.4 \cdot \sum_{j=1}^{4} c_j \right] \right.$$
$$\left. + (1-\delta)(80 + 0.6 \cdot \sum_{j=1}^{4} c_j) \right]$$

We have to differentiate between two cases depending on whether player 4 is the highest contributor or not, i.e., depending on where c_4 ranks compared to the highest contribution of the other group members c_3, increasing the contribution of player 4 by one unit changes her utility by the following amounts:

$$\frac{\partial U_4}{\partial c_4} = \begin{cases} 1.2\lambda - 0.2\lambda\delta - 0.6 & if \quad c_4 < c_3 \\ 1.2\lambda - 1.2\lambda\delta - 0.6 & if \quad c_4 \geq c_3 \end{cases}$$

From this it follows that

$$c_4^* = \begin{cases} 0 & if \quad \lambda < \frac{1}{2(1-\frac{1}{6}\delta)} \\ c_3 & if \quad \frac{1}{2(1-\frac{1}{6}\delta)} \leq \lambda < \frac{1}{2(1-\delta)} \\ 20 & if \quad \lambda > \frac{1}{2(1-\delta)} \end{cases}$$

i.e., player 4 free-rides if her overall social concern λ is lower than a lower threshold $\underline{\lambda} = \frac{1}{2(1-\frac{1}{6}\delta)}$. Depending on the player's concern for helping the worst-off player versus maximizing total social surplus δ, this threshold can take values between 0.5 (for $\delta = 0$) and 0.6 (for $\delta = 1$), i.e., the threshold for contributing a positive amount is monotonically increasing in δ. Given λ exceeds this threshold, player 4 exactly matches the highest contribution of the other group members c_3 if λ is smaller than an upper threshold $\overline{\lambda} = \frac{1}{2(1-\delta)}$, and contributes fully if λ also exceeds $\overline{\lambda}$. Note that $\underline{\lambda} \leq \overline{\lambda}$ for all $\delta \in [0, 1]$. Furthermore, note that $\overline{\lambda}$ can, in principle, take values between 0.5 (for $\delta = 0$) and infinity (for $\delta = 1$). However, as $\lambda \in [0, 1]$, $\lambda \geq \overline{\lambda}$ can only be fulfilled as long as $\delta \leq \frac{1}{2}$. Taken together, player 4 free-rides if her overall social concern is low. If she does not free-ride, she contributes her full endowment if her efficiency concern is sufficiently strong compared to her Rawlsian concerns, and matches the highest contribution of her group members otherwise. ■

F Experimental instructions for the Ind-Only treatment (translated from German)[19]

You are now taking part in an economic experiment. If you read the following instructions carefully, you can - depending on your decisions - earn a considerable amount of money in addition to the 2.50 Euro which you receive in any case for participating in the experiment. The entire amount of money which you earn with your decisions will be added up and paid to you in cash at the end of the experiment.

These instructions are solely for your private information. You are not allowed to communicate during the experiment. If you have any questions, please ask us. The violation of this rule will lead to the exclusion from the experiment and all payments. If you have questions, please raise your hand. A member of the experimenter team will come to you and answer them in private. During the experiment we do not speak of Euros, but of points. Your whole income will first be calculated in points. At the end of the experiment, the total amount of points you have earned will be converted to Euros at the following rate:

$$1 \text{ point} = 50 \text{ Cents}$$

Please also note the following:

- All participants will be randomly divided into groups of four members. Except for the experimenters, no one knows who is in which group.
- All decisions are made anonymously, i.e., no other participants will know the identity of someone who has a made a decision.
- The payment at the end of the experiment is also made anonymously, i.e., no participant will know another participant's payment.

<u>The decision situation</u>

You will learn how the experiment will be conducted later. We first introduce you to the basic decision situation.

You will be a member of a group consisting of 4 people. Each group member has to decide on the allocation of 20 points. You can put these 20 points into your private account or you can invest them fully or partially into a project. Each point you do not invest into the project automatically remains in your private account. Thus, you and the members of your group have to decide how many points you want to invest in the project and how many points you want to keep for yourself.

[19] The instructions for the other treatments are very similar any available upon request.

All group members make their decisions simultaneously. This means that nobody is informed about the other group members' decisions before making his or her own decision.

Your income from the private account

For each point you put into your private account you will exactly earn one point. For example, if you put 20 points into your private account (and therefore do not invest into the project), your income will amount to exactly 20 points out of your private account. If you instead put 6 points into your private account, your income from this account will be 6 points. No one except you earns something from your private account.

Your income from the project

Each group member will benefit equally from the amount you invest into the project. On the other hand, you will also benefit from the other group members' investments. The income for each group member will be determined as follows:

Income from the project = Sum of all contributions × 0.4

If, for example, the sum of all contributions to the project is 60 points, then you and the other members of your group each earn $60 \times 0.4 = 24$ points from the project. If the four members of the group contribute a total of 10 points to the project, you and the other members of your group each earn $10 \times 0.4 = 4$ points.

Total income

Your total income is calculated as follows:

Income from your private account (= 20 - contribution to the project)
+ income from the project (= 0.4 × sum of all contributions to the project)
= Total income

Example 1:

Every group member has 20 points. Assume you contribute 4 points to the project and every other group member each contributes 8 points to the project. Your income from your private account then amounts to 20-4=16 points. Your income from the project amounts to $0.4 \times (4+8+8+8) = 0.4 \times 28 = 11.2$ points in this case. Altogether your total income amounts to $16 + 11.2 = 27.2$ points. Your group members each receive $20 - 8 = 12$ points from their private account and

$0.4 \times (4+8+8+8) = 0.4 \times 28 = 11.2$ points from the project. Altogether each of your group members receives a total income of $12 + 11.2 = 23.2$ points.

Example 2:

Every group member has 20 points. Assume you contribute 16 points to the project and all your group members each contribute 12 points to the project. Your income from your private account then amounts to $20 - 16 = 4$ points. Your income from the project amounts to $0.4 \times (16 + 12 + 12 + 12) = 0.4 \times 52 = 20.8$ points. Altogether your total income amounts to $4 + 20.8 = 24.8$ points. Your group members each receive $20 - 12 = 8$ points from their private account and $0.4 \times (16+12+12+12) = 0.4 \times 52 = 20.8$ points from the project. Altogether each of your group members receives a total income of $8 + 20.8 = 28.8$ points.

Before explaining the exact sequence of the experiment, we ask you to answer some control questions regarding the decision situation. They are meant to increase your familiarity with the decision situation and make sure that each participant has fully understood the instructions.

Please answer the following questions

Every group member has 20 points. Assume that the four group members (including you) each contribute 0 points to the project.

Question 1: What is your total income in this case (in points)?

Question 2: What is the total income of each of the other group members in this case (in points)?

Every group member has 20. You contribute 20 points to the project. The three other group members also each contribute 20 points to the project.

Question 3: What is your total income in this case (in points)?

Question 4: What is the total income of each of the other group members in this case (in points)?

Every group member has 20 points. The three other group members together contribute a sum of 30 points to the project.

Question 5: What is your total income in this case (in points) if you contribute - in addition to the 30 points of the other three group members - 0 points to the project?

Question 6: What is your total income in this case (in points) if you contribute - in addition to the 30 points of the other three group members - 10 points to the project?

Question 7: What is your total income in this case (in points) if you contribute - in addition to the 30 points of the other three group members - 20 points to the project?

The Experiment

The experiment includes the decision situation just described. The decisions you make in this experiment will be paid in cash after the experiment.

As you know, you will have 20 points at your disposal which you can either place in your private account or contribute to the project. Each subject has to make two types of contribution decisions in this experiment, which we will refer to below as the "Contribution of Type I" and "Contribution of Type II". On the next page you will find detailed instructions on how to make your two decisions concerning your contribution.

Contribution of Type I

In the Contribution of Type I you decide how many of your 20 points you want to contribute to the project. Then you enter this amount into the input box.

Contribution of Type II

Your second task will be to make a decision on your Contribution of Type II. This decision will be made by completing a contribution table. In this contribution table you will find different possible combinations of contributions of the other group members. For each of these combinations you have to decide how much you want to contribute given these circumstances. That way, you can make your contribution decision conditional on the contributions of the other group members. This will be immediately clear to you if you take a look at the following table. The contribution table will appear immediately after you have determined your Contribution of Type I.

Contribution I	Contribution II	Contribution III	Your Contribution
0	5	10	

The numbers in the first three columns are possible Contributions of Type I to the project by the other group members. In the Contribution of Type II you simply have to enter the amount of points you want to contribute if the other group members decided to contribute the given amounts as their Contribution of Type I. For example, you can enter how many points you contribute to the project if one group member contributed 0 points, another 5 points and the last one 10 points to the project.

All in all you will be shown 36 of such contribution situations. Please note, that for each contribution situation you have to enter a number in the corresponding input box. Also, please note that the Contributions of Type I for the other group members are given in ascending order and therefore do not allow any inference on the identity of the group members.

Experiment Payoff

After each participant in every group has made their Contributions of Type I and Type II, three members of each group are chosen randomly. For these randomly chosen members, only their Contribution of Type I are payoff-relevant, meaning that those three randomly chosen members contribute their Contribution of Type I to the project. For the fourth group member, who was not chosen randomly, only the contribution table (Contribution of Type II) is payoff-relevant. The contribution situation from the contribution table that is relevant will be determined by the Contributions of Type I of the other three randomly chosen group members, meaning that the fourth group member contributes the amount stated in the corresponding contribution situation. The two following examples will clarify this.

Important:

- The experiment will only be conducted once, meaning that every decision is made only once.
- When you decide on your Contribution of Type I and II, you do not know whether you will be chosen by the random mechanism. Therefore, you have to carefully think about both your contribution decisions, as both of these can become relevant for your payoff.
- For each group member, it is made sure that one of the contribution situations in the table corresponds to the Contributions of Type I of the other group members.

Example 3:

Assume that the random mechanism did not choose you, meaning that your contribution table is relevant for your payoff. For the other three members of the group, the Contribution of Type I is relevant for payoff. Assume the other three group members decided to contribute 0 points, 2 points and 4 points to the project on their Contributions of Type I. If you have entered in your contribution table for the entry 0/2/4 that you will contribute 1 point, the total contribution of your group to the project will be given by $0 + 2 + 4 + 1 = 7$. Every group members therefore earns $0.4 \times 7 = 2.8$ points from the project plus their respective income from their private account. If you have instead entered in your contribution table that you will contribute 19 points when the other three members contribute 0, 2 and 4 points, the total contribution of the group to the project is given by $0+2+4+19 = 25$ points. All group members therefore earn $0.4 \times 25 = 10$ points from the project plus their respective income from their private account.

Example 4:

Assume you have been chosen by the random mechanism, meaning that for you and two other group members your Contribution of Type I is relevant for payoff. Your Contribution of Type I is 16 points, the Contributions of Type I of the other two group members are 18 and 20 points. If for the entry 16/18/20 the one group member who was not randomly chosen now entered a contribution of 1 point when the other three members contribute 16, 18 and 20 points, the total contribution of the group to the project will be given by $16 + 18 + 20 + 1 = 55$ Points. Every group member therefore earns $0.4 \times 55 = 22$ points from the project plus the respective income from their private account. If instead the group member that was not randomly chosen entered in her contribution table that she contributes 19 points, when the other three members contribute 16, 18 and 20 points, the total contribution of the group to the project will be given by $16 + 18 + 20 + 19 = 73$ points. Every group member therefore earns $0.4 \times 73 = 29.2$ points from the project plus the respective income from their private accounts.

Please answer the following questions

Every group member has 20 points. Assume the Contributions of Type I are given by the following distribution: You: 10 points, group member 1: 5 points, group member 2: 10 points, group member 3: 15 points. Assume that the random mechanism did not choose you, meaning your contribution table (Contribution of Type II) is relevant for your payoff. For the three other members of the group, the Contribution of Type I is relevant for payoff.

Question 8: What is your total income in this case (in points), if you entered in your contribution table for the entry (5, 10, 15) that you will contribute 20 points to the project?

Now assume that you, group member 1 and group member 3 have been chosen by the random mechanism, meaning that for you, group member 1 and group member 3 the respective Contribution of Type I is relevant for pay-off. For group member 2, which was not randomly chosen, the contribution table is relevant for payoff.

Question 9: What is your total income in this case (in points), if group member 2 entered in her contribution table for the entry (5, 10, 15) a contribution of 0 points to the project?

Chapter 4

Achieving Good or Preventing Bad - On the Effects of Losses on Cooperation

4.1 Introduction

Very often seemingly different decision situations inhere similar strategic circumstances. Likewise, in many cases the same decision problem can be represented in more than one way. An important question is whether economic actors behave equally in such situations or whether they are prone to be influenced by the respective representation. According to rational choice theory, different formulations of a logically equivalent problem should not affect behavior. Yet, evidence from experiments in psychology and economics suggest that description often does matter to preferences and choice (Pruitt, 1967; Selten and Berg, 1970). Such evidence have been subsumed under the term *framing effect* which is said to be present when different representations of the same decision situation lead individuals to change behavior, even though the underlying information and decision options remain essentially the same (Cookson, 2000).[1] In this study we investigate to what degree people's willingness to cooperate is affected by framing effects. In particular, we are interested in the interplay of (frame-induced) loss aversion and cooperation, i.e., we want to examine whether people are more or less likely to cooperate when this leads to the achievement of something good compared to when it leads to the prevention of something bad. For instance, while cooperation within a team that is striving

[1] As argued by Rabin (1998), one reason for such a framing effect is that even if two different descriptions of a problem are logical equivalent, this does not necessarily imply that they are also transparently equivalent, i.e., "... the presentation of a choice may draw our attention to different aspects of a problem, leading us to make mistakes in pursuing our true, underlying preferences."

for the completion of a project can be seen as an example for achieving something good, the original description of the prisoner's dilemma in which two prisoners who have to remain silent to avoid being imprisoned for long can be seen as an example for preventing something bad.

One related question behind this idea is whether people take into account and empathize with losses of others. So far, a huge amount of studies from the social sciences has provided overwhelming and robust evidence for two behavioral regularities in human decision making: *(i)* social preferences and *(ii)* loss aversion. The former refers to people's tendency to not only care about the own but also about the well-being of others (cf. Sobel, 2005; Cooper and Kagel, 2009, for a survey). The latter refers to people's tendency to evaluate outcomes as gains and losses relative to some reference point rather than in absolute terms, and to perceive losses to loom larger than similar-sized gains (Kahneman and Tversky, 1979). As a consequence, a given choice might be evaluated as less attractive when framed as a loss rather than framed as a gain. While framing and loss aversion has been primarily studied on an individual level, social preferences by definition needs at least two individuals to be involved. Yet, to the best of our knowledge little is known about the interaction of these two concepts and whether they can be combined.

In the present study we therefore try to combine both notions by analyzing framing effects with respect to gains and losses in a social dilemma game, in which outcomes not only depend on the own but also on the decision of others. Social dilemma games have a long tradition in economic research and are frequently used to study problems of cooperation and to investigate the presence of social preferences. The distinctive feature of social dilemmas is that they reflect a variety of important challenges in social and economic life such as environmental protection, voluntary provision of public goods, participation in collective action, tax compliance, or teamwork. As diverse as these examples appear, they can all be thought of as special cases of a more general problem in which individual and collective interests are at odds. This typically leads to an inefficient underprovision of the common good (Samuelson, 1954; Olson, 1965; Hardin, 1968). In game theory, one of the most prominent and simplest examples of such a situation is the so-called prisoner's dilemma in which two players have to simultaneously decide whether to cooperate or not.

In this study we examine such a prisoner's dilemma game and experimentally manipulate the framing of the decision situation. In four different treatments, we either induce a gain- or loss-framing (or a combination of both), and subsequently study whether and to what degree people's willingness to cooperate is sensitive to such framing. In line with previous studies, the results of our experiment indicate the presence of a significant framing effect on cooperation.[2] Yet, because of the simultaneous move structure of our design, we cannot disentangle the effects of beliefs and actions which we find both to be affected by our framing. Although treatment differences in behavior could, in principle, be perfectly explained by the differences in beliefs, this would only shift the focus from the behavioral level to the level of beliefs which would leave us with the question why expectations are so different across treatments. As a consequence, we (unfortunately) cannot conclusively answer the question of how loss aversion and the willingness to cooperate interact with each other. If anything, our results indicate that the involvement of losses tends to make people less cooperative. In order to gain a deeper understanding of our findings, it is planned to conduct a follow-up experiment in which the effects of beliefs on behavior are ruled out by design, for example by implementing a sequential-move structure.[3]

The remainder of this paper is structured as follows. In the next Section we provide an overview about the literature of framing effects and discuss how our experiment relates to it. After that, Section 3 describes the experimental design, the behavioral predictions, and the experimental procedures. The experimental results are presented and discussed in Section 4. Finally, Section 5 concludes.

4.2 Related Literature

By now there is a rich body of evidence suggesting the presence of framing effects. While research on this topic has been carried out in many different domains, the term framing effect has been largely coined by the psychologists Amos Tversky and Daniel Kahneman. In numerous studies they show that the way in which a task is framed significantly affects individual decision making. For example, in their experiment on the famous Asian disease problem (Tversky and Kahneman, 1981), they find that the majority of subjects is willing to take risks when the task is framed negatively, but tend to be risk-averse when being confronted with a positive-framed version of the problem.[4]

While these authors mainly focus on individual choice tasks, the question of how framing affects judgments and decision making has also been examined in more complex situations. Starting with Deutsch (1958), many subsequent studies have

[2]See the next section for a discussion of the related literature.

[3]See Section 5 for a more detailed discussion of possible solutions that improve our design and circumvent this problem.

[4]See Kühberger (1998) for a meta-analysis of the influence of framing on risky decisions.

investigated how different kinds of frame manipulations affect people's willingness to cooperate in social dilemma situations. While some studies have focused on the effects of different labels/wordings of e.g. the game, players, or actions, other studies have analyzed to what degree cooperation levels depend on whether essential information about the game are represented in a positive or negative light. While the latter manipulation is often referred to as *valence framing* (Levin et al., 1998), the former is sometimes called *label framing* (Dufwenberg et al., 2011) or *pure framing effect* (Elliott et al., 1998).

A well-known example for a pure labeling effect is given by Liberman et al. (2004). In their experiment they find that cooperation rates in a prisoner's dilemma are significantly higher when the game is called "Community Game" compared to when it is called "Wall Street Game".[5] In contrast, a typical example for valence framing is to compare so-called *give-some* and *take-some* social dilemma games. While in a give-some dilemma (or public goods dilemma), individuals have to decide how much of their resources they want to contribute to a common pool, in a take-some dilemma (or common-pool resource dilemma), individuals have to decide how many resources they want to withdraw from it. Although being strategically equivalent, the two games differ with regard to where the resources are allocated initially. As a consequence, whereas in the former the externality on others is positive (giving increases social welfare), in the latter it is negative (taking decreases social welfare).[6]

This difference has been shown to affect judgment of decisions by shedding different light on the possible alternatives. While in give-some games failing to cooperate can be described as an act of omission, in take-some games the corresponding equivalent of taking is an act of commission. In a recent experiment, Cubitt et al. (2011) find that subjects tend to judge the latter to be less immoral than the former. Interestingly, in social psychology some studies report an opposite effect called *omission bias* (Baron, 1988). For instance, Spranca et al. (1991) find that subjects evaluate harmful commissions as worse or less moral than equally harmful omissions. In line with this inconsistent evidence, on a behavioral level the results on framing effects in social dilemmas are rather mixed, too. While contributions are often found to be higher under a give- than under a take-frame (Andreoni, 1995; Sonnemans et al., 1998; Willinger and Ziegelmeyer, 1999; Park, 2000; Cookson, 2000), other studies

[5] Rege and Telle (2004), Dufwenberg et al. (2011), and Ellingsen et al. (2012) provide further examples for label-framing effects.

[6] As argued by Apesteguia and Maier-Rigaud (2006), there is an additional difference between public goods and common resource games making them not completely identical. While the former is characterized by non-excludability and non-rivalry, the latter is also non-excludable but possibly rival.

report neutral (Cubitt et al., 2011; Dufwenberg et al., 2011) or even opposite effects (Brewer and Kramer, 1986; McCusker and Carnevale, 1995; Sell and Son, 1997). Although these studies partly differ with regard to their experimental design, in general it can be concluded that the evidence for framing effects in social dilemma games is less conclusive than for individual decision tasks (Levin et al., 1998; Kühberger et al., 2002).[7]

In the past, framing effects have commonly been interpreted as evidence against standard expected utility theory and as a violation of rationality. A possible explanation that has been put forward is prospect theory (Kahneman and Tversky, 1979; Tversky and Kahneman, 1991) that comprises many features that help to fit the observed data from individual decision tasks. In strategic games, however, several different explanations are conceivable and there is no unique "theory of framing" that is consistent with the observed behavioral patterns. Two recent studies experimentally discriminate between some of the proposed explanations and provide insightful evidence that helps to better understand the underlying principle of framing and its effects on decision making. In a one-shot public goods game, Dufwenberg et al. (2011) find that framing affects not merely subjects' behavior but also their first- and second-order beliefs. By applying their results to psychological game theory, they suggest that framing effects can be understood as a two-part process where, as a first step, frames move beliefs, and, as a second step, beliefs shape motivation and choice. Ellingsen et al. (2012) provide further evidence for that frames enter people's beliefs rather than their preferences. In a prisoner's dilemma game they find framing effects to only be in place when the game is played simultaneously (and beliefs might be relevant for choices), but not when it is played sequentially (and beliefs should not matter for decisions).[8] They conclude that in a game with multiple equilibria, frames may put different emphasis on actions and, thereby, serve as a coordination and equilibrium selection device.[9] Both studies have in common that they make no reference to irrationality but explain framing effects within a rational-choice-based framework.

Yet, as suggested by Ellingsen et al. (2012), further studies are needed to test

[7] See also Goerg and Walkowitz (2010) who, using participants from four different countries, report subject-pool effects in the prevalence of framing effects on cooperation.

[8] Note that in contrast to Dufwenberg et al. (2011), they only make reference to first-order beliefs, i.e., beliefs about other player's actions. They thus do not test whether behavior might be influenced by, e.g., guilt aversion via second-order beliefs.

[9] Note that if individuals are completely selfish, there is only one Nash equilibrium in the prisoner's dilemma game. However, if people do not only care about maximizing own payoffs but exhibit some form of other-regarding preferences (cf. Sobel, 2005; Cooper and Kagel, 2009, for an overview), the game may turn into a Stag hunt game in utilities with multiple Pareto ranked equilibria (cf. Rabin, 1993; 1998; Fehr and Schmidt, 1999; Gächter and Fehr, 1999).

the robustness of these results. The experiment reported in this study is a first attempt to contribute to this request by applying a different kind of framing than they do. While Ellingsen et al. (2012) use a label framing ("Stock Market Game" vs. "Community Game"), in our experiment we induce a gain- or loss framing (or a combination of both) by varying an endowment subjects receive in addition to their payoff from the prisoner's dilemma which is adjusted accordingly. Although in some respects our manipulation is similar to the give- vs. take-framing, it also differs from that in important ways. First of all, the way in which the decision situation is described is quite different between both approaches. Second, while in the give- vs. take-framing actions have different connotations inducing different (moral) judgments (see discussion above), this is less likely in our experiment as actions in all treatments have the same label and reflect the same act. Last, while in the former, subjects usually can either only take or only give, we gradually shift payoffs from gains to losses. When transforming our game into a common resource game, this would imply that subjects can both, take and give.

Besides that, an additional advantage of our experimental design is that unlike many of the other studies cited above, we study a one-shot instead of a repeated game. The major advantage of one-shot games is that they eliminate confounding effects that might arise from strategic considerations in repeated interactions and, thus, allow for a cleaner test for the existence of framing effects (Cubitt et al., 2011). In the following, we explain our experimental design in more detail.

4.3 The Experiment

4.3.1 Experimental Design

The underlying decision situation of our experiment is a prisoner's dilemma game (PD) in which two players simultaneously and independently of each other have to decide whether to *cooperate (C)* or to *defect (D)*. The important property of this game is that individual incentives are such that the collective desirable outcome is often not reached. In particular, if agents are purely selfish, there is a clear behavioral prediction: Action D is the strictly dominant strategy because irrespective of the other player's decision, it yields a higher payoff than choosing C. Therefore, $(D,\ D)$ the only Nash equilibrium of the one-shot game.[10] Yet, this outcome is Pareto-dominated by the situation in which both players cooperate which leads to

[10] If the game is played repeatedly (*iterated PD*) with the final period being unknown to the players, an equilibrium with mutual cooperation can be sustained (see Axelrod, 1980, for a test of different strategies that facilitate cooperation).

the social efficient outcome that maximizes joint payoffs.

Table 4.1: Game Matrix Prisoner's Dilemma

	Cooperate	Defect
Cooperate	$a-e$; $a-e$	$d-e$; $c-e$
Defect	$c-e$; $d-e$	$b-e$; $b-e$

Within this basic setting, we investigate whether and, if so, to what degree people's willingness to cooperate depends on the *framing* of the decision situation. In a *between-subjects design* we conduct four different treatments in which we vary the initial endowment each player receives. At the same time, we adjust the payoffs of the PD game accordingly such that economic incentives are completely identical in all four treatments.

The general structure of the PD game is illustrated in Table 4.1 showing individual payoffs depending on both player's action, with $c > a > b > d$ being fixed numbers and e being the initial endowment given to the subjects. Importantly, while in all four treatments parameters a, b, c, and d are identical and set equal to $a = 2$, $b = 1$, $c = 2.5$, and $d = 0.5$ (in €), the endowment e varies across treatments. In particular, starting from treatment 1 to 4, we stepwise increase the endowment from €0 to €3 by increments of €1, and simultaneously lower the payoffs in each cell of the respective matrix by the same amount. This leads to the payoff matrices displayed in Table 4.2(a), (b), (c), and (d) which the subjects face in treatments 1, 2, 3, and 4 of the experiment, respectively.[11]

Our two main treatments are depicted by the payoff matrices in 4.2(a) and 4.2(d) which either contain only positive (Gain) or only negative outcomes (Loss). The comparison of these two treatments should give us a benchmark about how behavior depends on whether the game is framed in terms of gains or losses. The other two treatments are intermediate treatments in which some of the payoffs are positive and some are negative. We refer to them as Int-I and Int-II. Together with the first two treatments this allows us to gradually investigate the effects of shifting payoffs from the gain into the loss domain.

[11]Note that while in Table 4.1 and 4.2 we use the terms "cooperate" and "defect", in the experiment we use a neutral language and refer to these actions as "option A" and "option B", respectively. The numbers in the payoff matrices represent Euro amounts. The experimental instructions and a screenshot of the decision situation can be found in the appendix.

Table 4.2: Experimental Treatments

	Cooperate	Defect
Cooperate	2.00; 2.00	0.50; 2.50
Defect	2.50; 0.50	1.00; 1.00

(a) GAIN: Endowment = 0

	Cooperate	Defect
Cooperate	1.00; 1.00	-0.50; 1.50
Defect	1.50; -0.50	0.00; 0.00

(b) INT-I: Endowment = 1

	Cooperate	Defect
Cooperate	0.00; 0.00	-1.50; 0.50
Defect	0.50; -1.50	-1.00; -1.00

(c) INT-II: Endowment = 2

	Cooperate	Defect
Cooperate	-1.00; -1.00	-2.50; -0.50
Defect	-0.50; -2.50	-2.00; -2.00

(d) LOSS: Endowment = 3

4.3.2 Behavioral Predictions

As discussed above, standard expected utility theory yields the same equilibrium prediction irrespective of the frame. It thus cannot explain possible treatment differences in terms of behavior. The most common and best-developed alternative theory that has been proposed to explain the occurrence of framing effects is prospect theory (see above). While this theory of reference-dependent preferences has originally been formulated to deal with individual decision problems, some studies have tried to also apply some of its features to strategic environments (cf. Sell and Son, 1997; Iturbe-Ormaetxe et al., 2011). Comparing take-some and give-some games, they conclude that contributions should be higher under the take- than under give-frame. This prediction rests on their assumption that individuals take the status quo as the reference point which in case of a public goods game is owning the private good, and in the case of a resource game it is owning the common good. Because prospect theory implies loss aversion which predicts that individuals value things they own more than ones they do not (*endowment effect*), this should induce group members to not contribute in the former and to cooperate (not take) in the latter. However, as pointed out by Cookson (2000), in social dilemma games it is not so clear what serves as a reference point. The reason is that in these games, individuals' income consists of two components: the private and the common good. As a consequence, depending on which component is made more salient, under the give-frame contributing can either be seen as a gain (increasing the income from the public good) or as a loss (decreasing income from the private good). Similarly, under the take-frame the reference point could be thought of as starting with nothing in the private account and having the opportunity to gain, or, alternatively, as starting with everything in the public account and being confronted with the possibility of a loss.

Given the description and presentation of our PD game, however, we argue that our experimental design leaves less scope for such ambiguity in what serves as the reference point. The reason is that instead of referring to a public and a private account, we endow subjects with a fix endowment that is not affected by choices, and present payoff consequences as gains and losses relative to this endowment. Because of that, using this endowment as the reference point seems to be most natural and plausible in our context. Of course, it could also be that subjects mentally combine the endowment with the payoffs from the game. In this case, the outcomes of each treatment would be equal to those in GAIN which do not involve any losses. However, engaging in such calculations requires cognitive effort and evidence from social psychology suggests that individuals often behave as *cognitive misers* (Fiske and Taylor, 1991) who apply cognitive shortcuts rather than using all relevant information. Further empirical evidence suggests that many people tend to *bracket choices narrowly* (Read et al., 1999) and to use different *mental accounts* (cf. Thaler, 1999) which both is in favor of players treating outcomes separately rather than jointly.[12]

Apart from that, irrespective of which outcome is used as a reference point to evaluate relative payoffs, in our context loss aversion alone cannot predict different cooperation rates across treatments. The reason is that even if people are loss averse, free-riding remains the dominant strategy, either in terms of smaller losses or in terms of larger gains. Similarly, while theories of social preferences can explain why individuals decide to cooperate (especially when others do so as well), they usually only depend on actual outcomes and, thus, cannot explain different cooperation rates across frames. As a consequence, a combination of both elements is needed to make any novel predictions in our setting. In the following, we therefore derive theoretical predictions based on such a model. In particular, we assume that individuals maximize the following piecewise linear utility function:

$$U_i(x_i, x_j) = \begin{cases} x_i + \alpha_i \cdot x_j & if \quad x_i \geq 0; x_j \geq 0 \\ x_i + \alpha_i \cdot \lambda x_j & if \quad x_i \geq 0; x_j < 0 \\ \lambda x_i + \alpha_i \cdot x_j & if \quad x_i < 0; x_j \geq 0 \\ \lambda x_i + \alpha_i \cdot \lambda x_j & if \quad x_i < 0; x_j < 0 \end{cases} \tag{4.1}$$

with λ being the degree of loss aversion, $0 \leq \alpha_i \leq 1$ agent i's concern for agent j's

[12]Note that if subjects disregard the endowment completely, the most natural reference point is zero which would lead to the same predictions as derived below. Another possibility could be that subjects' reference points are shaped by their expectations about outcomes, as argued by e.g. Abeler et al. (2011).

well-being, and x_i and x_j agent i's and j's payoff from the game and the change in outcomes relative to their endowment, respectively.[13] Following the literature (cf. Kahneman et al., 1990), we assume losses to loom twice as large as equivalent gains, i.e. $\lambda = 2$. Importantly, we assume that individuals are not only loss averse in their own but also in the payoffs of their opponents. Although we are not aware of any study that empirically tests whether loss aversion also applies to the payoffs of others, we find it plausible that loss-averse agents who care about others' well-being also empathize with their losses, i.e., that they take into consideration others' perceived rather than their actual payoffs.[14] Certainly, whether this assumption is justified or not is an empirical questions that needs to be tackled.

Table 4.3: Transformed Payoff Matrices

	Cooperate	Defect
Cooperate	$2+2\alpha$; $2+2\alpha$	$0.5+2.5\alpha$; $2.5+0.5\alpha$
Defect	$2.5+0.5\alpha$; $0.5+2.5\alpha$	$1+\alpha$; $1+\alpha$

(a) GAIN: Endowment = 0

	Cooperate	Defect
Cooperate	$1+\alpha$; $1+\alpha$	$-1+1.5\alpha$; $1.5-\alpha$
Defect	$1.5-\alpha$; $-1+1.5\alpha$	0; 0

(b) INT-I: Endowment = 1

	Cooperate	Defect
Cooperate	0; 0	$-3+0.5\alpha$; $0.5-3\alpha$
Defect	$0.5-3\alpha$; $-3+0.5\alpha$	$-2-2\alpha$; $-2-2\alpha$

(c) INT-II: Endowment = 2

	Cooperate	Defect
Cooperate	$-2-2\alpha$; $-2-2\alpha$	$-5-\alpha$; $-1-5\alpha$
Defect	$-1-5\alpha$; $-5-\alpha$	$-4-4\alpha$; $-4-4\alpha$

(d) LOSS: Endowment = 3

Given the utility function described in (1), the monetary payoffs from the games

[13]The two border case $\alpha_i = 0$ and $\alpha_i = 1$ reflect situations in which individual i only cares about own payoff or cares about the other's payoff as much as about the own. If α_i is in between these two boundaries, this means that agent i cares about agent j's outcome but not as much as about the own. Social preferences in our case can thus be best described as a notion of altruism.

[14]We also analyzed the case when this assumption is relaxed, i.e., when agents are only loss averse about own but not about others' payoff. See footnote 16 for a discussion of the results.

depicted in Table 4.2 can be transformed into utility payoffs as shown in Table 4.3. Based on these transformed matrices, we use player i's best response function to calculate minimum thresholds levels for α so that player i is better off by choosing C rather than D.[15] In particular, for each of the other player's actions we compare player i's payoff for cooperation and defection and derive a condition for when the former exceeds the latter. These thresholds values are shown in Table 4.4 and are referred to as $\overline{\alpha}$.

As can be seen, for treatments GAIN and LOSS the threshold for α to make action C the dominant strategy is identical and equal to 1/3. This means that if agent i's concern for player j's well-being is larger than 1/3, she prefers choosing C over D. The reason for why the thresholds are the same in both treatments is that because payoffs in GAIN and LOSS are either all positive or all negative, respectively, utilities in these cases can be expressed by an affine transformation of each other. This can easily be seen by looking at equation 4.1. Because outcomes in the first and the last row either lie all to the right or to the left of the kink in the utility function, in the latter all arguments are multiplied by λ and the relationship between these two can thus be expressed by $g(x) = \lambda f(x)$.

In contrast, for INT-I and INT-II no such transformation is possible. The reason is that in these treatments, some of the payoffs are positive and some are negative so that the slope of the utility function depends on whether a certain outcome is above or below zero. As a consequence, in these treatments the threshold for α changes asymmetrically depending on the other player's action. When the other player cooperates, $\overline{\alpha}$ decreases below 1/3, and when she defects $\overline{\alpha}$ increases above 1/3. Loss aversion and the social concern for others encourage players to avoid these losses irrespective of whether they affect own or other's payoff. Because losses are particularly large when both players choose different actions, compared to the other two treatments this means that in INT-I and INT-II players have an increased incentive to match each other's action.

Table 4.4: Minimum thresholds levels $\overline{\alpha}$ by treatment

	GAIN	INT-I	INT-II	LOSS
$U_i(C\|C) \geq U_i(D\|C)$	$\alpha \geq 1/3$	$\alpha \geq 1/4$	$\alpha \geq 1/6$	$\alpha \geq 1/3$
$U_i(C\|D) \geq U_i(D\|D)$	$\alpha \geq 1/3$	$\alpha \geq 2/3$	$\alpha \geq 2/5$	$\alpha \geq 1/3$

Based on this, we expect cooperation rates to be similar in GAIN and LOSS, and

[15]Because of the symmetry of the game, it is sufficient to derive predictions only for player i since the conditions for both players are completely identical.

to be lower in Int-I compared to Int-II. The latter is the case because for each of the other player's action (C or D), the threshold α has to exceed to make C the preferred option is lower (and thus easier to fulfill) in Int-II compared to Int-I. Comparing the predictions of these two treatments with the ones in Gain and Loss is not straightforward because depending on (the beliefs about) the other player's action, cooperation could both be lower or higher.[16]

4.3.3 Experimental Procedures

Because of its very short duration, it was decided to combine this experiment with another short decision-making experiment focusing on coordination. Both parts were referred to as independent experiments and the one reported in this study was always conducted second.[17] The whole experiment was conducted at the Cologne Laboratory for Economic Research (CLER) in September 2012. We used the experimental software *z-Tree* (Fischbacher, 2007) and recruited student participants from the University of Cologne with the online recruiting software ORSEE (Greiner, 2004). In total, we conducted four experimental sessions in which 124 subjects participated. Each session involved 30 to 32 participants who were not allowed to take part in more than one treatment.

At the beginning of each session, participants were randomly assigned to cubicles in the lab and afterwards were explained the first experiment. Only after all subjects completed the first part, they were told that there is a second (unrelated) experiment.[18] Then, instructions for the second part were displayed on the computer screen explaining the decision situation, the incentives, and the rules of the game. Before starting the second experiment, we made sure that every participant

[16] Very similar predictions can be derived when the social-preference part of the utility function is modeled as inequality aversion based on perceived outcomes. In contrast, when agents are assumed to be altruistic and loss averse over own but not over others' payoffs (see footnote 14), then the threshold levels for α when agent j chooses C and D, respectively, are 1/3, 1/3 for Gain, 1/3, 2/3 for Int-I and Int-II, respectively, and 2/3, 2/3 for Loss. We thus would expect cooperation rates to be highest in Gain and lowest in Loss. For Int-I and Int-II we would expect the same level of cooperation lying somewhere between the levels obtained in Gain and Loss.

[17] To minimize problems that may arise due to order-effects (e.g. because of learning or reputation-building), assignment to treatments was completely randomized and groups were rematched so that subjects did not interact with each other more than once. Because subjects were informed about their earnings from the first experiment before the second experiment started, behavior could be influenced by income effects. Yet, in our data we find no evidence for such an effect. A Spearman's rank-order correlation between earnings from the first experiment and the decision to cooperate in the second experiment yields a very weak and insignificant relationship ($\rho = 0.011$, $p > 0.902$). Therefore, in the following we assume that results are not systematically influenced by the behavior and the earnings from the first experiment.

[18] This procedure ensures that behavior in the first experiment is not influenced by subjects' prospect of the opportunity to earn an additional amount of money.

had understood the game completely. After subjects had made their decisions, they were asked for their beliefs about their partner's action.[19] At the end of each session, subjects were asked to fill in a short questionnaire. Afterwards, they were informed about the decisions of their opponent and about their payoffs. Finally, participants were privately paid their individual earnings from both experiments in cash. On average, participants earned €5.90 (including €2.50 show-up fee) and all sessions lasted approximately 30 minutes.

4.4 Results

The results of our experiment are summarized in Table 4.5 and Figure 4.1 showing the percentage of cooperative choices and beliefs separated for each treatment. As can be seen, the frequency of cooperative choices is highest in Gain and Int-I (69%). It then decreases to 61% in Loss and finally drops to 41% in Int-II. When testing for the presence of an overall framing effect we find the frequency of cooperation to be significantly different across treatments (χ^2 - test: $p = 0.071$).[20]

Table 4.5: Percentage of cooperative choices and beliefs

Treatment	Choice of C	Belief of C	# Obs.
Gain	69% [22]	72% [23]	32
Int-I	69% [22]	72% [23]	32
Int-II	41% [13]	38% [12]	32
Loss	61% [17]	57% [16]	28

Note: Numbers in brackets display absolute frequencies.

Yet, when comparing treatments pairwise the only pronounced differences are found between Gain and Int-II, and Int-I and Int-II.[21] With regard to our two main treatments we find the fraction of subjects choosing C to be lower in Loss than in Gain, but the difference is not statistically significant (χ^2 - test: $p = 0.515$). This is in line with our theoretical predictions. In contrast, when comparing the intermediate treatments Int-I and Int-II we find evidence contrary to our predictions. While it was predicted that irrespective of the other player's decision cooperation should be easier to sustain in Int-II than in Int-I, the frequency of cooperative choices is significantly higher in the latter (χ^2 - test: $p = 0.024$). To check the

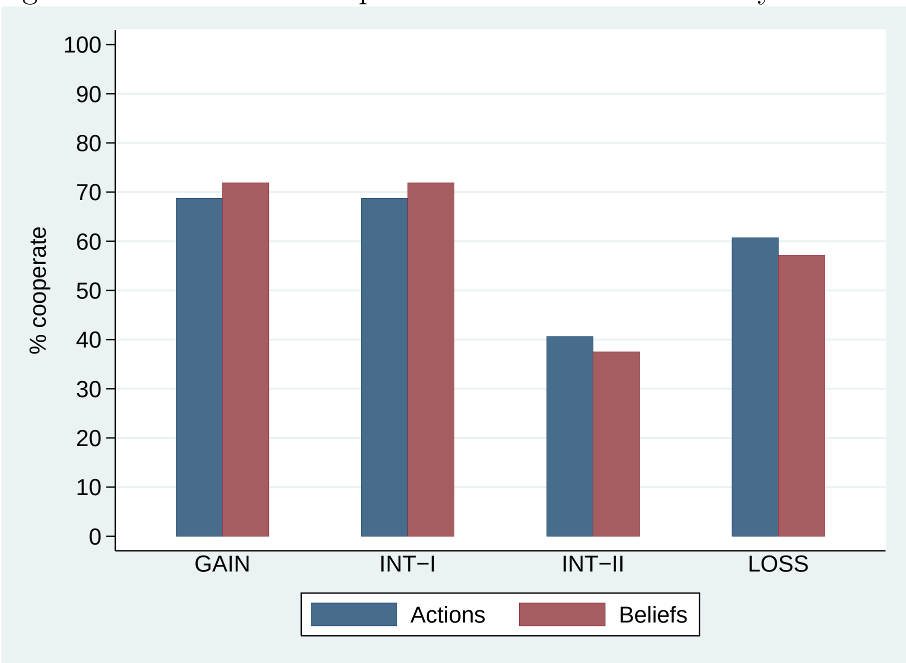
[19] In this case, beliefs were not incentivized. For a discussion of the advantages and disadvantages of incentivizing belief elicitation see Gächter and Renner (2010).

[20] Throughout the paper we always use two-sided test statistics.

[21] See Table 4.6 in the appendix for a complete overview of the p-values of pairwise χ^2 - tests.

robustness of these results, we run logistic regressions with treatment dummies as independent variables. The results are shown in Table 4.7 in the appendix and support the findings of the χ^2 - tests. So while cooperation is fairly similar in Gain, Int-I, and Loss, the question is why it is so much lower in Int-II. In the following we discuss some possible explanations for this somewhat surprising result.

Figure 4.1: Fraction of cooperative actions and beliefs by treatment.



One possible reason for why defection seems to be so much more attractive in Int-II than in Int-I could be that in contrast to the latter, in Int-II action D represents the only opportunity for players to receive a strictly positive payoff (namely when the other player simultaneously chooses C) which, in turn, may make this option more attractive. The question that is raised by this difference is why defection seems to be so much more attractive in Int-II or, analogously, why it is so much less chosen in Int-I. Another possibility could be that because the perceived payoff difference resulting from players choosing different actions is larger in Int-II than in Int-I, this creates an extra incentive to match the other player's action. Combined with the first argument, or if players suffer from earning less than their group member but not from earning more, this leads to an increased incentive to defect in Int-II compared to Int-I.

Besides from that, another prominent candidate for explaining differences in behavior are beliefs. For instance, as argued by (Costa-Gomes and Weizsäcker, 2008), "In most games of economic interest a player's optimal choice of play depends on the belief that she may hold about her opponents actions."[22] When looking at beliefs in our experiment, we find the frequency of subjects believing that the other player cooperates to be significantly different across treatments (χ^2 - test: $p = 0.014$). In particular, we find the ranking and the magnitude of cooperative beliefs to reflect the ranking and magnitude of cooperative choices quite closely (see Table 4.5). Furthermore, all the significant differences across treatments that exist for choices also hold for beliefs (see Table 4.6 in the appendix). As a consequence, when including beliefs as a control variable into our regression analysis, all treatment dummies turn insignificant (see model (2) of Table 4.7 in the appendix). Resulting from this one could conclude that treatment differences in the choice of C can be perfectly explained by the differences in beliefs which would be in line with the argument of Dufwenberg et al. (2011) and Ellingsen et al. (2012) stating that frames affect beliefs, and beliefs affect motivation and behavior. However, as noted by Costa-Gomes et al. (2010), including beliefs into the regression is very likely to cause problems of endogeneity which makes it difficult to draw any inference about a causal link between expectations and actions. Furthermore, this would only shift the focus from behavior to beliefs which would then raise the question why expectations differ across frames and treatments. In fact, as pointed out by Dufwenberg et al. (2011), developing a theory of framing that can explain how frames move beliefs is an important challenge for future work. Unfortunately, with our experimental design we are not able to answer this question conclusively. In the next section, we therefore discuss some possibilities of how to improve our design.

4.5 Discussion and Conclusion

In this study we investigate whether the framing of a decision situation affect people's willingness to cooperate in one-shot prisoner's dilemma games. In particular, we are interested in the interplay of loss aversion and cooperation, i.e., whether people are more likely to cooperate when this leads to the achievement of something good compared to when cooperation is needed to prevent something bad. By gradually shifting subjects' payoffs from a positive into a negative domain, in four different treatments we either induce a gain- or a loss-framing (or a combination of both), and subsequently study whether behavior is sensitive to such frame manipulation. In line with evidence from the related literature discussed in section 2, we find framing to significantly affect the frequency of cooperation across treatments. However, the

[22] See also Costa-Gomes et al. (2010) suggesting the presence of a causal relationship between actions and beliefs.

ranking of cooperation rates across treatments is not entirely in line with what was predicted by our model of loss aversion and altruism. Nevertheless, if anything, our results provide evidence indicating that the involvement of losses tends to make people less cooperative.

One constraint of our experimental design is that players choose actions simultaneously and, thus, behavior is likely to depend on subjects' beliefs about other players' actions. These beliefs turned out to significantly differ between treatments. While in principle, this could explain the differences found at the behavioral level, this does not answer the question why expectations itself are affected by framing. To answer this question, a more elaborate experimental design is needed that is especially intended for studying the emergence of expectations. However, the intention of our experiment was only to serve as a first benchmark of how people behave in social dilemma situations that include the possibility of incurring losses. Certainly, to understand more precisely how framing in such situations affects behavior, further studies are needed that either allow to infer the driving factors that shape expectations depending on the frame or that allow to study the interaction of frames and behavior independent of beliefs. With regard to the second alternative, one possibility is to use the same design as in this study, but let subjects choose actions sequentially. That way, by comparing behavior of the second movers one would have a clean test of the effects of losses on cooperation without any distortions due to beliefs. Unfortunately, we could not yet conduct such a follow-up experiment and include it in this chapter.

Nevertheless, in general we think that the question of how the concepts of loss aversion and social preferences interrelate with each other might be an interesting topic that could be further explored in the future. A similar approach has been initiated by some recent studies that investigate the connection between risk taking and social context (Bohnet et al., 2008; Bolton and Ockenfels, 2010). While both, risk behavior and loss aversion, have been originally studied in an individual context, we argue that broadening these concepts to a richer and social environment is a promising next step that may have many interesting fields of application such as in financial services where advisors sell products to advisees that often not only include high risks but also may entail the danger of incurring losses.

4.6 Appendix to Chapter 4

A Treatment Comparisons of Cooperative Choices and Beliefs

Table 4.6: p-values of pairwise Pearson's chi-squared tests comparing frequencies of cooperation

	Contributions			Beliefs		
	GAIN	INT-I	INT-II	GAIN	INT-I	INT-II
INT-I	1.000			1.000		
INT-II	0.044	0.044		0.006	0.006	
LOSS	0.515	0.515	0.121	0.233	0.233	0.128

B Logistic Regression Analysis

As a dependent variable in model (1) and (2) we use a binary variable taking on the value 1 if subjects choose action C and 0 otherwise. In model (3) the dependent variable is whether or not subjects belief that their group member's action is C. As independent variables we use treatment dummies with GAIN as the reference group. In model (2) we additionally control for subjects' beliefs.

Table 4.7: Logistic Regressions: Cooperation depending on treatment

Dependent variable:	Contributions		Beliefs
	(1)	(2)	(3)
INT-I	-0.000	-0.011	0.000
1 if treatment = INT-I	(-0.00)	(-0.03)	(0.00)
INT-II	-0.726**	-0.232	-1.449**
1 if treatment = INT-II	(-2.25)	(-0.60)	(-2.70)
LOSS	-0.217	-0.050	-0.651
1 if treatment = LOSS	(-0.65)	(-0.12)	(-1.19)
Belief		1.902***	
1 if Belief = C		(6.76)	
Constant	0.489**	-0.762**	0.938**
	(2.11)	(-2.27)	(2.39)
# Observations	124	124	124
Log Likelihood	-80.125	-53.998	-78.316

Note: z statistics in parentheses; * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

C Experimental Instructions (translated from German)

General Information

Before you will receive your earnings from this experiment, there will be another short experiment. In this experiment you can earn an additional amount of money. This amount, combined with your earnings from the first experiment, will be paid to you in cash after the experiment. The **payment** will be made **anonymously**, meaning that no participant learns about the payoff of another participant.

The **decisions** during the experiment are also made **anonymously**, meaning that no other participant gets to know the identity of the person who made a particular decision.

As in the first experiment, you are not allowed to communicate with the other. If you have any questions, please ask us. In case of non-compliance we must exclude you from the experiment and all payoffs. If you have questions, please raise your hand. A member of the study team will come to you and answer your question in private.

On the next screen you will find the instructions of the experiment. The instructions will explain what you have to do and how you can earn money. Every participant gets the same instructions. Please read the instructions carefully. To do this, please press [Continue].

The experiment

In this experiment we ask you to participate in a short decision situation. All participants are divided into groups of two. This means that you will play in a group with another participant. This participant will be **randomly** assigned to you.

The decision situation

In the beginning of the decision situation **you (Player 1)** and your **group member (Player 2)** receive an amount of money. We refer to this amount as your initial endowment. Both players receive the same initial endowment.

After that, you and Player 2 each have to decide between two options: **Option A** and **Option B**. You and Player 2 will make this decision **simultaneously**. This means that no player knows which option (A or B) the other player has chosen when making the own decision.

You make your decision by pressing one of the red buttons labeled **A** or **B** on the next screen. **Important:** This experiment will be conducted only once. This means that you only have to decide between Option A and Option B once.

Payment

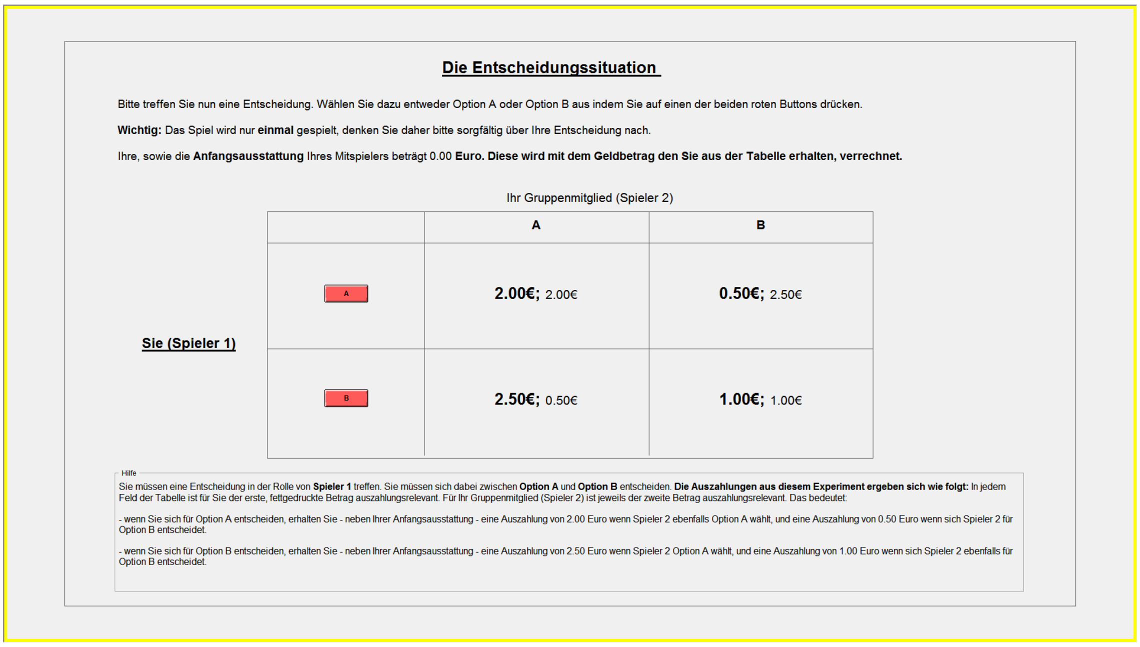
Your **total payoff** from this experiment results from your **initial endowment** and an **additional amount of money**. The size of this additional amount depends on your decision as well as the decision of the other player. The next screen will displays your initial endowment as well as an **overview table**. In this table you can see the additional amount of Euros you and your group member receive for each combination of decisions (both players choose A; You choose A and your group member chooses B; You choose B and your group member chooses A; both players choose B).
In every cell of the table the following applies:

- For you (Player 1) the first (bold) amount is payoff-relevant.
- For your group member (Player 2) the second (small-printed) amount is payoff-relevant.

Your initial endowment will be set off against the amount of money in the table.

If you have understood these instructions completely and want to proceed with the experiment, please press [Continue].

D Screenshot of the Decision Situation (Gain-treatment)



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10/2008–	**Doctoral Student** at the Cologne Graduate School in Management, Economics, and Social Sciences, University of Cologne

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Research Interests

Behavioral and Experimental Economics, (Applied) Microeconomics, Labor and Personnel Economics

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Education

2011/12	**Visiting PhD Student** at the University of Nottingham, Centre for Decision Research and Experimental Economics (CeDEx), supervisor: Prof. Simon Gächter
10/2008 –	**PhD Candidate** at the University of Cologne, supervisor: Prof. Dr. Dirk Sliwka
2008	**Diploma Thesis**: *"Money Illusion and Labor Supply - Evidence from an Experiment and a Questionnaire"*, supervisors: Prof. Dr. Armin Falk and Dr. Matthias Wibral
2006/07	**Visiting Student**, *Katholieke Universiteit Leuven*
2003 – 2008	**Diploma** (M.Sc. equivalent) in Economics, *University of Bonn* Special emphasis on: Behavioral Economics, Experimental Economics, Microeconomics

Working Papers

Inequality, Inequity Aversion and the Provision of Public Goods, `IZA DP 5514` (with Dirk Sliwka and Nannan Zhou), *submitted*

Heterogeneity and Cooperation in Privileged Groups: The Role of Capability and Valuation on Public Goods Provision, `CGS WP 03-08`, *submitted*

Academic & Professional Experience

10/2009 –	**Research Assistant** at the Seminar of Personnel Economics and Human Resource Management at the University of Cologne, chair: Prof. Dr. Dirk Sliwka
2008	**Intern** (2 month) at Federal Ministry of Economics and Technology (BMWi), *Bonn*
2007/08	**Teaching Assistant** (Tutor), Chair of Business Administration III, Prof. Dr. J. Budde, *University of Bonn*
2005 – 2007	**Student Research Assistant** at WIK Consult, Department of Cost Modelling and Internet Economics, *Bad Honnef*

Teaching Experience

2012/13	Advanced Seminar: "**The Impact of Management Practices on Firm Performance**" (Master/Diploma), *University of Cologne*
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2010, 2010/11	"**Experiments in Economics and Social Sciences**" (Bachelor/Diploma), *University of Cologne*
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Conferences, Invited Talks & Seminar Presentations

2012	Meeting of the Economic Science Association (ESA), *Cologne* 11^{th} Tiber Symposium on Psychology and Economics, *Tilburg* Research Colloquium on Business Ethics and Personnel Economics, *Cologne*
2011	CeDEx Workshop, *Nottingham* International Meeting of the Economic Science Association (ESA), *Chicago* Thurgau Experimental Economics Meeting (THEEM), *Kreuzlingen* Workshop on Behavioural and Experimental Economics, *Florence* 7^{th} International Meeting on Experimental and Behavioral Economics (IMEBE), *Barcelona*

2010	Jahrestagung Verein für Socialpolititk (VfS), *Kiel* 25^{th} Congress of the European Economic Association (EEA), *Glasgow* World Meeting of the Economic Science Association (ESA), *Copenhagen* 13. Colloquium on Personnel Economics (POEK), *Trier* Research Seminar in Applied Microeconomics, *Cologne*
2009	Research Seminar in Applied Microeconomics, *Cologne*

Summer Schools, Workshops & Conference Participations

2012	Workshop: Natural Experiments and Controlled Field Studies, *Holzhausen*
2011	10^{th} Tiber Symposium on Psychology and Economics, *Tilburg* Workshop on Experimental Research across Cultures, *Bonn* IZA Workshop: Cognitive and Non-Cognitive Skills, *Bonn*
2010	Summer School: Incentives and Behavioral Economics, *Bronnbach* Workshop: Communication of Research in Economics, *Cologne* Jahrestagung der Gesellschaft für experimentelle Wirtschaftsforschung (GfeW), *Luxemburg*
2009	Mannheim Empirical Research Summer School (MERSS), *Mannheim* IAREP Summer School in Psychological Economics and Economic Psychology, *Trento* 2^{nd} Behavioral and Experimental Economics Symposium, *Maastricht* Jahrestagung der Gesellschaft für experimentelle Wirtschaftsforschung (GfeW), *Essen*
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Refereeing

Journal of Economic Behavior and Organization

Grants & Scholarships

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Language Knowledge

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Computer Skills

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