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

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

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Abstract

We experimentally investigate cooperation in privileged groups which according to Olson (1965) are groups in which at least one member has an incentive to supply a positive amount of the public good. More specifically, we analyze group member heterogeneity with respect to two dimensions: *capability* and *valuation*. Our results reveal that with and without punishment opportunities, heterogeneity crucially affects cooperation and coordination within groups. Compared to non-privileged groups, asymmetric valuations for the public good have negative effects, and asymmetric capabilities in providing the public good have positive effects on voluntary contributions. The main reason for these results are the different externalities contributions have on the other group members' payoffs affecting individuals' willingness to cooperate. Hence, whether heterogeneity facilitates or impedes collective action, and whether privileged groups are as privileged as they initially seem is subject to the nature of their asymmetry.

Keywords: Public goods, heterogeneity, privileged groups, inequality, cooperation, punishment

JEL Classification: H41, D63, C92

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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 an question that is discussed controversially.[2] 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 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*[3] for the public good. For example, parks, swimming pools, dams, or other public facilities provide very different benefits to

[2]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, 2011).

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

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. 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 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 exclu-

[4] A different environment in which positive public goods contributions can be sustained in equilibrium

sive 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 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 (2011), one reason

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).

[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; 2011), 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.

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 inequality in endowments[7] or preferences[8]. The crucial point of studying capability differences

[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)

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. The Experiment

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 (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

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).

[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.

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

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

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 maximized 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

[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.

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

$$\pi_i = 20 - c_i + \delta_i \cdot \sum_{j=1}^{N} a_j \cdot c_j - 3 \sum_{j \neq i} p_{ji} - \sum_{j \neq i} p_{ij} \tag{2}$$

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 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 1, Column 5 shows public good benefits subjects receive from contributions 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

[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 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	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.

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. 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

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

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 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 in-

[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.

come 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* 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

[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.

introduced, however, we expect that it has a much weaker effect on increasing cooperation in VAL than in the other two treatments.

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 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).

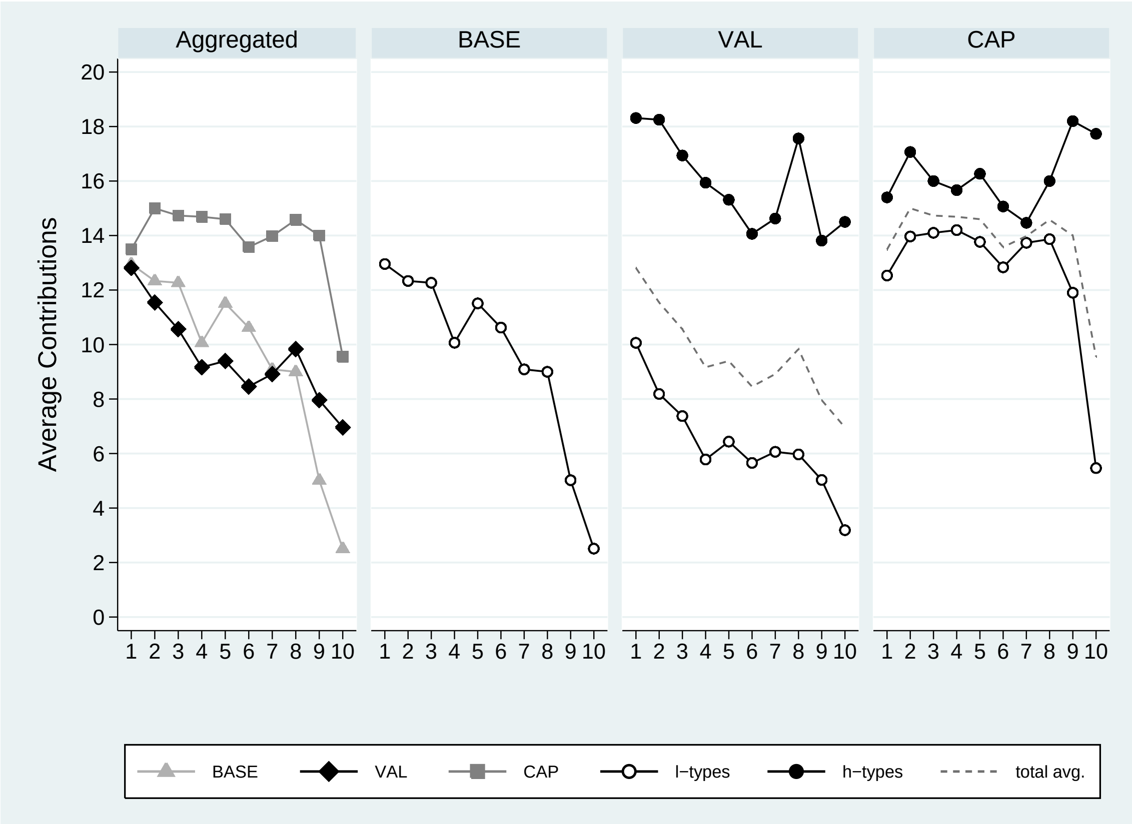
3. Results

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.

3.1. Voluntary Contributions without Punishment

Figure 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).

Figure 1: Average contributions over time without punishment



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 ($\rho = -0.474, p < 0.001$).

Very similar contribution dynamics can be observed in VAL. Contributions start at high but decrease to very low levels in the final period ($\rho = -0.333, p < 0.001$). As a result, average contributions are basically identical in both treatments (BASE: 9.54 and VAL: 9.56 tokens, see Table 2). In fact, a non-parametric Mann-Whitney U test[17] 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 de-

[17]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.

Table 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.

creased contributions of *l-types* (see Column 3 in Figure 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).[18] Altogether, we find that privileged groups whose asymmetry stems from differences in the preferences for the common good do not contribute more than normal groups.[19]

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 ($\rho = -0.077, p = 0.349$). In total, subjects in CAP contribute, on average, 13.82 tokens

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

[19]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.

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*.[20] 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 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 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,

[20]When looking at the Spearman's rank-order correlation coefficient of *l*- and *h-types*' contributions within groups, in VAL we find it to be small and indistinguishable from zero ($\rho = 0.164, p = 0.544$). In contrast, in CAP, this relationship is much stronger and highly significant ($\rho = 0.667, p = 0.007$).

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

Table 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)

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 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

[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.

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

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 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.

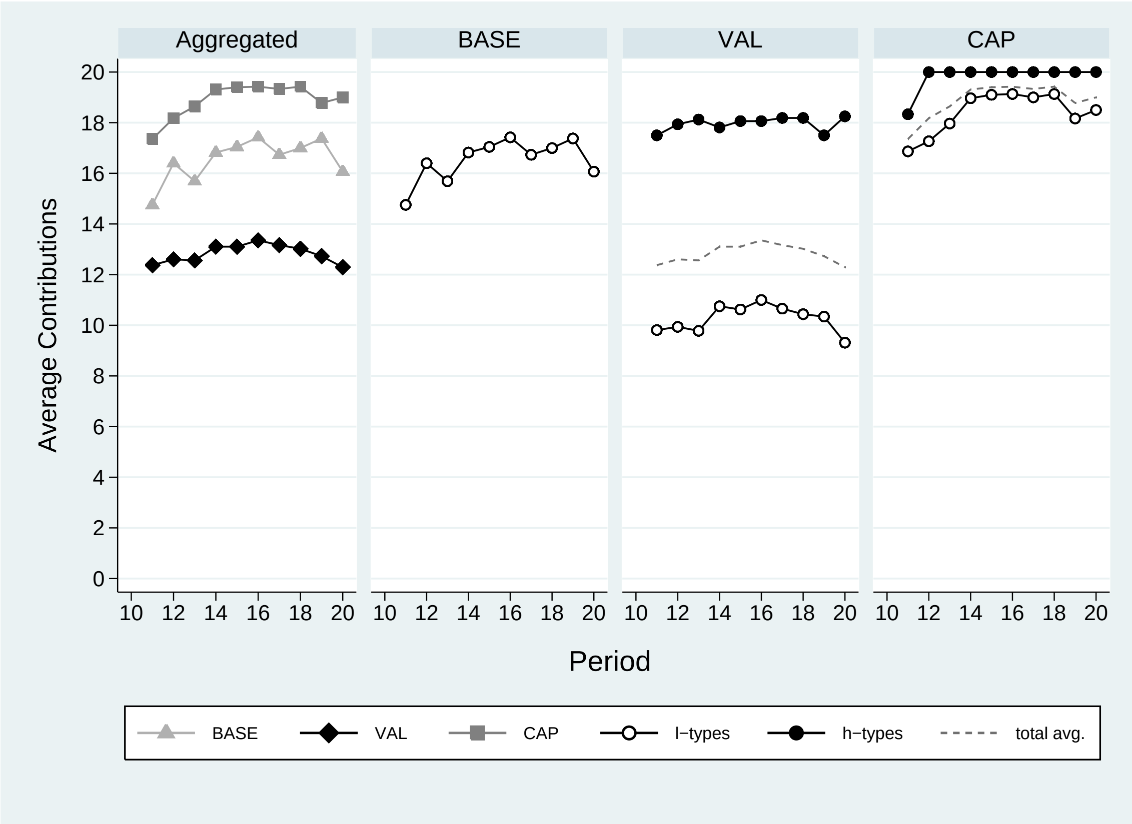
[24]In BASE, subjects earn on average 24.77 tokens per period, corresponding to 83% of the social optimum and to an inequality measure of 3.95.

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). 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: $\rho = 0.157, p = 0.056$; CAP: $\rho = 0.218, p = 0.007$). In contrast, contribution dynamics in VAL are rather flat ($\rho = 0.014, p = 0.858$), 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, 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

[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, $p = 0.179$).

Figure 2: Average contributions over time with punishment



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). The difference in contributions between both types amounts to 1.42 and 7.70 tokens (MWU, p = 0.009), respectively. Comparing both 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, $p < 0.002$).

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 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

[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, are contributions of *h-types* 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 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)

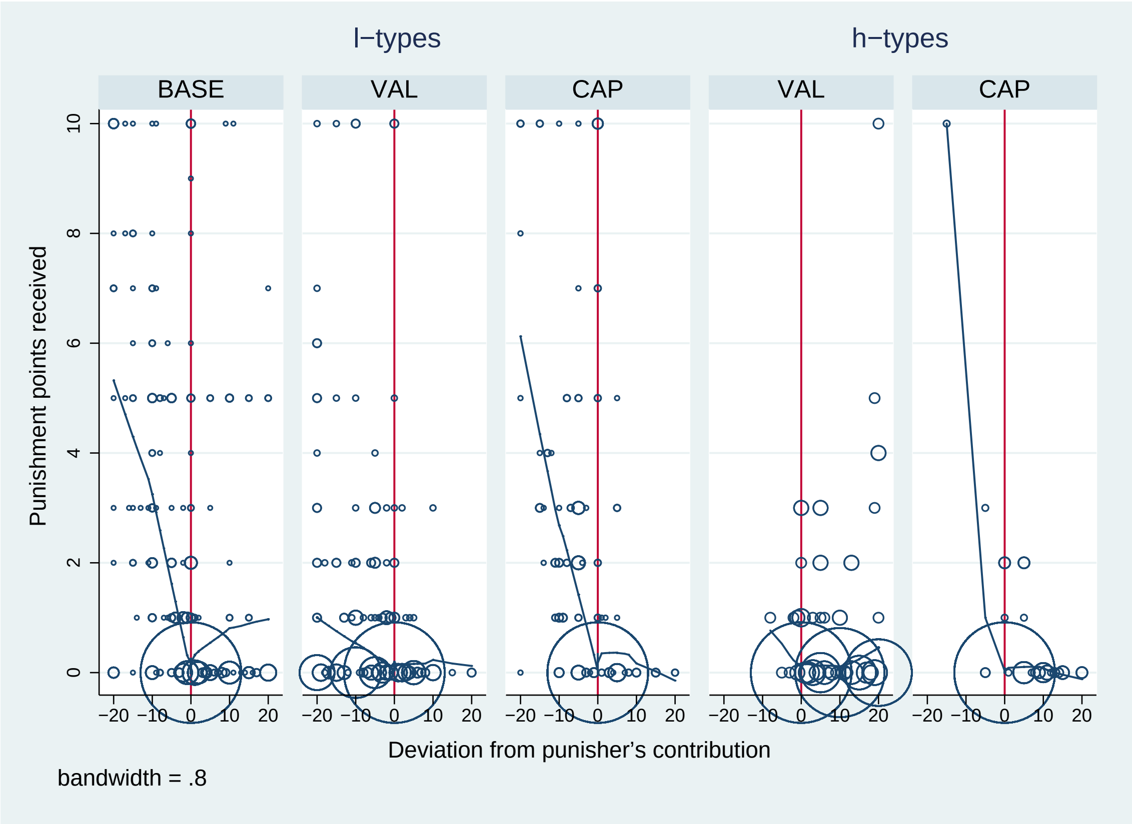
tolerated, suggesting that the norm of equal contributions is enforced less consequently. In line with other studies (see e.g. Herrmann et al., 2008), we observe some amount of antisocial punishment. This effect turns out to be statistically significant in BASE and VAL, but not in CAP.Compared to the 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 they follow a more modest goal of trying to only increase contributions of the lowest contributor, tolerating the fact that *l-types* contribute less they do themselves.

The differences in punishment behavior are neatly summarized in Figure 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 inter-

Figure 3: Punishment as a function of deviation from punisher's contribution



acted with the relative contributions within groups as independent variables (see Table 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 importantly, 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.

[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.

4. Conclusions

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 others' 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; 2011), 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 exogenously given and cannot be changed. 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). In contrast, 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).

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Appendix

A Regression on change in contributions

Table 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 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 × 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.