I Z A Institute
of Labor Economics
Initiated by Deutsche Post Foundation

DISCUSSION PAPER SERIES

IZA DP No. 11540

Peers or Police? Detection and Sanctions in the Provision of Public Goods

Gregory DeAngelo
Laura K. Gee

MAY 2018

DISCUSSION PAPER SERIES

IZA DP No. 11540

Peers or Police? Detection and Sanctions in the Provision of Public Goods

Gregory DeAngelo
West Virginia University

Laura K. Gee
Tufts University and IZA

MAY 2018

ABSTRACT

Peers or Police? Detection and Sanctions in the Provision of Public Goods*

Sanctions are a common method to discourage free-riding in the provision of public goods. However, we can usually only sanction those who are detected performing the bad act of free-riding. There has been considerable research on the type of sanctions imposed, but this research almost always automatically detects everyone's actions and broadcasts them to the group. This is akin to assuming that a group always has a police force or motivated peer reporting to detect and announce the actions of bad actors. However, in many situations bad acts go undetected and unknown to others. We use a lab experiment to compare public good contribution decisions in an environment where we relax the assumption that detection is automated. The common result that sanctions and the likelihood of detection share an inverse relationship continues to be found in our results. However, free-riders are unwilling to pay for detection when sanctioning is conducted at the group level, because a criminal does not want to fund the police who will catch his bad acts. But, when detection is conducted among peers, free-riders are willing to pay to detect other individuals that free-ride.

JEL Classification: C72, C91, C92, D7, H41

Keywords: public goods, punishment, detection, deterrence

Corresponding author:
Laura K. Gee
Department of Economics
Tufts University
305 Braker Hall
8 Upper Campus Rd.
Medford, MA 02155-6722
USA

E-mail: laura.gee@tufts.edu

* A huge thanks to Michael Kuhn for his comments on the experimental design. We would also like to thank for their comments participants at the Social Dilemmas Workshop, the New England Experimental Economics Workshop, the ESA conference, and the Appalachian State seminar. Thanks also to Abdul Haleem Kidwai for his excellent research assistance. This research was approved by the Tufts IRB (1408019).

1 Introduction

Sanctions are a common method to discourage free-riding in the provision of public goods. However, we commonly only sanction those who are detected performing a bad act. Consider the following examples: we only issue speeding tickets for drivers caught speeding by the police and we only complain to the neighbors when we hear their loud party. When speeding is done in the middle of the night, or the neighbors throw a party while you're out of town, then these bad acts go undetected and no sanctions are issued. This paper provides an experimental analysis of how the type of detection, automatic/endogenous and peer/group (e.g. peers vs. police), affects the provision of public goods.

Different types of detection may not be equally effective in eliciting sanctions or ultimately providing a public good.[1] For instance, peer detection of antisocial behavior doesn't require group coordination. This may take the form of reporting a noisy neighbor, shoddy goods from a seller on eBay or inappropriate social media posts on Facebook. In these settings, one detects only the peers one directly interacts with, and may remain uninformed about the actions of the whole population. In contrast, when detection is done by an agency formed by the group, that agency may inform you about the actions of many members of society and, in turn, may broadcast your actions widely. However, when detection is assigned to a group agency, implementing detection can become complicated. When group detection is an endogenous choice it requires a collective decision on how to implement detection and opens up the opportunity for a single individual or a subset of the group to veto implementation. For example, a subset of citizens could vote against sufficient taxes to adequately staff the police force [DeAngelo and Hansen, 2014], or a single permanent member country of the UN Security Council can exercise a veto to block a resolution to detect nuclear arms.[2]

We show that when detection is automatically imposed, then contributions to the public good are similar under either peer or group detection. However, this masks an important difference in the efficacy of the two detection regimes when detection is a costly endogenous choice instead of automatic. When detection is a costly endogenous choice this lowers detection rates and public contributions more under group detection than under peer detection. The reason for this differential decline in detection is that free-riders are willing to detect other free-riding peers but unwilling to implement a group detection regime that will catch their own bad acts. Intuitively, tax evaders don't want to fund the IRS who will detect their

[1] Grosse et al. [2011] provide an empirical analysis of the use of a central monitor versus peer monitoring in overcoming coordination and free-riding problems.

[2] See https://www.un.org/en/sc/meetings/voting.shtml.

tax evasion, but they are happy to report others who aren't contributing enough.

Exploring these questions with observational data is difficult due to the endogenous adoption of detection/sanction combinations and the difficulty in measuring all instances of free-riding behavior. So to demonstrate the potential for research in this area, we use a 2 x 2 x 2 between-subjects design. In all our games, subjects play a linear public goods game in fixed groups of four for 10 periods. In each period the subjects must divide an endowment between a public good that pays returns to all group members and a private good that pays returns only to them. First, we compare detection done by peers with detection done by a group agency. Second, we vary whether detection is automatically imposed versus a costly endogenous choice. And third, we vary whether sanctions are assigned to a single neighbor or if sanctions from all group members are concentrated on the largest free-rider. Our neighbor sanctioning mechanism differs from the traditional peer-to-peer sanctioning by allowing a subject to only sanction a single person, while in our concentrated sanctioning mechanism subjects can collectively punish the lowest detected contributor to the public good.[3] In both sanctioning mechanisms, subjects can only be sanctioned if a subject is detected. The four resulting detection and sanction combinations (PeerDetect-NeighborSanction, PeerDetect-ConcentratedSanction, GroupDetect-NeighborSanction, and GroupDetect-ConcentratedSanction) may seem very different, but by design the average costs of detection, expected number of detected people, and possible earnings are the same across all four. We test these four detection-sanction pairs under exogenous automatic detection versus costly endogenous detection, for a total of eight experimental treatments.

These detection and sanctioning pairs are examples of the type of combinations that can arise. The peer detection and neighbor sanctioning combination (PeerD-NeighborS) is a stylized version of detecting whether your neighbor shoveled their snow or not, and, if they did not, writing them a nasty note in response. Peer detection and concentrated sanctioning (PeerD-ConcentratedS) could represent how eBay buyers monitor the sellers they interact with, such that, if reported, the worst offenders are removed from the website. Group detection and neighbor sanctioning (GroupD-NeighborS) can be thought of as a simplification of websites like charitynavigator.com, which provides ratings of charities and then allows individuals to withhold contributions from poorly rated charities. Last, group detection and concentrated sanctioning (GroupD-ConcentratedS) is a stylized version of the police, which

[3]Our concentrated sanctioning mechanism can be thought of as a directed star network and is closely related to the sanctioning mechanisms of Yamagishi [1986], Andreoni and Gee [2012], and Andreoni and Gee [2015], these sanctioning mechanisms are meant to capture the idea that it is common to punish only the largest detected offenders (e.g. the loudest neighbors, the fastest speeders, the worst teachers).

detect wrongdoing, and turn that information over to the courts, which sanction individuals. The specific formulations used in our study are meant to be one of any number of examples of detection regimes and sanctioning mechanisms.

Under these specific formulations we find that when detection is exogenously automatic, as has been common in the previous experimental designs, then both peer and group detection results in similar public good provision. However, exogenous automatic detection assumes individuals are willing to pay to either individually investigate others' actions or to create a group monitoring agency. In reality, the optimal type of detection mechanism might be highly dependent on the individual's or group's willingness to pay for detection. Indeed in our experiments we find that contributions to the public good are lower under centralized detection than under peer detection if subjects have to coordinate to implement a detection regime. The coordination failure stems from the largest free-riders being unwilling to support a centralized agency (e.g., the IRS) whose sole purpose is to expose their free-riding and enable sanctioning. We also find that contributions to the public good are lower under concentrated sanctioning than under neighbor sanctioning when only a few people are detected (either by the group or peer detection regime). In these instances, even hefty fines do not deter bad behavior when someone knows they are unlikely to be caught.

In the next section we review some of the related literature, with special attention to the experimental literature on public goods games. In Section 3 we present a model of our experimental design as well as theoretical predictions regarding detection and sanctioning behavior. In Section 4 we present the results of our experiment, and in Section 5 we offer concluding remarks.

2 Related Literature

There is a long-standing debate about whether groups are better off with a centralized authority or with self-governance [Hobbes, 1651, Ostrom, 2015]. Although centralization (e.g., the police or a homeowner association) is common in the real world, some observational research has noted that peers can be just as effective [Cason and Gangadharan, 2016]. For example, Karstedt-Henke [1991] notes that for every juvenile crime detected by police, parents detect at least four, teachers detect two, and friends detect more than five similar crimes. [4] Moreover, informal sanctioning mechanisms like shaming have proven quite useful

[4] Cason and Khan [1999] and Cason et al. [2012] discuss several aspects of monitoring, importantly noting that both verbal communication and the ability to monitor another subject will increase public goods contributions, but that the cost of monitoring has a mitigating effect.

in deterring antisocial acts in some settings.[5]

While observational research has examined the effect of different types of detection and sanctioning, these analyses struggle with endogeneity issues. Namely, locations with higher willingness to pay for enforcement might invest in higher levels of centralized enforcement or supplement centralized enforcement with peer enforcement. In either situation, the level and type of enforcement is endogenously determined. Moreover, these environments can usually only measure detections and sanctions that are centrally administered (e.g., administrative records note when a speeder is detected by police or when fines are levied by a court), but can't measure informal peer detection or neighbor sanctions (e.g., it is difficult to measure when someone has detected a noisy party but doesn't call the police or when someone has shamed a neighbor for bad behavior). In light of these shortcomings, controlled lab experiments provide a fruitful environment for examining how different types of detection and sanctions interact and how selection of a certain type of detection drives the efficacy of that detection regime.

Sanctions

Many previous experiments have concentrated on the optimal sanctioning or punishment mechanism to increase public goods provision. Both peer-to-peer sanctioning[6], where every person in a group can punish any other person, and centralized/concentrated sanctioning[7] have been shown to increase public contributions relative to no sanctioning.

Concentrated sanctions might be especially effective because they allow the group to assign larger sanctions which are often focused on the largest free-riders. Larger sanctions can increase pro-social actions [Beccaria, 1986, Becker, 1968, Grogger, 1991, Rauhut, 2009, Rauhut and Junker, 2009]. For example, Nikiforakis and Normann [2008] find that higher peer-to-peer sanctions result in higher public contributions. However, beyond the public goods setting, the evidence is mixed, with some finding the optimal fine to be the maximum fine [Polinsky and Shavell, 1984] and others finding the opposite (see Andreoni [1991] and

[5]See DeAngelo and Smith [2016], DeAngelo and Reimers [2017], **?**, Greif [1993, 1994], Harel and Klement [2005], and Teichman [2005] for empirical work on the effectiveness of peer detection and sanctioning. Levitt [1997], Klick and Tabarrok [2005], and DeAngelo and Hansen [2014] examine the effectiveness of centralized enforcement and sanctioning on antisocial behavior. Acemoglu and Wolitzky [2015], Acemoglu and Jackson [2015], and Deb and González-Dıaz [2014] offer theoretical contributions on the relationship and effectiveness of both community and peer enforcement, both independently and interdependently.

[6]See Egas and Riedl [2008], Gächter et al. [2008], Fehr and Gächter [2002], Fehr and Gachter [2000], Fuster and Meier [2010], and Ostrom et al. [1992].

[7]See Baldassarri and Grossman [2011], Dickinson and Villeval [2008], Falkinger et al. [2000], and Yamagishi [1986].

Polinsky and Rubinfeld [1991]).[8] Indeed, whether subjects make larger contributions in the context of concentrated rather than peer sanctions depends on the exact setting and costs. For example, Andreoni and Gee [2012] find that public contributions are similar when comparing peer-to-peer sanctioning alone relative to concentrated sanctioning alone. But when both peer-to-peer and concentrated sanctions are available simultaneously, contributions are higher than the levels that are observed when peer-to-peer sanctioning only is permitted.

Detection

In many of the aforementioned experimental public goods papers, the detection of unwanted behavior has been exogenously imposed, costless, and centralized, such that information is broadcast to the whole group with 100% certainty. So there has been relatively little investigation into the optimal type of detection. One line of work related to optimal detection finds that adding uncertainty about whether the actions detected have actually taken place generally lowers cooperation.[9] Also, outside the public goods setting, research has shown that marginal increases in the probability of detection are more effective than marginal increases in sanctions (see Grogger [1991], Bar-Ilan and Sacerdote [2001], Machin and Marie [2011], DeAngelo and Charness [2012], Friesen [2012]). More closely related to this paper is previous work that explores how detection of only a subset of the group affects cooperation.

Fatas et al. [2010] find that centralized detection does not always result in the highest contributions when there is no sanctioning mechanism. They find that public contributions are highest when a single central subject's contribution is known to all other group members, and that central subject also knows everyone else's contributions (a.k.a. an undirected star network). The public contributions from the standard complete network (the setting where everyone is able to detect everyone else) are the next highest, although the two are not always statistically significantly different from each other. These two detection regimes outperform a bi-directional circle or bi-directional line network.[10] So even without any sanctioning, it is not clear whether the standard centralized detection regime results in the greatest public

[8] Anderson et al. [2017] test whether decreasing or increasing sanctions are optimal, finding support for decreasing penalty structures. There is also a debate about whether extrinsic fines are necessary for compliance [Dwenger et al., 2016].

[9] See Aoyagi and Frechette [2009], Grechenig et al. [2010], Fudenberg et al. [2012], Ambrus and Greiner [2012], Fischer et al. [2013], Nageeb and Miller [2013] and Dal Bó and Fréchette [2014].

[10] In an bi-directional circle network, a person can detect the actions of their left- and right-hand-side neighbors; this differs from our setup, which is a directed circle where a person can only detect their right-hand-side neighbor. A line is similar, but the endpoints can only detect the actions of one neighbor. In an undirected star, the center person can detect everyone's contributions and can themselves be detected by everyone, while the arms of the star can only be detected by the center person.

good provision.

Adding in the option to sanction further complicates the main findings in this literature. Papers that explore the optimal number of subjects to detect and sanction find mixed results. Boosey and Isaac [2016] and Carpenter et al. [2012] find no difference in contributions between the standard complete network setting where everyone is able to detect/sanction everyone else and a setting where each subject can only detect/sanction their two neighbors in a bi-directional circle. Similarly, O'Gorman et al. [2009] find no difference in contributions, yet increased net earnings when comparing the standard complete network setting with a setting where a single subject can sanction everyone. Faillo et al. [2013] find that when subjects must concentrate their sanctions on the largest free-riders, if they detect all contributions (similar to our group detection and concentrated sanction treatment), this can increase contributions and earnings, but if the group only detects the lowest contributors, there is a decline in contributions and earnings. Carpenter [2007] uses four different detection/sanctioning treatments and finds that the lowest contributions come from a directed circle network where subjects can only detect/sanction a single subject on a directed circle (similar to our peer detection neighbor sanction treatment). However, in a follow-up paper, Carpenter et al. [2012] find that the level of contributions in this same directed circle network is actually higher than that in the standard complete network.[11] Leibbrandt et al. [2015] find that contributions are higher under the standard complete network setting where everyone can punish or be punished by any other player than when compared to two other detection/sanction combinations. Thus, there is not currently a consensus on the optimal choice of joint detection/sanctions. Furthermore, to our knowledge, all previous research has made the ability to detect/sanction exogenously automatic.

Endogenous Choice

Nevertheless, there is evidence that some subjects are willing to endogenously choose to detect/sanction others. For example, Page et al. [2008] find that about 20% of subjects will pay a $1 cost to detect/sanction the actions of the group, [Ramalingam et al., 2016] find about 60% of subject opt into a sanctioning mechanism, and Andreoni and Gee [2012] find that 72% to 85% of subjects will pay an average of $0.50 each to implement a centralized sanctioning mechanism. Yet, Botelho et al. [2007] find that subjects do not vote for a peer-

[11] See also Carpenter and Matthews [2012] for a discussion of second versus third party sanctioners, finding that second party sanctioners punish to yield norm conformance whereas third party sanctioners punish to increase efficiency.

to-peer sanctioning mechanism. Similarly, Ertan et al. [2009] find that subjects do not vote for a peer-to-peer sanctioning mechanism initially, but that eventually they do support such a mechanism if it only punishes the largest free-rider.[12] Although the exact level of opting into a sanctioning mechanism varies in the previous work, it is clear that when subjects are given a choice to detect/sanction, we do not see the same results as when detection/sanctions are exogenously imposed.

3 Model and Experiment

The experiment is a $2 \times 2 \times 2$ design run between subjects. The first dimension we vary is whether detection of others' actions is carried out by a peer or by a group detection regime. The second dimension we vary is whether the choice to detect is exogenously automatic or endogenously determined. The third dimension we vary is whether the sanctioning mechanism allows sanctions to be imposed by a single neighbor or by many group members and concentrated on the largest free-rider. Note that we do not allow subjects to choose between detection regimes; rather, subjects decide whether to make a monetary contribution to use the detection regime they have been assigned to. That leaves us with the following eight treatments:

1. EXG PeerD-NeighborS: Exogenous Peer Detect-Neighbor Sanction
2. EXG PeerD-ConcentratedS: Exogenous Peer Detect-Concentrated Sanction
3. EXG GroupD-ConcentratedS: Exogenous Group Detect-Concentrated Sanction
4. EXG GroupD-NeighborS: Exogenous Group Detect-Neighbor Sanction
5. ENDG PeerD-NeighborS: Endogenous Peer Detect-Neighbor Sanction
6. ENDG PeerD-ConcentratedS: Endogenous Peer Detect-Concentrated Sanction
7. ENDG GroupD-ConcentratedS: Endogenous Group Detect-Concentrated Sanction
8. ENDG GroupD-NeighborS: Endogenous Group Detect-Neighbor Sanction

[12] There are also papers that explore whether subjects prefer a peer-to-peer sanctioning mechanism to a centralized/concentrated sanctioning mechanism (See Traulsen et al. [2012], Markussen et al. [2014], Kamei et al. [2015], Nicklisch et al. [2016] and Gross et al. [2016]). In our study, we allow subjects only the choice of whether to use the assigned type of detection, as opposed to choosing the type of detection.

The experiment lasts a total of 10 periods with three stages in each period. Subjects are paid for one randomly selected period to minimize income effects. We chose to have subjects remain in the same group of four for all 10 periods, with fixed identities to approximate the repeated interactions that arise in small groups providing public goods.

At the beginning of experiment, before making any decisions, subjects are told the details of the detection regime and sanctioning mechanism they have been assigned to. In stage 1, subjects play a linear public goods game knowing they will make detection and sanction decisions in stages 2 and 3. In stage 2, if detection is exogenously automatic, then the actions of other subjects are probabilistically revealed. If detection is endogenously chosen, then, depending on whether the subject/group payed for the ability to detect, the actions of other subjects are probabilistically revealed. In stage 3, each subject chooses whether to sanction other group members, depending on whether that subject has detected the behavior of other group members.

Below, we describe the actions in all three stages and then the equilibrium predictions.

3.1 Stage 1: Contribution

In stage 1 in all treatments, subjects play a linear public goods (LPG) game. Each subject is endowed with $\omega_1 = 5$ tokens that they can allocate between a private account that pays $\beta =$ \$2 per token to only that subject, or to a public account that pays $\alpha =$ \$1 to every subject in their four-subject group, which makes group returns to the public account $N * \alpha =$\$4. Each subject chooses an integer amount g_i to contribute to the public account. Stage 1 payoffs can be represented by the following equation:

$$\pi_i^1 = 2(5 - g_i) + \sum_{j=1}^{4} g_j \tag{1}$$

3.2 Stage 2: Detection

In stage 2, subjects can detect the actions of other group members. We examine two different detection environments: exogenous and endogenous detection. In both environments, the subjects are provided a stage 2 supplement of \$1.[13] In the exogenous detection treatments (EXG), the supplement is automatically paid to an information fund that makes the subject eligible to observe the contributions of other group members.[14] In the endogenous detection treatments (ENDG), the subjects are given a choice of whether they would like to keep the \$1 stage 2 supplement or use it to become eligible to detect others. We will discuss this choice further in the following sections.

3.2.1 Peer Detection

In the peer detection treatments (ENDG/EXG PeerD-NeighborS and PeerD-ConcentratedS), each subject is assigned to detect their right-side group member's contribution, g_r. That means that subject A is assigned to detect the actions of subject B. It follows that B detects C, C detects D, and D detects A, so that information flows as shown in Figure 1. This is meant to approximate the idea of detecting only the people one interacts with closely (e.g., your immediate neighbors, your friends on Facebook, specific buyers/sellers on eBay), while also emphasizing that a single person is responsible for monitoring one other person. Importantly, this design ensures that each subject is pivotal to detecting the actions of exactly one other subject, meaning that subjects cannot rely on others to seek out this information. So, lack of detection cannot be attributed to mis-coordination.

In the exogenous environment, subjects automatically pay their stage 2 supplement and

[13] We also explore peer vs. group detection as explained in detail in the following section. In both detection regimes each person is pivotal in the choice to detect: in peer detection because they are assigned to exactly one other group member, and in group detection because we require unanimity for the detection regime to be implemented. This makes it impossible to free-ride on detection. In other words, the only way that a person will be detected is if the individual charged with monitoring them opts to invest in detection.

[14] For brevity and ease of comprehension, we do not inform subjects in the exogenous enviroment that they have been given a \$1 supplement that will automatically be paid.

are eligible to detect their right-side group member's contributions. In the endogenous treatment, subjects have a choice between keeping their $1 stage 2 supplement and using it to be eligible to observe their right-side group member's contributions. A group member can be sanctioned in stage 3 only if detected in stage 2, and subjects know this when they make the choice to detect.

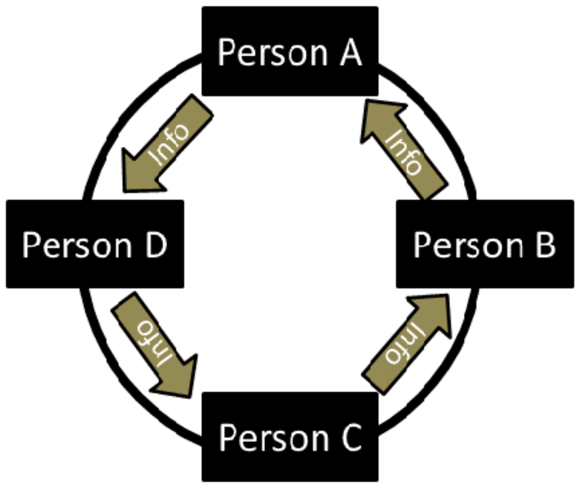


Figure 1: Peer Detection Information Flow

If the stage 2 supplement is paid, then a subject's right-side group member is detected with probability $Prob = \frac{2}{3}$. We set $Prob < 1$ because we wanted a range of zero to four subjects to be detected in both the exogenous and endogenous environments. In the special case where the stage 2 supplement is paid and the right-side group member exhibits pro-social behavior (i.e., contributes her whole stage 1 endowment to the public good, $g_i = \omega_1 = 5$), that pro-social person is detected with probability $Prob = 1$. This is meant to capture the idea that when a neighbor behaves pro-socially, she has no reason to hide her behavior, whereas a free-riding neighbor may try to hide this action from others, so there is a non-zero probability that she will go undetected.[15] Stage 2 payoffs can be summarized as $\pi_i^{2,PeerD} = \pi_i^1$

[15]This also means that if a subject pays the stage 2 supplement and doesn't detect the peer's action, then

if the stage 2 supplement is paid, or $\pi_i^{2,PeerD} = \pi_i^1 + 1$ if the stage 2 supplement is not paid.

For each subject, a random number is drawn from a uniform distribution between zero and one; if that number is less than or equal to two-thirds, then that person is detected if the stage 2 supplement was paid (either automatically in the exogenous environment or by choice in the endogenous environment). So, the probability of detecting the actions of the right-side group member can be summarized as:

$$Prob^{PeerD} = \begin{cases} \frac{2}{3} & \text{if supplement is paid and} \quad g_r < \omega_1 = 5 \\ 1 & \text{if supplement is paid and} \quad g_r = \omega_1 = 5 \\ 0 & \text{if supplement is not paid} \end{cases}$$

At the end of stage 2, subjects are shown the actions of their right-side group member if detected.

3.2.2 Group Detection

In the group detection treatments (ENDG/EXG GroupD-NeighborS and GroupD-ConcentratedS), subjects must collectively fund a group detection regime. When the detection regime is in place, it will report information about all detected members to everyone in the group. This is meant to approximate the idea that centralized group detection requires some form of group agreement and group information dissemination.

In the exogenous environment, subjects automatically pay their stage 2 supplement and are eligible to detect everyone in the group. In the endogenous treatment, subjects have a choice between keeping their stage 2 supplement and pledging it toward a group detection regime. This is meant to approximate a costly vote or costly fundraising to hire an investigator. Each subject is told that they will *only* be able to sanction another group member

the peer must have contributed less than the full endowment. We believe this may bias people toward paying the stage 2 supplement in the next period since it appears there are actions worth detecting and sanctioning. As discussed in the results section, we observe very low levels of detection when the choice is endogenous, and would likely have observed even lower levels without always showing the actions of full contributors.

in stage 3 if that person is detected in stage 2, and subjects know this when they make the choice to detect in the endogenous environment.

In the endogenous environment, if everyone pledges their stage 2 supplement such that the sum of pledges is \$4, then the group detection regime is implemented, and everyone pays the \$1 supplement.[16] If the sum of pledges is lower than \$4, then no one is detected, and no one pays the \$1 supplement (a.k.a a full refund of the pledge).

We require unanimity for the endogenous group detection treatments to keep the costs of detection the same across peer versus group detection. In peer detection, it costs \$1 per two-thirds chance of seeing the actions of any single subject in the group. In group detection, it costs \$4 per two-thirds chance of seeing the actions of all four subjects in the group (i.e., an average of \$1 per chance of seeing the actions of any single subject in the group).

If we were to use a voting rule other than unanimity—for example, if we were to require three of the four group members to implement group detection—then the costs would fall to \$3 per two-thirds chance of seeing the actions of all four subjects in the group; i.e., an average of \$0.75 per chance of seeing the actions of any single subject in the group.[17] Thus, we would be changing both the price of detection and the type of detection simultaneously, which would not enable us to isolate the effect of peer detection versus group detection from the effect of the price change.

Although unanimity is a common way for groups to make decisions, it certainly is not the only way. It is not immediately obvious what would happen if we were to lower the requirement from unanimity to three out of four in the group. Lowering the threshold to three out of four could increase the likelihood of group detection being implemented by lowering both the costs and the number of subjects who need to choose detection. On the other hand,

[16] By requiring that all four group members pay for detection in central detection, we make it impossible for an individual to free-ride off the willingness to pay (WTP) of others (which could occur if we only required three out of four).

[17] We could also change the price of the pledge from \$1 per subject to \$1.33 per subject and require only three out of four, but then we would be changing the stage 2 supplement of our subjects.

lowering the threshold to three out of four could decrease the likelihood of implementation by creating coordination issues and making individuals less pivotal. It is therefore an empirical question whether unanimity decreases the chances that group detection will be implemented.

We do, however, have data from pilot sessions to address this question. We found that lowering the threshold from unanimity to three out of four nearly halves the proportion who pledged the information fee.[18] This implies that were we to loosen the unanimity requirement, we would be even less likely to observe group detection implemented than we are in our current setup.

When the group detection regime is implemented, the actions of each group member are detected with probability $Prob = \frac{2}{3}$. It is made clear to the subjects that these are independent draws, so that when the group detection regime is implemented, the subjects may see the stage 1 contributions of zero, one, two, or all three of their other group members. It is similarly known that when the group detection regime is implemented, the subjects' own actions may or may not be revealed to the group. However, in the special case when the group detection regime is implemented and a subject contributed her whole stage 1 endowment to the public good ($g_i = \omega_1 = 5$), then that subject is detected with probability $Prob = 1$, again to approximate that people do not hide their pro-social actions.[19] Stage 2 payoffs can be summarized as:

[18]See footnote 27 for details.

[19]This also means that if a group implements group detection and does not detect one of the group member's actions, then this group member must have contributed less than the full endowment. We believe that this may bias people toward paying the stage 2 supplement in the next period since it appears that there are actions worth detecting and sanctioning. As discussed in the results section, we observe very low levels of detection when the choice is endogenous, and would likely have observed even lower levels without always showing the actions of full contributors.

$$\pi_i^{2,GroupD} = \begin{cases} \pi_i^1 & \text{if the supplement is pledged, and \$4 is raised} \\ \pi_i^1 + 1 & \text{if the supplement is pledged, but less than \$4 is raised} \\ \pi_i^1 + 1 & \text{if the supplement is not pledged} \end{cases}$$

And the probability of detecting the actions of each group member can be summarized as:

$$Prob_i^{GroupD} = \begin{cases} \frac{2}{3} & \text{for each } i \text{ if group regime implemented and } \quad g_i < \omega_1 = 5 \\ 1 & \text{for each } i \text{ if group regime implemented and } \quad g_i = \omega_1 = 5 \\ 0 & \text{if group regime not implemented} \end{cases}$$

At the end of stage 2, subjects are shown the actions of all detected group members. After stage 2 has concluded, subjects move to stage 3.

3.3 Stage 3: Sanctions

In stage 3, subjects can assign sanctions to other detected group members. Note that it does not matter how subjects are detected (by a peer or group detection regime). Subjects experience a treatment with either neighbor sanctions or concentrated sanctions, and they are aware of which treatment they are in before taking any actions. Moreover, each individual can sanction using any amount of their stage 1 earnings, so that potential sanctions are the same across all the detection-sanction pairs.

3.3.1 Neighbor Sanctions

In the neighbor sanction treatments (ENDG/EXG PeerD-NeighborS and GroupD-NeighborS), each subject is assigned to sanction their right-side group member if that subject was detected in stage 2. That means that subject A is assigned to sanction subject B. It follows that B sanctions C, C sanctions D, and D sanctions A, so that sanctions flow as shown in Figure 2. This is meant to approximate a situation where you can only sanction the person you interact with the most—i.e., your closest neighbor—and you do not require any group consensus to do so. Note that a subject can sanction a detected neighbor no matter how that right side neighbor was detected in stage 2 (e.g. via group detection or via peer detection).

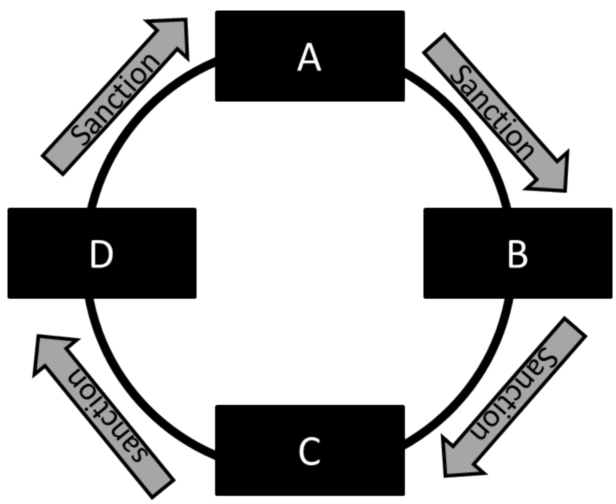


Figure 2: Neighbor Sanction Flow

Subjects decide how many sanctioning points they would like to assign to their right-side neighbor. Note that in the special case where their right-side neighbor has given the maximum to the public good, a subject cannot assign any sanctioning points,[20] so that $p_{i,r}$ is the number of sanctioning points from subject i to their right-side group member r. Each

[20]We prohibit this type of antisocial sanction because such sanctions are not available in our centralized sanctioning mechanism. Antisocial sanctions are one of the reasons that peer level sanctioning (what we call neighbor sanctions) may result in lower contributions than centralized (what we call concentrated) sanctioning, so by precluding this extreme antisocial sanctioning, we bias ourselves toward finding fewer differences between our neighbor and concentrated sanctioning mechanisms.

sanctioning point costs person i \$1 and reduces the payoff of the right-side group member r by \$3. We denote sanctioning points assigned to player i from the person to their left as $p_{l,i}$. So stage 3 payoffs can be summarized as:

$$\pi_i^{3,NeighborS} = \begin{cases} \pi_i^2 - s_{i,r} - 3s_{l,i} & \text{if detect right-member and if person } i \text{ detected} \\ \pi_i^2 - s_{i,r} & \text{if detect right-member and if person } i \text{ not detected} \\ \pi_i^2 - 3s_{l,i} & \text{if do not detect right-member and if person } i \text{ detected} \\ \pi_i^2 & \text{if neither right-member nor } i \text{ detected} \end{cases}$$

Under the neighbor sanctioning mechanism, each subject may sanction exactly one other subject, and each subject may be sanctioned by exactly one other subject. So lack of sanctions can't be attributed to mis-coordination.

3.3.2 Concentrated Sanctions

In the concentrated sanctions treatments (ENDG/EXG PeerD-ConcentratedS and GroupD-ConcentratedS), subjects can assign sanctions that will reduce the payoff of a single group member who is chosen by the concentrated sanctioning mechanism. This is meant to approximate a situation where a group hires a single agency to punish the largest offender, similarly to how courts usually fine the fastest speeders first, or how a department chair usually admonishes the worst teachers.

The cost structure is the same as in the neighbor sanction treatments. Each sanctioning point costs person i \$1 and reduces the payoff of the sanctioned group member by \$3. The concentrated sanctioning mechanism examines the stage 1 contributions (g_i) of all the subjects who were detected in stage 2 and locates the subject with the lowest *detected* contribution in the group. If multiple players tie for the lowest contribution, then the sanction is split evenly among them.[21] If the lowest detected contributor gave their whole endowment $g_i = 5$, then no sanctions are levied and payments for sanction points are refunded to subjects. This is meant to approximate the idea that enforcement would not sanction a person obeying the law. If the lowest detected contributor did not contribute the full amount, however, then she will have her payoff reduced by three times the sum of the group's sanctioning points, $3\sum_j^N s_j$. Stage 3 payoffs can be summarized as:

$$\pi_i^{3,ConcentratedS} = \begin{cases} \pi_i^2 - s_i - 3\sum_j^N s_j & \text{if lowest detected member} \\ \pi_i^2 - s_i & \text{if not lowest detected member} \\ \pi_i^2 & \text{if no one detected} \end{cases}$$

Under the concentrated sanctioning mechanism, each subject may sanction exactly one other subject, but a single subject may be sanctioned by multiple other subjects.[22] At the end of stage 3, subjects are shown their own and others' stage 3 payoffs.

Figure 3 summarizes the 8 treatments by the choice environment (Exogenous vs. Endogenous), the detection regime (Peer vs. Group) and the sanction mechanism (Neighbor vs. Concentrated).

[21] Alternatively we could have randomly chosen one of the subjects from all those who tied. Because subjects have been shown to have issues understanding compound lotteries [Halevy, 2007], we instead opted to evenly split sanctions amongst those who tied with certainty. Ties were not very common, only occurring 11% percent of the time.

[22] With the exception of ties for lowest detected contributions, all those tied split the sanction equally between them. Note that under concentrated sanctions it is also possible for a subject to sanction herself. This can occur if she is the lowest detected contributer and then decides to assign herself a positive value for sanctions. A subject would be aware of this happening, and it is hard to come up with any reason why a subject would want to do this. We only see a subject sanction herself less than 2% of the time.

EXG = subjects forced to pay $1		
	Peer Detect	Group Detect
Neighbor Sanction	PeerD - 2/3 chance see action of right side group member NeighborS -Subjects sanction right hand group member if detected. All subjects can pay $1 to sanction $3	GroupD - 2/3 chance see actions of other 3 group members. NeighborS -Subjects sanction right hand group member if detected. All subjects can pay $1 to sanction$3
Concentrated Sanction	PeerD - 2/3 chance see action of right side group member ConcentratedS -Lowest detected contributor to public good is sanctioned. All subjects can pay $1 to sanction$3	GroupD - 2/3 chance see actions of other 3 group members. ConcentratedS -Lowest detected contributor to public good is sanctioned. All subjects can pay $1 to sanction$3

ENDG = subjects choose to pledge/pay $1		
	Peer Detect	Group Detect
Neighbor Sanction	PeerD - If individual pays $1, then 2/3 chance see action of right side group member NeighborS -Subjects sanction right hand group member if detected. All subjects can pay $1 to sanction $3	GroupD - If group pledges $4, then 2/3 chance see actions of other 3 group members. If pledges < $4, then refund NeighborS -Subjects sanction right hand group member if detected. All subjects can pay $1 to sanction $3
Concentrated Sanction	PeerD - If individual pays $1, then 2/3 chance see action of right side group member ConcentratedS -Lowest detected contributor to public good is sanctioned. All subjects can pay $1 to sanction $3	GroupD - If group pledges $4, then 2/3 chance see actions of other 3 group members. If pledges < $4, then refund ConcentratedS -Lowest detected contributor to public good is sanctioned. All subjects can pay $1 to sanction $3

Figure 3: Summary of 8 Treatments

3.4 Equilibrium

In treatments with either neighbor or concentrated sanctioning, in the last period there is no incentive for subjects to invest in costly sanctioning, so we expect $s_i = 0$ for all i. So, under both sanctioning mechanisms, we expect self-interested subjects to not sanction in stage 3 in the final period.

In treatments with peer or group detection in stage 2, since no sanctions will take place in stage 3, there is no reason to pay a fee to detect subjects that will not be sanctioned either by a neighbor or by a group mechanism. As we expect no subject to pay the \$1 supplement, there is a $Prob = 0$ probability of detection in the endogenous treatments. In the exogenous treatments, subjects do not take any action in stage 2 because detection is automatic. However, since subjects will not sanction in stage 3 in the final period, they will essentially ignore any information provided by an exogenous detection regime.

Since no sanctions are levied in stage 3, the stage 1 game is the simple linear public goods game with the following payoffs:

$$\pi_i^1 = 2(5 - g_i) + \sum_{j=i}^{4} g_j \tag{2}$$

Since the payoff to keeping a token is \$2, while the payoff to contributing a token is only \$1, the subgame equilibrium is for each subject to choose $g_i = 0$, which would result in $\pi_i^1 = \$10$. However, the group utility maximizing choice would instead set $g_i = \omega = 5$, which would result in $\pi_i^1 = \$20$. Thus, in all treatments, the Nash equilibrium prediction is zero contributions to the public good, with no one paying for detection and no sanctions being levied. Subjects play for a finite number of periods, so, using backward induction, we have this same subgame equilibrium in each period.

4 Results

We recruited 272 students to participate in the laboratory at the University of Massachusetts Amherst, using the Online Recruitment System for Experimental Economics software [Greiner, 2015]. Subjects participated in one of the eight treatments in fixed groups of four for 10 periods, for a total of approximately 60 minutes. Subjects only interacted during the experiment via a computer program that was created using z-Tree [Fischbacher, 2007]. The number of subjects per treatment varied from 28 to 40 subjects, and each session always had at least 12 subjects to preserve anonymity. On average, subjects earned a payoff of $19.20 (inclusive of a $5.00 show-up payment).

As we previously noted, almost all research related to public goods games has automatic detection and reporting of all actions to all group members. We relax this assumption by allowing subjects in our endogenous treatments to choose whether they invest in a regime that allows either peer or group detection. In focusing on these changes to the detection of subjects, we contribute to the research on public goods by determining how/whether detection alters sanctions and contribution behavior relative to the benchmark where subjects are automatically detected and observed by others.

4.1 Detection

Given that this research focuses on modifications to the detection mechanism in the standard public goods game, we start with a discussion of the effect of the environment and detection regime on behavior. As we report in Table 1, the number of subjects detected in the exogenous environment is around 2.47, by design, for all detection-sanction combinations.[23]

[23] In the standard public goods game, four subjects are always detected because detection is automatic, with 100% probability. In our setup we set the probability of detection at two-thirds, so we expect two-thirds of the four-person group (approximately 2.66 subjects) to be detected in the exogenous treatments. The actual average number of subjects detected was 2.47. This could be a problem if the average number detected differed by treatment. But pair-wise, t-tests of the average number detected by group are statistically insignificant between the four exogenous treatments (t-test values are always less than 1.16).

Exogenous automatic detection has been standard in the public goods literature. Implicitly, however, this research design is analogous to assuming that all residents in a community either help fund group detection (e.g., police) or individually detect the actions of their peers. However, citizens typically sort into communities with a higher willingness to pay for detection services [Tiebout, 1956, Fehr and Williams, 2013].

Table 1: **Summary Statistics by Treatment**

Treatment	**Individual Public Contribution**	**Number Detected**	**WTP to Detect**	**Total Sanctions**	**Net Earnings**	**Obs.**
EXG GroupD-ConcentratedS	2.94	2.38	1.00	2.09	13.78	400
	(1.54)	(1.10)	(0.00)	(6.31)	(6.21)	
EXG GroupD-NeighborS	2.49	2.50	1.00	1.05	13.93	320
	(1.69)	(1.21)	(0.00)	(2.97)	(4.64)	
EXG PeerD-ConcentratedS	2.80	2.50	1.00	1.63	13.97	360
	(1.90)	(0.67)	(0.00)	(3.30)	(4.45)	
EXG PeerD-NeighborS	2.48	2.50	1.00	1.61	13.34	320
	(1.92)	(1.03)	(0.00)	(3.84)	(4.96)	
ENDG GroupD-ConcentratedS	1.73	0.04	0.34	0.04	14.41	360
	(1.82)	(0.42)	(0.47)	(0.69)	(3.71)	
ENDG GroupD-NeighborS	1.71	0.00	0.34	0.00	14.41	280
	(1.92)	(0.00)	(0.47)	(0.00)	(3.84)	
ENDG PeerD-ConcentratedS	2.71	0.86	0.25	1.32	14.85	320
	(1.86)	(0.80)	(0.43)	(3.36)	(4.67)	
ENDG PeerD-NeighborS	2.66	0.98	0.28	1.12	14.91	360
	(1.99)	(0.96)	(0.45)	(3.18)	(4.82)	

Note: This table reports the mean and standard deviation in parentheses. There were a total of 272 subjects in fixed groups of four who each played for 10 periods. Contributions could be between zero and five tokens. Number Detected could be between zero and four subjects per group. WTP to Detect is the proportion of subjects (0%–100%) who were willing to pay to detect. In the EXG environment, subjects automatically had to pay, so 100% of subjects paid. In the ENDG environment, subjects had a $1 stage 2 supplement. In peer detection treatments, WTP to Detect is the proportion of subjects who paid $1 to detect their right-side group member. In group detection treatments, WTP to Detect is the proportion of subjects who pledged $1 toward a group detection regime, but if the group did not collect $4, this amount was refunded back. Total Sanctions is the cost of assigned sanctions added to received sanctions. Net Earnings represents the total earnings minus the costs of sanctions both assigned and received.

As has been noted in Hadfield and Weingast [2012, 2016], community detection is a critical component in generating public goods (e.g., public safety). But a community may not have residents who are willing to incur the cost to detect others. Since we can only sanction those we detect, we focus on changes in detection when detection is endogenous. Indeed, we see an 80% decline in the number of detected subjects when the choice to detect is made endogenous as opposed to being represented by the more standard exogenous, automatic detection.[24] First, in the endogenous peer detection regime, subjects only pay the cost to

[24] The average number detected is 2.47 in the exogenous treatments and 0.49 in the endogenous treatments.

detect their right-side group member 26% of the time, resulting in an average of 0.92 subjects being detected in each group. Second, when the choice to detect is endogenous, the group detection regime is implemented less than 1% of the time, resulting in an average of 0.02 people detected per group.[25] Thus, when detection is endogenous, we observe 63% and 98% decreases in peer and group detection, respectively.[26]

By introducing a group detection regime that requires unanimous commitment to detection, we open up the opportunity for a single person or small minority to veto implementation (e.g., a single juror insisting on innocence, a single faculty member refusing to reach consensus on a vote, or a permanent member of the UN Security Council exercising veto power). But, as aforementioned, data from pilot sessions show that lowering the need for support from unanimity to three out of four members nearly halves the number of people willing to pay for detection.[27] This implies that if we were to loosen the unanimity requirement we would be even less likely to observe group detection implemented relative to our current

---

Hence, there is an 80% decline in the number of detected subjects ($\frac{2.47-0.49}{2.47} = 0.80$). This difference is statistically significant if we use one observation per group with 33 groups in exogenous treatments and 35 groups in the endogenous treatments. The two-sample t-test with equal variances is $t = 17.9082$ $Pr(|T| > |t|) = 0.0000$.

[25]There are a total of 16 groups in the endogenous group detection regime (nine in ENDG GroupD-ConcentratedS and seven in ENDG GroupD-NeighborS), and each plays 10 periods. The group detection regime was successfully implemented once out of 160 possible times.

[26]These differences are statistically significant if we use one observation per group. There are 17 groups in the exogenous peer detection treatments (average detected, 2.5) and 17 groups in the endogenous peer detection treatments (average detected, 0.92). The two-sample t-test with equal variances yields $t = 10.6050$ $Pr(|T| > |t|) = 0.0000$) . There are 18 groups in the exogenous group detection treatments (average detected, 2.4) and 16 groups in the endogenous group detection treatments (average detected, 0.025) The two-sample t-test with equal variances is $t = 40.2590$ $Pr(|T| > |t|) = 0.0000$).

[27]We ran 24 subjects in the GroupDetect-NeighborSanction treatment, with a threshold of three and 26 subjects in the GroupDetect-NeighborSanction treatment, with a threshold of four. These pilot sessions are not directly comparable to the data reported in this paper because we used randomly rematched groups in the pilot sessions, but used fixed groups in this paper. In our pilot sessions only 14% of subjects in the GroupDetect-NeighborSanction treatment, with a threshold of three, pledged to the information fund, while in the pilot sessions, with a threshold of four, 27% pledged to the information fund. This difference is statistically significant at the 12% level, using a random effects regression (results available from the authors upon request). Using randomly rematched groups, fewer people pledged to the information fund (27%, with $N = 360$ subject-period observations) compared to the proportion of people who pledged in the fixed-group treatment (34%, with $N = 280$ subject-period observations); this difference though is not statistically significant using a random effects regression ($z = -0.75$ $P > |z| = 0.451$).

setup.

Result 1: When we no longer assume that everyone will automatically opt to detect the actions of others, we see an 80% decline in the number of detected subjects.

4.1.1 Who Pays to Detect?

When the choice to detect is endogenous, we might suspect that subjects engaged in the most free-riding would be the least willing to pay for detection. Intuitively, those who do not contribute to the public good would seem unlikely to hire agents to identify free-riders. This is precisely what we observe in the right column of Figure 4 (see Figure 9 in the Appendix for average willingness to pay by period), as subjects who make smaller contributions to the public good are also less likely to pay for a group detection regime.[28]

However, when there is peer detection, no clear relationship emerges between contributions to the public good and payment for detection. Those making large contributions to the public good might want to detect others to discern who is not contributing, so as to encourage higher contributions, from which everyone benefits. By the same logic, though, a free-rider would want to detect for the same reason—that is, because detecting other free-riders might encourage those free-riders (via sanctions) to contribute more to the public good. In addition to this reason, a free-rider might also want to detect other free-riders because detecting other free-riders may lower one's own received sanctions (see Freeman et al. [1996]). We see evidence that free-riders are willing to pay to detect in the left-hand column of Figure 4, which shows willingness to pay for detection by public contributions. In the left-hand column, we do not observe a simple upward sloping relationship; rather, similar

[28] We confirm that a positive, linear relationship exists between contributions to the information fund and public goods contributions in the group detection treatments in appendix Table 6. The average willingness to pay for detection is not statistically significantly different across the endogenous treatments if we use one observation per group, as our pair-wise t-test statistics are always below 1.3425.

proportions of free-riders and large contributors are willing to pay for detection.[29]

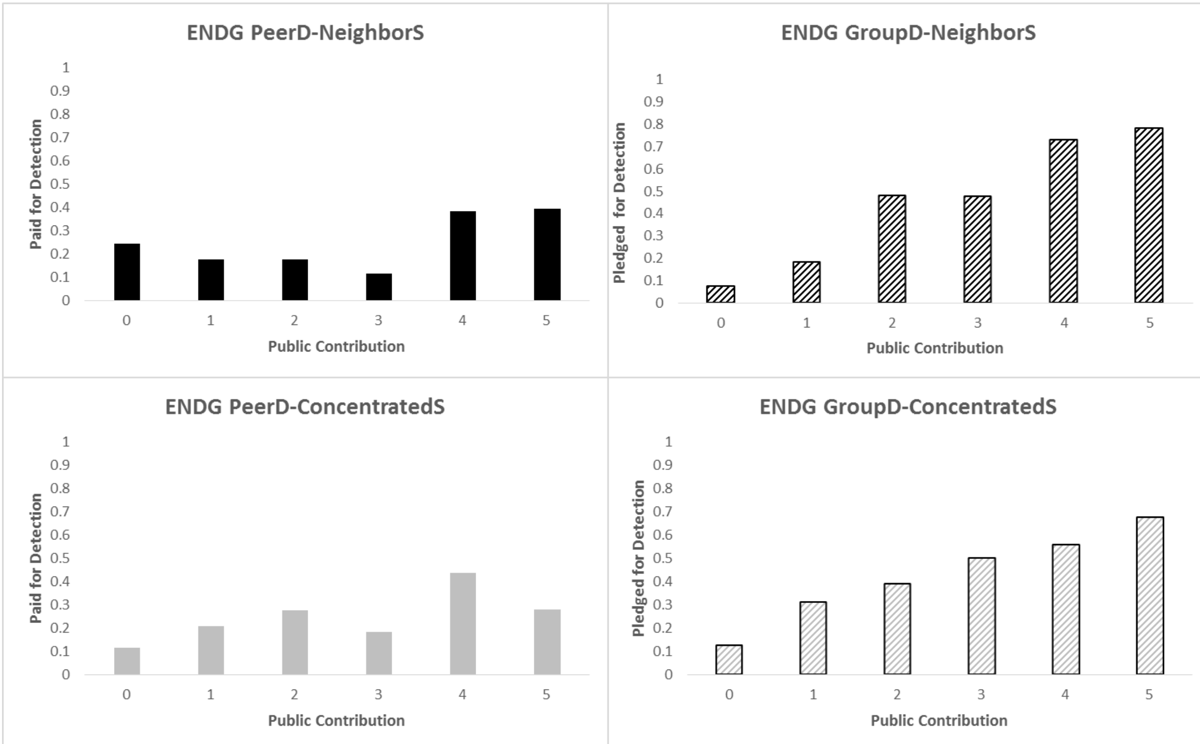


Figure 4: Average Proportion Who Paid/Pledged for Detection by Treatment (ENDG Environment only)

Result 2: Under group detection, free-riders are unwilling to pay for the detection regime that might detect their low contributions to the public good. In contrast, under peer detection, both those who contribute to the public good and those who free-ride exhibit similar willingness to pay for detection.

[29]In the ENDG PeerD-ConcentratedS treatment, we cannot observe significance in the linear or quadratic relationship between public goods contributions and information fund contributions, whereas in the ENDG PeerD-NeighborS treatment, both the linear and quadratic terms are significant. In ENDG PeerD-NeighborS, the relationship between public goods contributions and willingness to pay for detection is negative for those contributing less than $4 to the public good, but positive for individuals contributing $4 or $5. See Appendix Table 6.

4.2 How Do Differences in Detection Change Outcomes?

Given that the environment (ENDG/EXG) as well as the detection regime (group/peer) lead to different choices about who is willing to pay to detect, we might expect sanctioning, contributions, and, therefore, net earnings to respond to these differences. We now explore these possibilities.

4.2.1 Sanctioning

As we saw in the previous section, the number of detected subjects declines precipitously when we endogenize the decision to detect. However, the economics of deterrence literature [Becker, 1968] points out that decreases in the likelihood of detection and sanctions have an interdependent relationship, since deterrence depends on the expected sanction, not just the likelihood of detection or the size of the sanction alone. Having examined the likelihood of detection, we now turn our attention to the level of sanctioning.

If we look at sanctions using a value of zero when either no sanction took place or no sanction was allowed, then the average total costs of sanctions are quite similar as shown in Table 1, ranging between \$1.05-\$2.09 per subject per period, for all our treatments except for the two endogenous group detection regimes. The total costs of sanctions for the ENDG GroupD-ConcentratedS and ENDG GroupD-NeighborS are a mere \$0.04 and \$0.00 because almost no one is actually detected and thus no one is eligible for sanctions in these treatments.[30]

Figure 5 presents both the assigned and the received sanctions across all of the treatments of the experiment (not including 0 when sanctions were not permitted because no one was detected; see Figure 11 in the Appendix for average total sanctions by period). We will only discuss the results for received sanctions in text, since received sanctions are directly related

[30]Two way t-tests on the coefficients from the random effects regression reported in Table 2 show no significant difference in total sanctioning costs when we use a zero when no sanctioning was available.

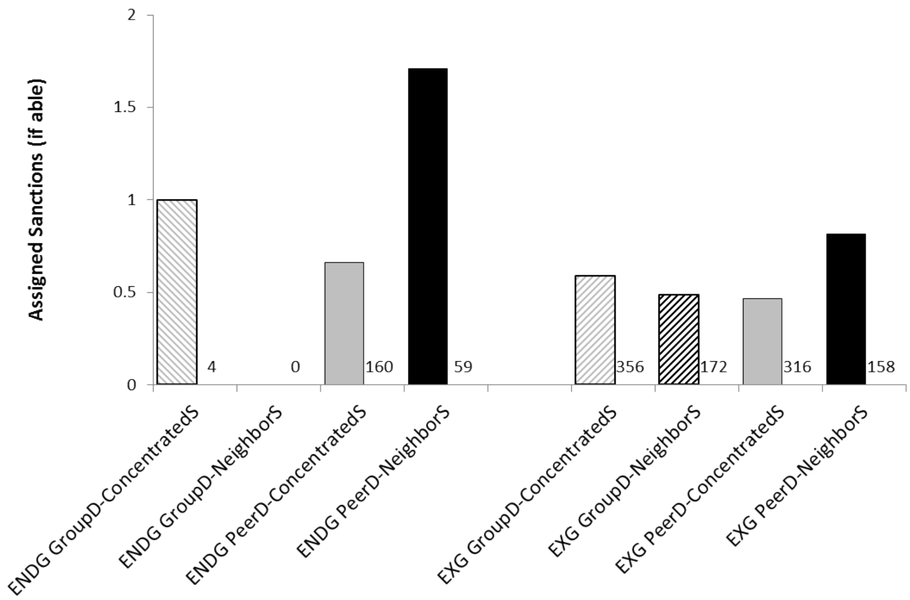
to assigned sanctions insofar as each sanction assigned must also be received by another subject.

In the bottom panel of Figure 5, we find that received sanctions are always higher when penalties are concentrated (gray bars) than when penalizing one's neighbor (black bars).[31] Interestingly, in the ENDG environment, the higher received sanctions conform to the economics of deterrence literature. Stated differently, since the probability of being detected is significantly lower in the ENDG treatments, we should expect higher sanctions in the ENDG rather than the EXG environment. Specifically, in the EXG environment, the likelihood of being eligible to be sanctioned is 38.6%, while it is 7.8% in ENDG environment. The average sanctions received when eligible are 3.155 and 6.145, in the EXG and ENDG environments, respectively. Thus, the expected sanction in the EXG environment is 1.22, whereas the expected sanction in the ENDG environment is 0.48.[32]

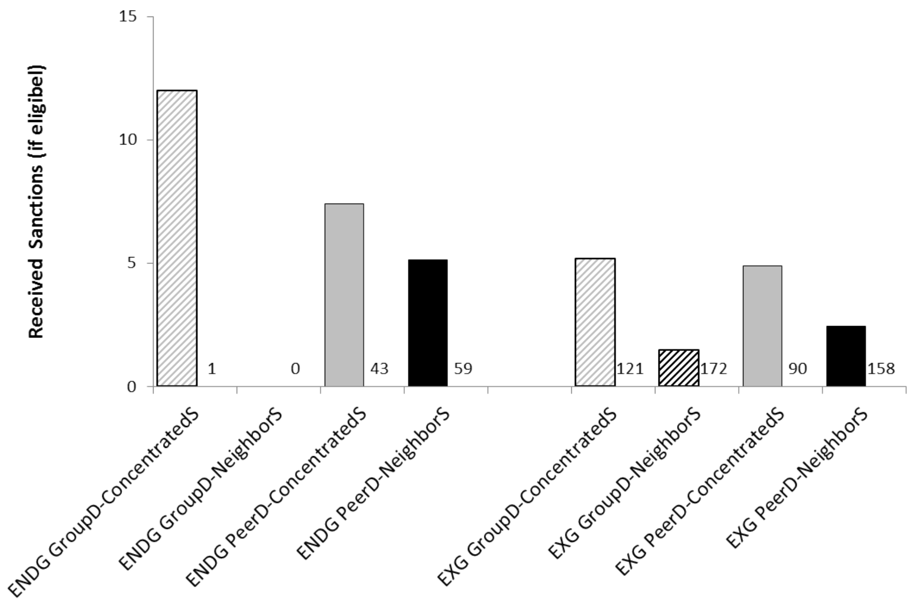
Result 3: Actual sanctions received are higher when detection is a costly endogenous choice. This may be because the probability of detection falls when detection is a costly endogenous choice, and so increases in realized sanctions may be an attempt to equalize expected sanctions across the endogenous and exogenous detection treatments.

[31] Two-way t-tests reported in Appendix Table 5, from the random effects regression reported in Appendix Table 4, show that these differences are statistically significant.

[32] This difference is statistically significant if we use one observation per group, with 35 groups in the exogenous treatments and 33 groups in the endogenous treatments. The two-sample t-test with equal variances yields $t = 3.4636$ $Pr(|T| > |t|) = 0.0005$.



(a) Assigned Sanctions (if Able to Assign)



(b) Received Sanctions (if Eligible to Receive)

Figure 5: Assigned and Received Sanctions by Treatment (With Null Values)

Note: Panel (a) shows the average per subject per period sanctions assigned when there are null values if a subject was not able to assign a sanction either because there was no detection or the recipient gave their full endowment to the public good. Panel (b) shows the average per subject per period sanctions received when there are null values if a subject was not eligible to receive a sanction either because there was no detection or the recipient gave their full endowment to the public good. The numbers to the right of each bar are the total observations of this type. In both Panel (a) and Panel (b), there are instances of the ability to assign/receive sanctions where a value of 0 is assigned/received.

4.2.2 Public Goods Contributions

Given that detection and sanctioning levels show considerable variation across treatments, we now examine public goods contributions across these contexts. Figure 6 shows the average public contributions by treatment (see Figure 8 in the Appendix for average public contributions by period). The left side of Figure 6 displays the endogenous detection treatments, while the right side examines the exogenous detection treatments, which are more typical in the public goods literature.

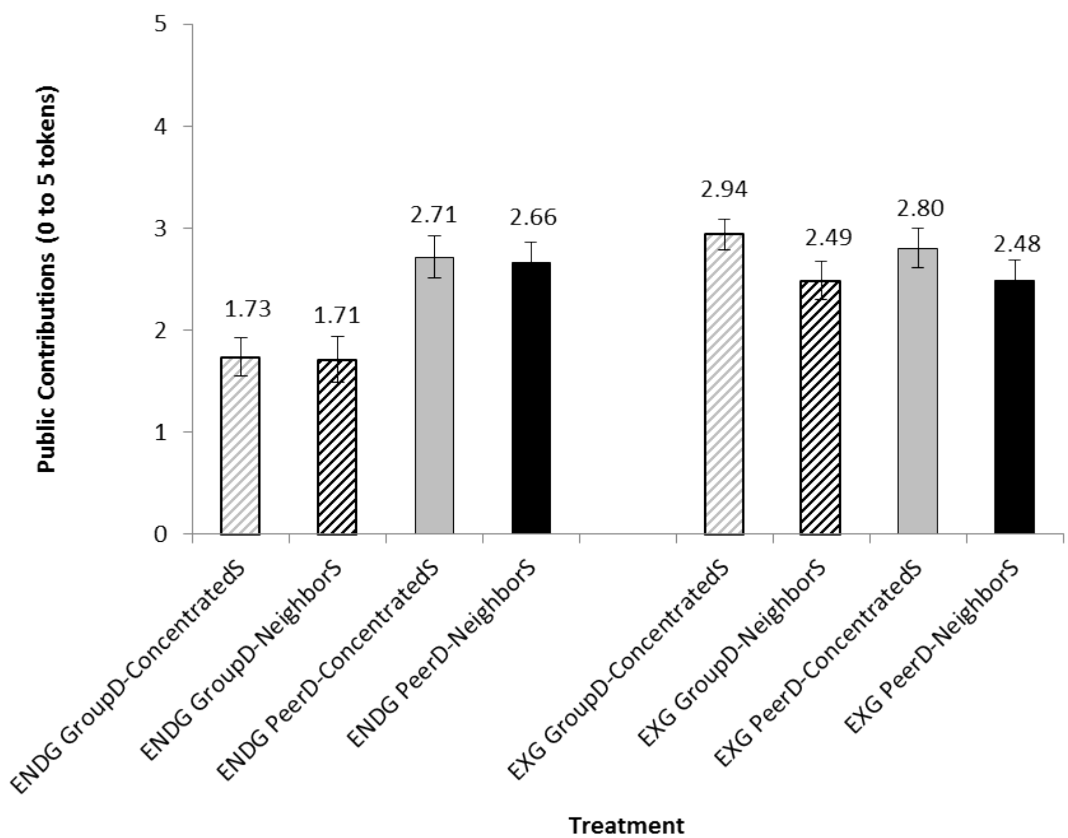


Figure 6: Average Contributions by Treatment and Environment

Note: In this figure we show the average per person contributions to the public good by treatment out of a possible five tokens and the 95% confidence interval. The four bars on the left represent treatments where detection only took place if subjects endogenously chose it by paying a \$1 supplement. The four bars on the right represent treatments where detection was exogenously made automatic. A bar has a striped pattern if there was a group detection regime. A bar has gray shading if there was a concentrated sanctioning mechanism.

The first thing we note is that endogenizing detection lowers public good contributions by 17%.[33] Examining the left side of Figure 6, where detection is a costly endogenous choice, group detection leads to contributions that are 35% lower than under peer detection (the striped bars in Figure 6 are shorter than the solid bars).[34] This appears to occur because endogenous group detection leads to a very low probability of detection, as explained above.

When we examine the treatments with exogenously assigned detection, public goods contributions are not statistically different whether subjects experience the group or peer detection regime.[35] However, public contributions are higher when there are concentrated sanctions instead of neighbor sanctions (looking at the right four bars, the gray bars are higher than the black bars).[36] This is because fines received are higher with a concentrated sanctioning mechanism.

Result 4: When detection is exogenously automatic, public contributions are similar for group versus peer detection, but when detection is a costly endogenous choice, then group detection results in a 35% reduction in public contributions.

[33]This difference is statistically significant if we use one observation per group with the 36 groups in ENDG treatments contributing 2.22 of 5 tokens and the 35 groups in EXG treatments contributing 2.69 of 5 tokens. The two-sample t-test with equal variance yields $t = 2.1027$ $Pr(|T| > |t|) = 0.0197$. In case it is useful in a similar set-up Andreoni and Gee [2012] find with automatic 100% detection and no sanctioning subject contribute an average of 1.56 out of 5 tokens.

[34]This difference is statistically significant if we use one observation per group with 17 groups in ENDG PeerD-NeighborS/PeerD-ConcentratedS treatments and 16 groups in ENDG GroupD-NeighborS/GroupD-ConcentratedS treatments. The two-sample t-test with equal variance yields $t = 2.9690$ $Pr(|T| > |t|) = 0.0057$.

[35]This difference is statistically insignificant if we use one observation per group with 17 groups in EXG PeerD-NeighborS/PeerD-ConcentratedS treatments and 18 groups in EXG GroupD-NeighborS/GroupD-ConcentratedS treatments. The two-sample t-test with equal variances yields $t = -0.3104$ $Pr(|T| > |t|) = 0.6209$.

[36]This difference is statistically significant at the 16% level if we use one observation per group with 16 groups in EXG PeerD-NeighborS/GroupD-NeighborS treatments and 19 groups in EXG PeerD-NeighborS/GroupD-NeighborS treatments. The two-sample t-test with equal variances yields $t = -1.4213$ $Pr(|T| > |t|) = 0.1646$.

4.2.3 Net Earnings

Thus far, we have identified significant differences in the likelihood of detection, sanctions, and public good provisions, while the mechanics (i.e., detection, sanctions, and contributions) of each of these environments and treatments are considerably different. Yet looking at Figure 7 makes it is clear that subjects adjust their behavior to account for these differences, such that net earnings are nearly identical.[37]

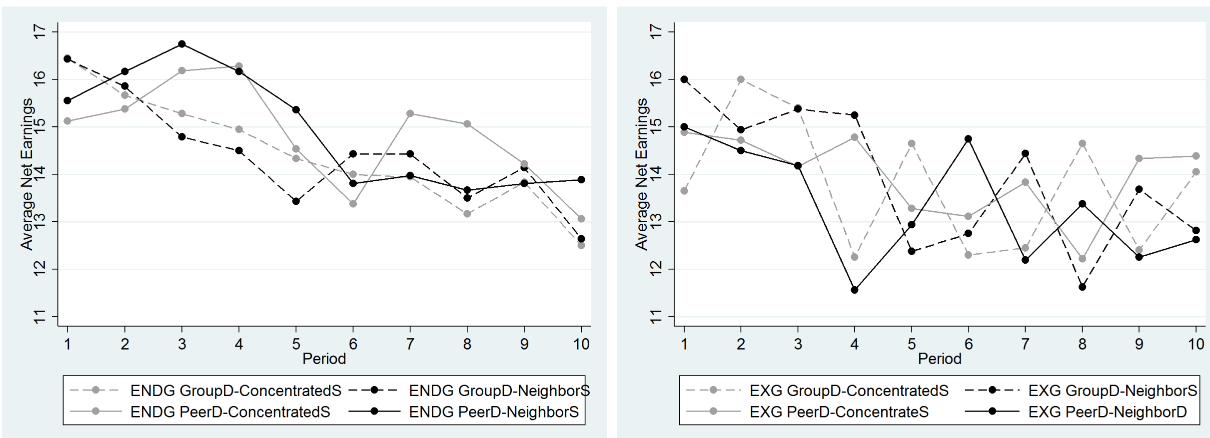


Figure 7: Average Net Earnings per Period by Treatment

5 Conclusion and Discussion

Research on the optimal provision of public goods has focused on whether informal peer-to-peer sanctions or formal centralized sanctions should be utilized to discourage free-riding. While this is an important research endeavor, it makes strong assumptions concerning the likelihood of detection. Since a community can only sanction those persons that it catches behaving badly, attention to the detection mechanism is warranted. Most previous research has assumed an automatic and central detection technology that broadcasts information to the

[37]Only ENDG PeerD-ConcentratedS ($14.85) and ENDG PeerD-NeighborS ($14.91) both have net earnings that are statistically significantly higher than those in EXG PeerD-NeighborS ($13.34). All other comparisons are not statistically significantly different. See Appendix Table 2 and Appendix Table 3.

whole group. In this paper, we show that whether one can–exogenously or endogenously– detect the actions of everyone or just those of a close neighbor significantly affects contributions to the public good. Furthermore, the optimal detection-sanction pair varies considerably if the decision to detect is a costly endogenous choice, rather than being automatic.

When detection is exogenously automatic, then contributions to the public good are similar whether a person can detect only their closest neighbor or instead can see information about the whole group's actions through group detection. However, the story is very different when the choice to detect is made endogenous. Peer detection leads to increases in public contributions in the endogenous environment as subjects do not have to coordinate to detect other's actions. And contributions decrease in the group detection environment because the largest free-riders are unwilling to fund the group detection regime that might catch them misbehaving.

Overall, we observe an 80% reduction in detection when the choice to detect is made endogenous versus being the more standard automatic detection. This decline in detection may not lead to a decline in deterrence if sanctions are high enough, though. We find that concentrating sanctions leads to higher received sanctions. But those higher sanctions only consistently translate into higher contributions if a community can be counted on to detect free-riding, since even the highest threatened sanction is non-deterrent if a free-rider knows that they will not be caught.

This research indicates that it is not advisable to centralize detection when the community might let free-riding members go undiscovered. While we have examined only a few specific formulations of detection regimes and sanctioning mechanisms, we view the treatments considered in our research as stylized versions of any number of examples of the detection-sanctioning pairs that might be observed in practice. Further research into what specific attributes of a detection regime or sanctioning mechanism lead to higher provision of the public good is necessary.

An interesting ordering of what led to the highest provision of the public good emerged in our analysis. Under conditions of exogenously imposed automatic detection, group detection with concentrated sanctioning (EXG GroupD-ConcentratedS) generates higher contributions to the public good than peer detection with neighbor sanctioning (EXG PeerD-NeighorS), although the difference is not statistically significant. However, when we endogenize the detection decision, we find that the ordering switches, such that the group detection with concentrated sanctioning (ENDG GroupD-ConcentratedS) yields lower public goods contributions than peer detection with neighbor sanctioning (ENDG PeerD-NeighborS). Stated differently, when the residents of a community always engage in detection, then a homeowner association that can detect and fine residents has better results than detecting your neighbor and writing nasty notes. But if that choice to detect is endogenous, then the ordering and effectiveness flips.

This flipping of ordering and effectiveness could make the decision of the social planner difficult. However, in either the exogenous or endogenous environment, peer detection with concentrated sanctioning (EXG/ENDG PeerD-ConcentratedS) results in high public contributions that are not statistically significantly different from the other successful combinations (EXG GroupD-ConcentratedS and ENDG PeerD-NeighborS).[38]

There are many examples of the peer detection and concentrated sanctioning pair: Facebook, where users report the misconduct of other users to the central complaints department that boots off the worst offenders; universities, where individual students report poor teachers to the administration who fires the worst un-tenured offenders; cities, where one can report a noisy neighborhood party to the police who shut down the loudest parties. Peer detection and concentrated sanctioning may be so popular because the organizer of a group (e.g., Facebook, universities, or cities) does not always know if their population will be willing

[38]Contributions in the ENDG PeerD-ConcentratedS treatment are statistically significantly higher than those in the GroupD-ConcentratedS. Contributions in the EXG PeerD-ConcentratedS are not statistically significantly different from those in the other EXG treatments.

to pay a cost to detect others, and this combination of detection and sanctioning is robust to either exogenous or endogenous choice of detection.[39] Thus, when a social planner is unsure if detection can be automated or will be by choice, peer detection coupled with concentrated sanctioning is a relatively safe way to ensure public good provision.

This research highlights that the common assumption of automatic detection of each group member's actions in the public goods game can lead to very different conclusions about what is optimal for public good provision relative to the scenario where we allow people to shirk the responsibility of detecting others. Centralizing detection when the community might let free-riding members go undiscovered results in the under-provision of public goods.

[39] Additionally, information is relatively more costly for authorities to gather relative to one's peers.

References

D. Acemoglu and M. O. Jackson. History, expectations, and leadership in the evolution of social norms. *The Review of Economic Studies*, 82(2):423–456, 2015.

D. Acemoglu and A. Wolitzky. Sustaining cooperation: Community enforcement vs. specialized enforcement. *NBER Working Paper*, 21457, 2015.

A. Ambrus and B. Greiner. Imperfect public monitoring with costly punishment: An experimental study. *The American Economic Review*, 102(7):3317–3332, 2012.

L. Anderson, G. DeAngelo, W. Emons, B. Freeborn, and H. Lang. Penalty structures and deterrence in a two-stage model: Experimental evidence. *Economic Inquiry*, Forthcoming, 2017.

J. Andreoni. Reasonable doubt and the optimal magnitude of fines: should the penalty fit the crime? *The RAND Journal of Economics*, pages 385–395, 1991.

J. Andreoni and L. K. Gee. Gun for hire: delegated enforcement and peer punishment in public goods provision. *Journal of Public Economics*, 96(11):1036–1046, 2012.

J. Andreoni and L. K. Gee. Gunning for efficiency with third party enforcement in threshold public goods. *Experimental Economics*, 18(1):154–171, 2015.

M. Aoyagi and G. Frechette. Collusion as public monitoring becomes noisy: Experimental evidence. *Journal of Economic theory*, 144(3):1135–1165, 2009.

D. Baldassarri and G. Grossman. Centralized sanctioning and legitimate authority promote cooperation in humans. *Proceedings of the National Academy of Sciences*, 108(27):11023–11027, 2011.

A. Bar-Ilan and B. Sacerdote. The response to fines and probability of detection in a series of experiments. *NBER Working Paper*, 2001.

C. Beccaria. *On crimes and punishments*. Hackett, Indianapolis, IN, 1986.

G. Becker. Crime and punishment: An economic approach. *Journal of Political Economy*, 76, 1968. URL http://EconPapers.repec.org/RePEc:ucp:jpolec:v:76:y:1968:p:169.

L. Boosey and R. M. Isaac. Asymmetric network monitoring and punishment in public goods experiments. *Journal of Economic Behavior & Organization*, 132:26–41, 2016.

A. Botelho, G. W. Harrison, L. M. C. Pinto, and E. E. Rutström. Social norms and social choice. 2007.

J. P. Carpenter. Punishing free-riders: How group size affects mutual monitoring and the provision of public goods. *Games and Economic Behavior*, 60(1):31–51, 2007.

J. P. Carpenter and P. H. Matthews. Norm enforcement: Anger, indignation, or reciprocity? *Journal of the European Economic Association*, 10(3):555–572, 2012. ISSN 1542-4774. doi: 10.1111/j.1542-4774.2011.01059.x. URL http://dx.doi.org/10.1111/j.1542-4774.2011.01059.x.

J. P. Carpenter, S. Kariv, and A. Schotter. Network architecture and mutual monitoring in public goods experiments. *The Review of Economic Design*, 2012.

T. N. Cason and L. Gangadharan. Swords without covenants do not lead to self-governance. *Journal of Theoretical Politics*, 28(1):44–73, 2016.

T. N. Cason and F. U. Khan. A laboratory study of voluntary public goods provision with imperfect monitoring and communication. *Journal of development Economics*, 58(2):533–552, 1999.

T. N. Cason, L. Gangadharan, and P. Maitra. Moral hazard and peer monitoring in a laboratory microfinance experiment. *Journal of Economic Behavior & Organization*, 82 (1):192–209, 2012.

P. Dal Bó and G. R. Fréchette. On the determinants of cooperation in infinitely repeated games: A survey. *Available at SSRN 2535963*, 2014.

G. DeAngelo and G. Charness. Deterrence, expected cost, uncertainty and voting: Experimental evidence. *Journal of Risk and Uncertainty*, 44(1), 2012.

G. DeAngelo and B. Hansen. Life and death in the fast lane: Police enforcement and roadway safety. *American Economic Journal: Economic Policy*, 6(2), 2014.

G. DeAngelo and T. Smith. Private security, piracy and the international provision of public goods. *Working Paper*, 2016.

H. B. DeAngelo, Gregory and I. Reimers. Are public and private enforcement complements or substitutes evidence from high frequency nhl. *Journal of Economic Behavior & Organization*, 2017.

J. Deb and J. González-Dıaz. Enforcing social norms: Trust-building and community enforcement. Technical report, Working paper, 2014.

D. Dickinson and M.-C. Villeval. Does monitoring decrease work effort?: The complementarity between agency and crowding-out theories. *Games and Economic Behavior*, 63(1): 56–76, 2008.

N. Dwenger, H. Kleven, I. Rasul, and J. Rincke. Extrinsic and intrinsic motivations for tax compliance: Evidence from a field experiment in germany. *American Economic Journal: Economic Policy*, 8(3):203–232, 2016.

M. Egas and A. Riedl. The economics of altruistic punishment and the maintenance of cooperation. *Proceedings of the Royal Society of London B: Biological Sciences*, 275(1637): 871–878, 2008.

A. Ertan, T. Page, and L. Putterman. Who to punish? individual decisions and majority rule in mitigating the free rider problem. *European Economic Review*, 53(5):495–511, 2009.

M. Faillo, D. Grieco, and L. Zarri. Legitimate punishment, feedback, and the enforcement of cooperation. *Games and Economic Behavior*, 77(1):271–283, 2013.

J. Falkinger, E. Fehr, S. Gächter, and R. Winter-Ebmer. A simple mechanism for the efficient provision of public goods: Experimental evidence. *The American Economic Review*, 90 (1):247–264, 2000.

E. Fatas, M. A. Melendez-Jimenez, and H. Solaz. An experimental analysis of team production in networks. *Experimental Economics*, 13(4):399–411, 2010.

E. Fehr and S. Gachter. Cooperation and punishment in public goods experiments. *American Economic Review*, 90(4):980–994, September 2000. doi: 10.1257/aer.90.4.980. URL http://www.aeaweb.org/articles?id=10.1257/aer.90.4.980.

E. Fehr and S. Gächter. Altruistic punishment in humans. *Nature*, 415(6868):137–140, 2002.

E. Fehr and T. Williams. Endogenous emergence of institutions to sustain cooperation. 2013.

U. Fischbacher. z-tree: Zurich toolbox for ready-made economic experiments. *Experimental Economics*, 10(2):171–178, 2007.

S. Fischer, K. R. Grechenig, and N. Meier. Cooperation under punishment: Imperfect information destroys it and centralizing punishment does not help. *MPI Collective Goods Preprint*, (2013/06), 2013.

S. Freeman, J. Grogger, and J. Sonstelie. The Spatial Concentration of Crime. *Journal of Urban Economics*, 40(2):216–231, September 1996. URL https://ideas.repec.org/a/eee/juecon/v40y1996i2p216-231.html.

L. Friesen. Certainty of punishment versus severity of punishment: an experimental investigation. *Southern Economic Journal*, 79(2), 2012.

D. Fudenberg, D. G. Rand, and A. Dreber. Slow to anger and fast to forgive: Cooperation in an uncertain world. *American Economic Review*, 102(2):720–749, 2012.

A. Fuster and S. Meier. Another hidden cost of incentives: The detrimental effect on norm enforcement. *Management Science*, 56(1):57–70, 2010.

S. Gächter, E. Renner, and M. Sefton. The long-run benefits of punishment. *Science*, 322 (5907):1510–1510, 2008.

K. Grechenig, A. Nicklisch, and C. Thöni. Punishment despite reasonable doubta public goods experiment with sanctions under uncertainty. *Journal of Empirical Legal Studies*, 7 (4):847–867, 2010.

A. Greif. Contract enforceability and economic institutions in early trade: The maghribi traders' coalition. *The American Economic Review*, pages 525–548, 1993.

A. Greif. Cultural beliefs and the organization of society: A historical and theoretical reflection on collectivist and individualist societies. *Journal of Political Economy*, pages 912–950, 1994.

B. Greiner. Subject pool recruitment procedures: organizing experiments with orsee. *Journal of the Economic Science Association*, 1(1):114–125, 2015. ISSN 2199-6784. doi: 10.1007/s40881-015-0004-4. URL http://dx.doi.org/10.1007/s40881-015-0004-4.

J. Grogger. Certainty vs. severity of punishment. *Economic Inquiry*, 29(2):297–309, 1991. ISSN 1465-7295. doi: 10.1111/j.1465-7295.1991.tb01272.x. URL http://dx.doi.org/10.1111/j.1465-7295.1991.tb01272.x.

J. Gross, Z. Z. Méder, S. Okamoto-Barth, and A. Riedl. Building the leviathan–voluntary centralisation of punishment power sustains cooperation in humans. *Scientific reports*, 6, 2016.

S. Grosse, L. Putterman, and B. Rockenbach. Monitoring in teams: Using laboratory experiments to study a theory of the firm. *Journal of the European Economic Association*, 9(4):785–816, 2011. ISSN 1542-4774. doi: 10.1111/j.1542-4774.2011.01026.x. URL http://dx.doi.org/10.1111/j.1542-4774.2011.01026.x.

G. K. Hadfield and B. R. Weingast. What is law? a coordination model of the characteristics of legal order. *Journal of Legal Analysis*, 4(2):471–514, 2012.

G. K. Hadfield and B. R. Weingast. Is rule of law an equilibrium without private ordering? *Available at SSRN*, 2016.

Y. Halevy. Ellsberg revisited: An experimental study. *Econometrica*, 75(2):503–536, 2007. ISSN 1468-0262. doi: 10.1111/j.1468-0262.2006.00755.x. URL http://dx.doi.org/10.1111/j.1468-0262.2006.00755.x.

A. Harel and A. Klement. The economics of shame: Why more shaming may deter less. *Working Paper*, 2005.

T. Hobbes. *Leviathan, 1651*. Scolar Press, 1651.

K. Kamei, L. Putterman, and J.-R. Tyran. State or nature? endogenous formal versus informal sanctions in the voluntary provision of public goods. *Experimental Economics*, 18(1):38–65, 2015.

S. Karstedt-Henke. Attribution theory and deterrence research: A new approach to old problems. *Developments in Crime and Crime Control Research*, pages 22–40, 1991.

J. Klick and A. Tabarrok. Using terror alert levels to estimate the effect of police on crime. *Journal of Law and Economics*, XLVIII, 2005.

A. Leibbrandt, A. Ramalingam, L. Sääksvuori, and J. M. Walker. Incomplete punishment networks in public goods games: experimental evidence. *Experimental Economics*, 18(1): 15–37, 2015.

S. Levitt. Using electoral cycles in police hiring to estimate the effect of police on crime. *American Economic Review*, 87(3), 1997.

S. Machin and O. Marie. Crime and police resources: The street crime initiative. *Journal of the European Economic Association*, 9(4):678–701, 2011. ISSN 1542-4774. doi: 10.1111/j.1542-4774.2011.01018.x. URL http://dx.doi.org/10.1111/j.1542-4774.2011.01018.x.

T. Markussen, L. Putterman, and J.-R. Tyran. Self-organization for collective action: An experimental study of voting on sanction regimes. *The Review of Economic Studies*, 81 (1):301–324, 2014.

A. S. Nageeb and D. A. Miller. Enforcing cooperation in networked societies. *Working Paper*, 2013.

A. Nicklisch, K. Grechenig, and C. Thöni. Information-sensitive leviathans. *Journal of Public Economics*, 144:1–13, 2016.

N. Nikiforakis and H.-T. Normann. A comparative statics analysis of punishment in public-good experiments. *Experimental Economics*, 11(4):358–369, 2008.

R. O'Gorman, J. Henrich, and M. Van Vugt. Constraining free riding in public goods games: designated solitary punishers can sustain human cooperation. *Proceedings of the Royal Society of London B: Biological Sciences*, 276(1655):323–329, 2009.

E. Ostrom. *Governing the commons.* Cambridge University Press, 2015.

E. Ostrom, J. Walker, and R. Gardner. Covenants with and without a sword: Self-governance is possible. *American Political Science Review*, 86(02):404–417, 1992.

T. Page, L. Putterman, and B. Garcia. Getting punishment right: Do costly monitoring or redistributive punishment help? *Available at SSRN 1084064*, 2008.

A. M. Polinsky and D. L. Rubinfeld. A model of optimal fines for repeat offenders. *Journal of Public Economics*, 46(3):291–306, 1991.

A. M. Polinsky and S. Shavell. The optimal use of fines and imprisonment. *Journal of Public Economics*, 24(1):89–99, 1984.

A. Ramalingam, S. Godoy, A. J. Morales, and J. M. Walker. An individualistic approach to institution formation in public good games. *Journal of Economic Behavior & Organization*, 129:18–36, 2016.

H. Rauhut. Higher punishment, less control? experimental evidence on the inspection game. *Rationality and Society*, 21(3):359–392, 2009.

H. Rauhut and M. Junker. Punishment deters crime because humans are bounded in their strategic decision-making. *Journal of Artificial Societies and Social Simulation*, 12(3):1, 2009.

D. Teichman. Sex, shame, and the law: An economic perspective on megan's law. *Harvard Journal on Legislation*, 42(2), 2005.

C. M. Tiebout. A Pure Theory of Local Expenditures. *Journal of Political Economy*, 64:416–416, 1956. doi: 10.1086/257839. URL https://ideas.repec.org/a/ucp/jpolec/v64y1956p416.html.

A. Traulsen, T. Röhl, and M. Milinski. An economic experiment reveals that humans prefer pool punishment to maintain the commons. *Proceedings of the Royal Society of London B: Biological Sciences*, page rspb20120937, 2012.

T. Yamagishi. The provision of a sanctioning system as a public good. *Journal of Personality and Social Psychology*, 51(1):110, 1986.

6 Appendix (For Online Publication)

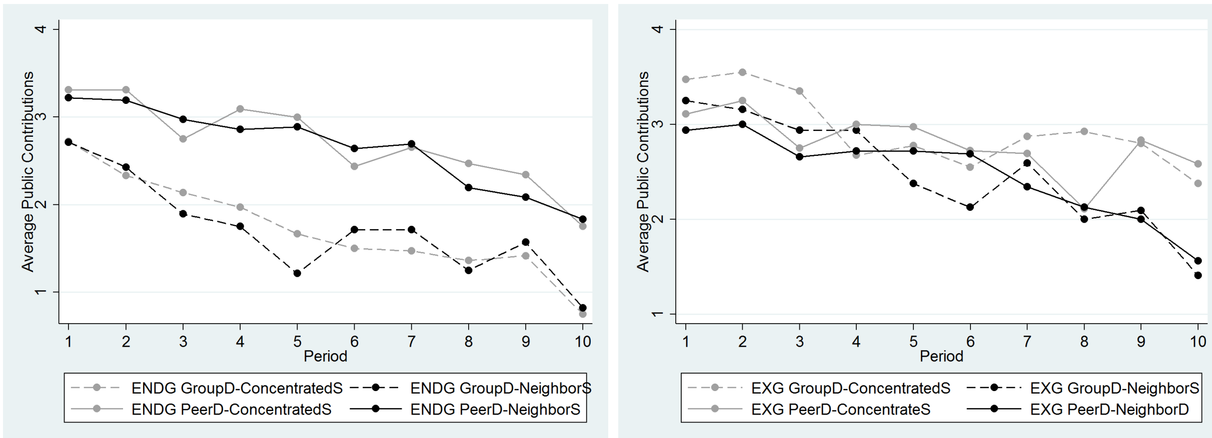


Figure 8: Average Contributions per Period by Treatment

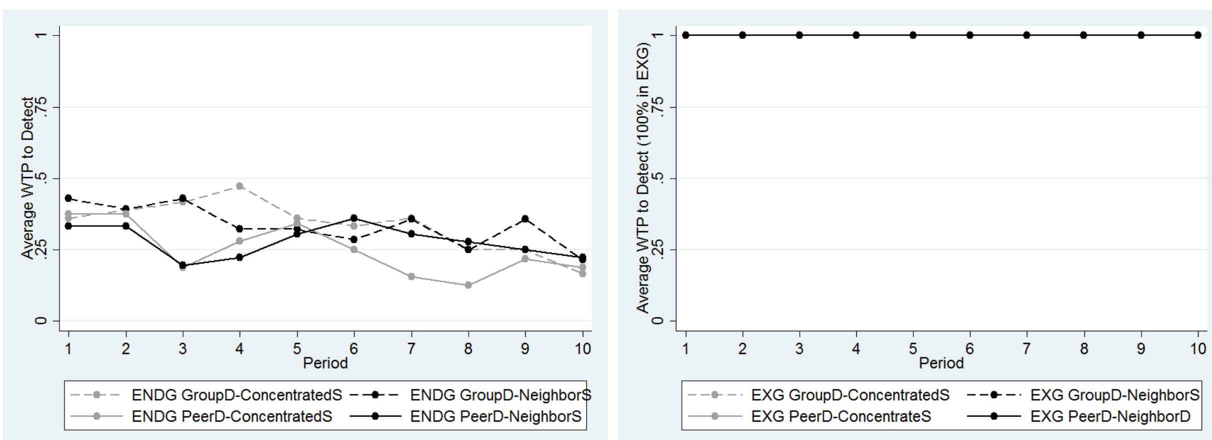


Figure 9: Average Proportion Willing to Pay to Detect per Period by Treatment

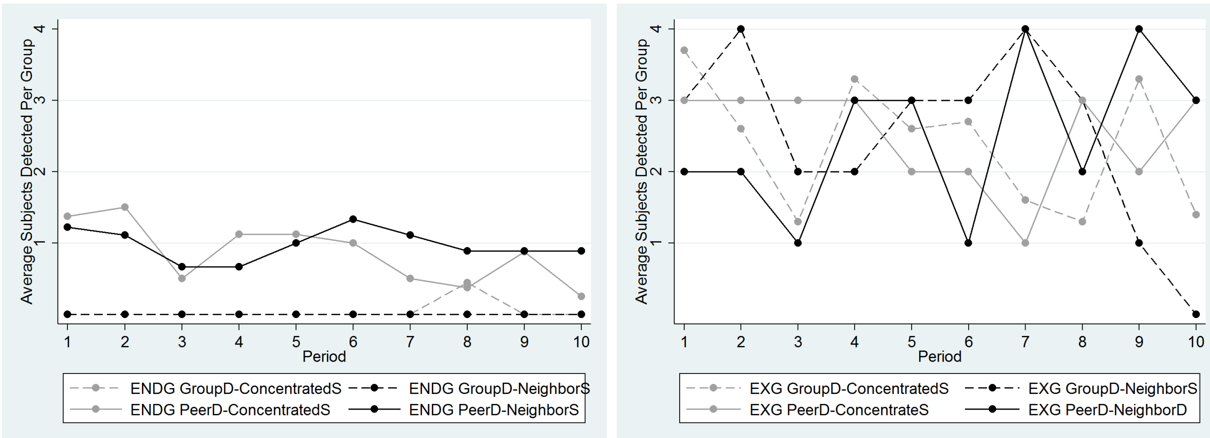


Figure 10: Average Subjects Detected in Group per Period by Treatment

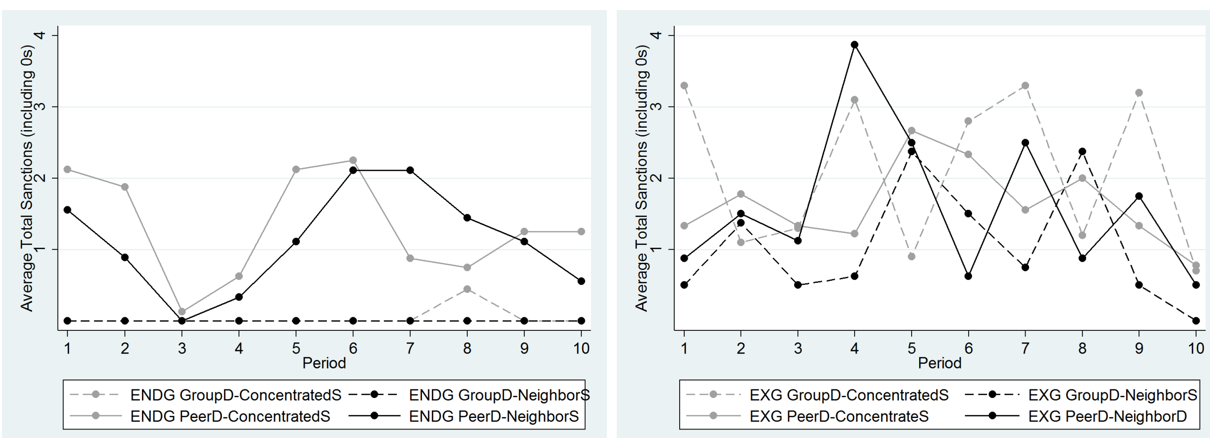


Figure 11: Average Total Sanctions per Period by Treatment

Table 2: Treatment Effects on Contributions and Net Earnings

	(1) Contributions	(2) Net Earnings
ENDG GroupD-ConcentratedS	−0.74+	1.07
	(0.39)	(0.80)
ENDG GroupD-NeighborS	−0.77*	1.08
	(0.37)	(0.75)
ENDG PeerD-ConcentratedS	0.24	1.51+
	(0.37)	(0.79)
ENDG PeerD-NeighborS	0.18	1.58
	(0.41)	(0.96)
EXG GroupD-ConcentratedS	0.46	0.44
	(0.35)	(0.77)
EXG GroupD-NeighborS	0.01	0.59
	(0.28)	(0.81)
EXG PeerD-ConcentratedS	0.33	0.63
	(0.41)	(0.91)
Period	−0.14***	−0.26***
	(0.01)	(0.03)
Intercept	3.24***	14.77***
	(0.23)	(0.51)
overall R^2	0.09	0.03
N	2720	2720

EXG PeerD-NeighborS is the omitted category. Sanctions are assigned sanctions plus received sanctions (note that four multiplied by assigned sanctions equals total sanctions and that three multiplied by assigned sanctions equals received sanctions). Random effects regression with period controls and standard errors clustered at the group level are reported (68 clusters). *** $p < 0.001$, ** $p < 0.001$, * $p < 0.05$, + $p < 0.1$.

Table 3: t-Test Results for Treatment Effects on Contributions and Net Earnings

	ENDG GroupD-ConS	ENDG GroupD-NeighborS	ENDG PeerD-ConS	ENDG PeerD-NeighborS	EXG GroupD-ConS	EXG GroupD-NeighborS	EXG PeerD-ConS	EXG PeerD-NeighborS
ENDG GrpD-ConS	-, -		c	c	c	c	c	c
ENDG GrpD-NeighborS		-, -	c	c	c	c	c	c
ENDG PeerD-ConS	c	c	-, -					n
ENDG PeerD-NeighborS	c	c		-, -				n
EXG GrpD-ConS	c	c			-, -			
EXG GrpD-NeighborS	c	c				-, -		
EXG PeerD-ConS	c	c					-, -	
EXG PeerD-NeighborS	c	c	n	n				-, -

This table presents the results from two-way t-tests on the coefficients from the random effects regression reported in Table 2. A letter c denotes whether the public goods contributions are statistically significantly different at the the 10% level. A letter n denotes whether net income is statistically significantly different at the the 10% level. A dash denotes a comparison is not possible.

Table 4: Treatment Effects on Sanctions

	(1) Total Sanctions	(2) Assigned Sanctions	(3) Received Sanctions
ENDG GroupD-ConcentratedS	−1.57***	0.17	9.60***
	(0.24)	(0.15)	(0.49)
ENDG GroupD-NeighborS	−1.61***	.	.
	(0.23)	.	.
ENDG PeerD-ConcentratedS	−0.29	−0.19	5.27***
	(0.32)	(0.20)	(1.59)
ENDG PeerD-NeighborS	−0.49	0.74**	1.96**
	(0.40)	(0.23)	(0.76)
EXG GroupD-ConcentratedS	0.48	-0.24	2.78
	(0.71)	(0.29)	(2.35)
EXG GroupD-NeighborS	−0.56	−0.40+	−1.37+
	(0.44)	(0.24)	(0.76)
EXG PeerD-ConcentratedS	0.02	−0.39*	2.33*
	(0.35)	(0.18)	(0.96)
Period	−0.02	−0.01	−0.13
	(0.02)	(0.01)	(0.08)
Intercept	1.70***	0.94***	3.41***
	(0.26)	(0.19)	(0.81)
overall R^2	0.03	0.08	0.03
N	2720	1225	644

EXG PeerD-NeighborS is the omitted category. Total sanctions are assigned sanctions plus received sanctions. Random effects regression with period controls and standard errors clustered at the group level are reported. (Column 1 has 68 clusters. Columns 2 and 3 have 51 clusters.) *** $p < 0.001$, ** $p < 0.001$, * $p < 0.05$, + $p < 0.1$.

Table 5: t-Tests for Treatment Effects on Sanctions (Total, Assigned, and Received)

	ENDG GroupD-ConS	ENDG GroupD-NeighborS	ENDG PeerD-ConcS	ENDG PeerD-NeighborS	EXG GroupD-ConS	EXG GroupD-NeighborS	EXG PeerD-ConcS	EXG PeerD-NeighborS
ENDG GrpD-ConS	-,-,-	-,-,-	t, r, a	t, r, a	t, r, a	t, r, a	t, r, a	t, r
ENDG GrpD-NeighborS	-,-,-	-,-,-	t, -, -	t, -, -	t, -, -	t, -, -	t, -, -	t, -, -
ENDG PeerD-ConS	t, r, a	t, -, -	-,-,-	r, a		r	r	r
ENDG PeerD-NeighborS	t, r, a	t, -, -	r, a	-,-,-	a	r, a	a	r, a
EXG GrpD-ConS	t, r, a	t, -, -		a	-,-,-	r		
EXG GrpD-NeighborS	t, r, a	t, -, -	r	r, a	r	-,-,-	r	r, a
EXG PeerD-ConS	t, r, a	t, -, -	r	a		r	-,-,-	r, a
EXG PeerD-NeighborS	t, r	t, -, -	r	r, a		r, a	r, a	-,-,-

This table presents the results from two-way t-tests on the coefficients from the random effects regression reported in Table 4. A letter t denotes whether the total sanctions are statistically significantly different at the the 10% level. A letter a denotes whether assigned sanctions are statistically significantly different at the the 10% level. A letter r denotes whether received sanctions are statistically significantly different at the the 10% level. A dash denotes a comparison is not possible.

Table 6: Effect of Public Goods Contributions on Information Fund Choice

	(1) GroupD-ConcentratedS	(2) GroupD-NeighborS	(3) PeerD-ConcentratedS	(4) PeerD-NeighborS
Contribution	0.15***	0.17***	0.07	-0.10*
	(0.04)	(0.05)	(0.06)	(0.05)
Contribution^2	-0.01	-0.01	-0.00	0.03**
	(0.01)	(0.01)	(0.01)	(0.01)
Intercept	0.12***	0.09**	0.11*	0.25***
	(0.03)	(0.03)	(0.05)	(0.04)
adj. R^2	0.19	0.39	0.06	0.13
N	360	280	320	360

Regression with group fixed effects. *** p<0.001, ** p<0.001, * p<0.05, + p<0.1.