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Synergistic effects of voting and enforcement on internalized motivation to cooperate in a resource dilemma

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Abstract

We used psychological methods to investigate how two prominent interventions, participatory decision making and enforcement, influence voluntary cooperation in a common-pool resource dilemma. Groups (N=40) harvested resources from a shared resource pool. Individuals in the Voted-Enforce condition voted on conservation rules and could use economic sanctions to enforce them. In other conditions, individuals could not vote (Imposed-Enforce condition), lacked enforcement (Voted condition), or both (Imposed condition). Cooperation was strongest in the Voted-Enforce condition (Phase 2). Moreover, these groups continued to cooperate voluntarily after enforcement was removed later in the experiment. Cooperation was weakest in the Imposed-Enforce condition and degraded after enforcement ceased. Thus, enforcement improved voluntary cooperation only when individuals voted. Perceptions of procedural justice, self-determination, and security were highest in the Voted-Enforced condition. These factors (legitimacy, security) increased voluntary cooperation by promoting rule acceptance and internalized motivation. Voted-Enforce participants also felt closer to one another (i.e., self-other merging), further contributing to their cooperation. Neither voting nor enforcement produced these sustained psychological conditions alone. Voting lacked security without enforcement (Voted condition), so the individuals who disliked the rule (i.e., the losing voters) pillaged the resource. Enforcement lacked legitimacy without voting (Imposed-Enforce condition), so it crowded out internal reasons for cooperation. Governance interventions should carefully promote security without stifling fundamental needs (e.g., procedural justice) or undermining internal motives for cooperation.

Keywords: cooperation, internalized motivation, institutional acceptance, resource dilemma, social dilemma, voting, sanctions, motivational crowding, procedural justice, self-determination, self-other merging.

1 Introduction

Many pressing social and environmental problems arise from fundamental shortcomings in cooperation (Parks et al., 2013). For example, in a *common-pool resource (CPR) dilemma*, multiple agents compete for access to a shared resource (e.g., forest), and are tempted to harvest more than their share (Hardin, 1968). Without proper constraints, these agents may collectively destroy the CPR (e.g., FAO, 2012), placing severe social, environmental, and economic burdens on society (MEA, 2005).

Even heavily monitored and regulated CPRs may be exploited (Ostrom, 2007, 2010a), because monitoring is often imperfect (e.g., large, remote, or relatively hidden resources) and agents may choose not to obey conservation policies. Thus, some voluntary cooperation (Sutinen & Kuperan, 1999), reinforced by effective governance interventions (e.g., participatory decision making, enforcement), is often needed to ensure lasting cooperation and conservation (DeCaro & Stokes, 2008; Ostrom, 1990, 2010b; Sarker, 2013).

Communities of concerned citizens, and broader networks of collaborative partnerships (e.g., irrigation cooperatives), often help protect CPRs by filling regulatory voids left by more traditional governments (see Berkes, 2007; Ostrom, 1990, 2010a, Sarker, 2013 for review). Several factors, or *design principles* (Ostrom, 1990, 2010a), have been shown to improve cooperation in resource dilemmas protected by community-based governance (see Cox et al., 2010; Crook & Jones, 1999; Weinstein, 2000 for review). Many of these principles may also apply to other types of social dilemmas (e.g., public goods) and governance situations (e.g., Messick & Brewer, 1983; Frey et al., 2004).

However, design principles do not guarantee success (Ostrom, 2007). For example, rule monitoring and enforcement (e.g., economic sanctions), sometimes undermine voluntary cooperation (Bowles, 2008). The factors that determine when such interventions will be beneficial are poorly under-

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stood (Ostrom, 2010b; Poteete et al., 2010), leading to their widespread misapplication (e.g., Agrawal & Ribot, 2014; DeCaro & Stokes, 2013). Laboratory experiments that investigate the psychological effects of interventions may clarify when and why interventions fail under certain conditions and help us understand the motivations and perceptions that underlie sustained cooperation (Anderies et al., 2011).

We investigate how two prominent design principles, participatory decision making (e.g., voting) and enforcement (e.g., economic sanctions), influence cooperation in CPR dilemmas. We predict that these interventions affect cooperation differently when they are combined. We measure four fundamental social-psychological processes to investigate this hypothesis: fundamental needs (e.g., procedural justice, self-determination, and security), internalized motivation, institutional acceptance, and group norm adoption (through self-other merging). Each of these processes has been linked to effective human governance (e.g., De Cremer & Tyler, 2005; Frey et al., 2004). However, research investigating their joint effects, and impact in CPR dilemmas, is limited. We describe relevant research linking these processes next.

2 Internalized motivation and institutional acceptance

Many disciplines assert that *institutional acceptance* underpins effective governance (DeCaro & Stokes, 2013). Generally speaking, individuals are more cooperative and rule abiding when they accept the governance systems, decision-making procedures, authority figures, and institutions (e.g., rules, norms) they encounter (e.g., Greenberg, 1990; Tyler, 1990). *Internalized motivation* (Schafer, 1968) refers more specifically to how much individuals wholeheartedly endorse a behavior as ideally matched to their personal values and desires (Kerr et al., 1997; Sheldon & Elliot, 1998). Internally-motivated individuals typically enact behaviors more voluntarily, without external incentives, and persist despite obstacles. In contrast, individuals motivated primarily for external reasons (e.g., monetary reward, punishment) may not persist without continued external reinforcement (Deci & Ryan, 2000, 2008).

Both institutional acceptance (e.g., McComas et al., 2011) and internalized motivation (e.g., De Young, 1986; Pelletier, 2002) have been implicated in environmentally-responsible behavior and, more recently, cooperation in CPR dilemmas (e.g., Frey et al., 2004; Sheldon & McGregor, 2000; Travers et al., 2011; Vollan, 2008). However, few CPR experiments have explicitly assessed participants' self-reported motivations, and those that have did not use an integrative approach assessing multiple processes (e.g., Kubo & Supriyanto, 2010; Jenny et al., 2006; Tyler & Degoey, 1995).

The basic psychological processes involved in the formation of institutional acceptance and internalized motivation have been described in social psychology (Deci & Ryan, 2000; Greenburg, 1990). Humans have fundamental social-psychological needs that are essential for psychological well-being and believed to fundamentally energize behavior (see Baumeister & Leary, 1995; Deci & Ryan, 2000; Leotti et al., 2010 for review). *Procedural justice,* fair institutional decision-making procedures that support one's voice and decision-making control (Colquitt, 2001; Tyler, 1988, 1990), and *self-determination,* pursuing goals in ways that align with one's core values (Ryan & Deci, 2006; Sheldon & Elliot, 1998), rank high among these needs. Other potentially important needs include material needs, competence, belonging, and security (Sheldon et al., 2001). Research suggests that people look to social systems, such as government, family, and markets to fulfill these needs (Moller et al., 2006; van Prooijen, 2009; Frey et al., 2004). Social systems that satisfy these needs may increase acceptance and promote internalization (Deci & Ryan, 1987, 2000; Frey & Jegen, 2001), thereby promoting cooperation (Deci & Ryan, 2008; Frey et al., 2004; Tyler, 1990).

We propose that factors that promote cooperation in CPR dilemmas, such as Ostrom's (1990, 2010a) design principles (e.g., participatory decision making), do so by affecting fundamental social-psychological needs that influence institutional acceptance and internalized motivation, in addition to other mediating processes, such as perceived costs/benefits of cooperation (see Ostrom, 2000; Frey et al., 2004 for a similar proposal).

3 Design principles

Interventions such as Ostrom's (1990, 2010a) design principles aim to improve cooperation by altering either the nature of the dilemma or the perceived rewards associated with cooperation (Messick & Brewer, 1983; Parks et al., 2013). We review the potential linkages of participatory decision making and enforcement to fundamental needs, institutional acceptance, and internalized motivation in CPR governance.

3.1 Participatory decision making

Participatory decision-making procedures like voting, consultation, and deliberation give institutional stakeholders more voice or choice in governance, and are regarded as foundational to institutional legitimacy (Fung, 2006; Tyler, 2006). Such participation can improve resource conservation and promote cooperation in CPR dilemmas (e.g., Andrade & Rhodes, 2012; Bardhan, 2000; Cox et al., 2010; Ostrom, 1990). It can also improve environmentally responsible behavior more generally, by satisfying fundamental needs that underlie internalized motivation and rule accep-

tance (e.g., De Young, 1986; McComas et al., 2011). Participatory processes may therefore play a similar role in CPR governance (DeCaro & Stokes, 2008, 2013).

Social dilemma researchers often evoke principles of procedural justice and self-determination to explain their results (see Bowles, 2008; Frey & Jegen, 2001; Frey et al., 2004; Ostrom, 2000 for review). However, with a few notable exceptions, these underlying perceptions are rarely measured, especially in CPR dilemmas (see Anderies et al., 2011 more generally). For example, Vollan (2008) attributed success of a voting system in a CPR dilemma experiment to heightened self-determination and internalized motivation, but did not measure these underlying perceptions (see also Vyrastekova & van Soest, 2003).

A few case studies and experiments provide additional support for this general hypothesis. For example, Jenny et al. (2006) reported that perceptions of procedural justice in governance of a shared solar power system in Cuba correlated with villagers' rule acceptance and compliance, controlling for other factors, such as punishment and rule desirability (see also, Kubo & Supriyanto, 2010; McComas et al., 2006; Tyler and Degoey, 1997). Van Vugt et al. (2004) found that individuals exited public goods situations they perceived as controlling (e.g., autocratic leadership) even when their earnings were lower, because they valued procedural justice and self-determination (see also, Hunton et al., 1998; Rutte & Wilke, 1985).

Participation may also backfire (Arnstein, 1969), undermining procedural justice and self-determination (DeCaro & Stokes, 2008, 2013). For example, Rauchdobler et al. (2010) found that voting on investments to a public good was no better than having investment thresholds imposed by the experimenter because the losing voters did not cooperate (see also, Bó et al., 2010; Kamei, 2014). Janssen et al. (2008), Vrastekova & van Soest (2003), and Vollan (2008), found similar results in CPR experiments. These results suggest that individuals may reject rules decided by participatory processes that limit their control of final outcomes or marginalize their political voice (e.g., Arnstein, 1969; Leventhal, 1980).

Participatory processes vary greatly (Fung, 2006) and produce mixed results in different settings (Reed, 2008). The factors responsible for their failures are poorly understood, making it difficult to anticipate when participation will be beneficial (Chess & Purcell, 1999; DeCaro & Stokes, 2013). Enforcement has been proposed as a crucial deciding factor in success of CPR governance (Hardin, 1968). We therefore explore the relationship between participatory decision making and enforcement next.

3.2 Enforcement

Effective community-based governance typically utilizes some kind of enforcement (e.g., graduated sanctions) to improve cooperation (Cox et al., 2010; Ostrom, 1990). Moreover, groups in public good experiments and field studies often transition to enforcement after experiencing failure without it, thereby improving their overall performance (e.g., Fehr & Fischbacher, 2004; Gächter, Renner, & Sefton, 2008; Gürerck et al., 2006; Yamagishi, 1986; see Balliet et al., 2011 for review).

It has been proposed that self-interested agents will not cooperate without enforcement mechanisms compelling them to do so (Hardin, 1968; Hobbes, 1951/1909). According to traditional rational choice theory, sanctions may improve cooperation by making defection less attractive (Becker, 1974). Enforcement may also reassure rational agents that others will comply. Threat of enforcement should create a sense of security that enables each actor to make a credible commitment to the collective good, reinforcing their cooperative agreements (see Bowles, 2008; Ostrom, 1990; Mulder et al., 2006 for theoretical overviews).

However, it has been argued that traditional economic principles of rational self-interest do not fully capture observed results (Bowles, 2008; Fehr & Gächter, 2002; Poteete et al., 2010; Sutinen & Kuperan, 1999). For example, individuals cooperate more than expected given the benefit of defection and likelihood of being sanctioned (e.g., Frey et al., 2004), and they voluntarily sanction defectors even when they personally gain nothing economically for doing so (e.g., Fehr & Fischbacher, 2004), suggesting that intrinsic social values like fairness also contribute to cooperative behavior. In addition, enforcement may "crowd out" intrinsic reasons for cooperation, undermining voluntary cooperation (e.g., Gneezy & Rustichini, 2000; see Bowles, 2008; Frey & Jegen, 2001; Deci et al., 1999 for review). Many field and laboratory experiments in public goods dilemmas (e.g., Chen et al., 2009; Mulder et al., 2006; Tenbrunsel & Messick, 1999) and CPR dilemmas (e.g., Cardenas et al., 2000; Ostrom, et al., 1992; Janssen et al., 2010) report that cooperation deteriorated with the introduction of enforcement. Cooperation typically worsened especially after enforcement was later removed and cooperation became strictly voluntary.

The mechanisms that determine when enforcement will be beneficial are unclear (Bowles, 2008; Kerr, 2013), but many complementary theories have been proposed. First, enforcement may be perceived as coercive (Deci & Ryan, 1987; Ryan et al., 1983), undermining procedural justice and self-determination, and crowding out internalized motivation (Frey et al., 2004; Moller et al., 2006). Second, enforcement may encourage individuals to think about cooperation in economic, self-interested terms (i.e., as an economic transaction), leading them to deemphasize more internal reasons for cooperation, such as their moral obligation or a rule's inherent importance (e.g., Gneezy & Rustichini, 2000; McCusker & Carnevale, 1995; Tenbrunsel & Messick, 1999). Enforcement may also convince group mem-

bers that others cooperate only because they are being monitored. This mindset can create a dependency on sanctioning systems, so that group members only trust one another in the presence of enforcement. When enforcement is removed or weakened, cooperation may fail (e.g., Chen et al., 2009; Mulder et al., 2006).

It may be crucial to promote security without undermining internal motives for cooperation. According to Ostrom (2000), enforcement might actually increase internalized motivation (and institutional acceptance more generally) if it is used to support stakeholder self-determination and promote their competence (see also, Thøgersen, 2003).[1] For example, Vollan's (2008) CPR experiment observed that groups with high prior trust (Namibians) cooperated less when rule violators were sanctioned, whereas groups with low prior trust (South Africans) cooperated more, especially when they voted unanimously to use sanctions. Thus, enforcement appeared to empower the low-trust groups by helping them address their distrust and concern for security. In contrast, enforcement may have been perceived as unjustified or overly controlling among the high-trust groups, which had demonstrated ability to cooperate voluntarily.

Voluntariness or choice may be essential to successful enforcement. Vyrastekova and van Soest (2003) found that enforcement was more effective when elected by the majority of a group than when imposed by the experimenter or voted against (see also, Grossman & Baldassarri, 2012; Markussen et al., 2014; Sutter et al., 2010; Tyran & Feld, 2006). Cardenas et al. (2000) likewise obtained a crowding-out effect of enforcement when both a conservation rule and enforcement were imposed on participants by the experimenter (see also, Janssen et al., 2010; Ostrom et al., 1992). Finally, in successful cases of community-based governance, enforcement typically occurs within a context of participatory decision making and is rarely imposed, without stakeholder support (Cox et al., 2010; Ostrom 1990; see also, Hilbe et al., 2014).

We therefore hypothesize that there is a synergistic relationship between participatory decision making and enforcement. In particular, participatory decision making may legitimize the use of sanctions (see also, Grossman & Baldassarri, 2012; Tyler, 2006), and sanctions may help secure voluntarily-elected conservation agreements (see also, Rauchdobler et al., 2010). Thus, unlike enforcement without participation (e.g., Cardenas et al., 2000), the combination of participatory decision making and enforcement may bolster security and deter defectors without undermining procedural justice and self-determination, allowing internalized motivation and institutional acceptance to thrive.

[1] This prediction derives from Ryan and Deci's (1983) assertion that intervention's that support individual competence (i.e., efficacy or effectiveness) often facilitate self-determination. However, they explicitly hypothesized that monitoring, punishments, and surveillance are coercive (e.g., Deci & Ryan, 1987).

4 Self-other merging

Participatory decision making and enforcement may also influence cooperation by affecting group identity. Groups successfully engaged in community-based governance typically develop a cohesive group identity, which helps them overcome issues of trust and maintain group norms (McCay & Acheson, 1987; Ostrom, 1990, 2005). In groups, *self-other merging* refers to the process of transitioning from thinking of oneself as separate and emotionally detached (an "I"), to thinking of oneself as close and positively linked to the group ("We"; De Cremer et al., 2005). De Cremer and Tyler (2005) observe that self-other merging facilitates cooperation in social dilemmas by aligning individual self-interest more closely with the group interest (see also, Poteete et al., 2010). Specifically, as group members merge and internalize the group's norms, acting self-interestedly becomes more synonymous with acting for the group (e.g., De Cremer & van Vugt, 1999; Kerr et al., 1997). After merging, individuals may cooperate in a more coordinated fashion, facilitated by a group norm.

Participatory decision making may encourage self-other merging by satisfying fundamental needs (De Cremer & Tyler, 2005). For example, De Cremer et al. (2005) found that participatory leadership improved self-other merging and cooperation in a public goods experiment, compared to autocratic leadership. This effect was mediated by perceptions of procedural justice. Similar effects may emerge in CPR dilemmas, using different forms of participatory decision making (e.g., voting; Vollan, 2008).

Participatory decision making may also encourage self-other merging by facilitating cooperation during early stages of coordination. Research indicates that prior cooperation promotes self-other liking (e.g., Abele & Stasser, 2008), and may help establish a cooperative reputation, facilitating future cooperation (e.g., Miliniski et al., 2002). Participation could theoretically help initiate this process by improving cooperation early on (e.g., by increasing rule acceptance).

The effects of enforcement on group self-other merging have not been widely investigated (De Cremer et al., 2012). However, if enforcement facilitates cooperation (e.g., via deterrence), then the resulting security and cooperation may help positive reputation effects to emerge (e.g., Fehr et al., 2002), increasing self-other merging. Conversely, if enforcement creates animosity (e.g., Janssen et al., 2010), or does not reliably deter defectors, then it may contribute to negative reputation effects (e.g., Mulder et al., 2006), decreasing self-other merging.

5 Current study

The current research seeks to better understand when and why participatory decision making and enforcement

improve cooperation by examining the involvement of four social-psychological processes: fundamental social-psychological needs, internalized motivation, institutional acceptance, and self-other merging. We compare the effect of voting on conservation rules, versus having rules imposed by the experimenter, in the presence versus absence of enforcement. We anticipate that these interventions affect fundamental social-psychological processes synergistically, yielding different effects when used independently versus in combination. If it is crucial to promote security without stifling procedural justice and self-determination, or undermining internal motivations for cooperation, then voting plus enforcement may be superior to voting or enforcement alone. Voting with enforcement may also benefit self-other merging. If either voting or enforcement is sufficient by itself, then these effects will be revealed. For example, enforcement may have a positive effect on cooperation regardless of condition, or it may be counterproductive without voting. Differential support for these hypotheses would help identify and explain conditions whereby voting and enforcement crowd out versus facilitate voluntary cooperation.

6 Methods

6.1 Participants

We conducted this research in Spring 2012 at a large, public Midwestern U.S. university (Indiana University, Bloomington). Undergraduate students (N=160; 53% male; age M=19.54, SD=1.25) from a range of social science backgrounds volunteered for 90 minutes. Participants received \$5 for participation, and could earn up to \$15–\$40 total in the decision task.

6.2 Research design and procedure

Task introduction. After completing informed consent, participants were escorted to a computer station with partitions. All instructions and experimental tasks were completed on the computer. Each session included eight participants, and random assignment was used to create two, four-person groups (N=40 groups). Communication was prohibited at this point, and participants were told they would be participating in group decision-making experiment.

After participants read the introductory instructions, they completed a quiz, which tested their understanding of the CPR environment, basic controls, and payment procedures. To ensure their attention, participants were paid \$0.50 for each correct answer (\$1.00 maximum). The computer displayed the correct answers and payment at the end of the quiz, and the experimenter privately addressed any remaining questions to ensure participants understood the task. Next, participants completed a four-minute practice round, in a private resource environment. After practice, the experimenter answered any remaining questions.

The instructions for Round 1 informed participants that they were randomly assigned to one of two four-person groups for the rest of the experiment, and that group members received a permanent Player ID (from 1–4). Moreover, everyone in their group now had access to the same shared resource, and their decisions (i.e., harvesting behavior) would affect their payment. Finally, instructions explained the procedures used to protect individual anonymity, and that each round would last four minutes and everyone's actions (movements, harvests, earnings) would be visible to the group. All other instructions varied by experimental treatment (see Supplement, Section A).

Experimental design. We sought to investigate both the immediate and long-term, carry-over effects of voting and enforcement. We divided the experiment into three phases. Each phase consisted of three rounds (four minutes each), for a total of nine rounds. During *Phase 1*, there were no experimental treatments, and groups simply harvested the resource, providing a baseline measure of performance. During *Phase 2*, we introduced the experimental treatments (voting and enforcement). During *Phase 3*, we removed the ability to enforce.

These procedures created a 2(voting: voted, imposed) × 2(enforcement: can enforce, cannot enforce) × 3(phase: baseline, treatment, enforcement cessation) mixed-factorial design. We administered three surveys to assess participants' perceptions throughout the experiment. As shown in Table 1, this design allowed us to compare behaviors and perceptions from groups whose cooperation must be entirely voluntary during the entire experiment (i.e., Voted, Imposed) to those (i.e., Voted-Enforce, Imposed-Enforce) who could enforce cooperation at first (Phase 2) but had to rely on voluntary cooperation later (Phase 3). After Phase 3, we debriefed participants and paid them in cash according to their individual earnings, using confidential sealed envelopes.

6.3 CPR dilemma

To study cooperative behavior in the lab, we used a foraging task (Janssen, 2010; Janssen, et al., 2010). The foraging task creates a CPR dilemma that simulates fundamental temporal and spatial characteristics of a CPR system (e.g., a forest) such as spatial dispersion of resources (forage-able plants) and density-dependent growth. This environment permits one to evaluate context-specific conservation policies (e.g., territorial rights, temporal harvesting strategies) that often emerge in real-world CPR governance (e.g., Ostrom 1990; see Janssen & Ostrom, 2008).

During each round of the foraging task, participants saw themselves on screen as a yellow avatar (circle), which was

Table 1: Experimental design.

Condition	Groups (Individuals)	Phase 1 Baseline	Vote Treatment	Survey	Phase 2 Treatment	Survey	Phase 3 Carryover	Survey
V-E	10 (40)	No rule	Voted	1	Enforcement	2	–	3
V	10 (40)	No rule	Voted	1	–	2	–	3
I-E	10 (40)	No rule	Imposed	1	Enforcement	2	–	3
I	10 (40)	No rule	Imposed	1	–	2	–	3

Note: V-E = Voted-Enforce. V = Voted. I-E = Imposed-Enforce. I = Imposed.

identified by a personal ID number (see Figure 1). The CPR consisted of star-shaped tokens ("plants") randomly placed on a 26 × 26 cell field. Each token was worth \$0.02, and participants could harvest them in real-time by moving over one and pressing the spacebar. This action was visible to each group member. A timer showing the time remaining in the round and each person's total tokens harvested that round was also displayed. Each round, tokens were randomly distributed across 25% of the field. The CPR grew (more tokens were added) if there was at least one token remaining, and growth was dependent on token density. Thus, tokens grew faster when they were clustered together.

When participants harvested every token on the field, they exhausted the resource for that round and had to wait for time to expire, before continuing to the next round. When groups managed the CPR well, it lasted longer, producing more tokens and allowing each person to harvest an average of approximately \$25 in tokens across the entire experiment (including the \$5 show-up fee and any quiz earnings). Actual individual earnings were lower than this ideal due to individual behavior and experimental treatment (*Range*=\$8.20–\$22.96; *M*=\$17.08, *SD*=\$2.66). The optimum harvest level to sustain the CPR, and generate the greatest individual earnings for all players, depends on the initial starting conditions (e.g., token dispersal), location(s) where individuals harvested, their rate of harvest, and the associated density-based rate of regrowth.[2]

6.4 Experimental treatments

Each group was randomly assigned to one of the four experimental conditions (Table 1), created by crossing the voting factor (voted, imposed) with the enforcement factor (can enforce, cannot enforce).

Voting. After completing Phase 1 (baseline), participants in the Voted-Enforce and Voted conditions elected a conservation rule using a majority vote. The following information was presented in the instructions. Each person in the group could "nominate" an option (i.e., "strategy"), including a default no-rule option, to manage their group's harvests for the rest of the experiment. The option with the most nominations was selected. This process was anonymous, and completely mediated by the computer. To avoid simple priming effects, we did not mention the concepts "voting," "conservation," or "rules". The tallies for each option would be displayed when the group's chosen option was revealed. Moreover, neither the experimenter nor the computer would intervene to help implement the chosen strategy. Finally, ties were broken with the computer choosing one of the tied rules at random. These procedures ensured that an ostensibly equitable method was used to decide the rule (Patall et al., 2008), that the procedures were transparent, and that each person's preferences were kept private.

This is the list of rule options used in the experiment (participants did not see the labels):

60 Second Rule. Wait 60 seconds for the screen to fill up with tokens (the timer will be have 180 seconds left). Then everyone collect tokens for the remaining amount of time.

40 Token Rule. Collect 40 tokens, then wait 30 seconds. Repeat this process until time runs out or the tokens are all gone.

Private Property Rule. Players "divide" the field up into four equally-sized areas and can do whatever they want within their area. So with four people, each person takes an area around one of the four corners.

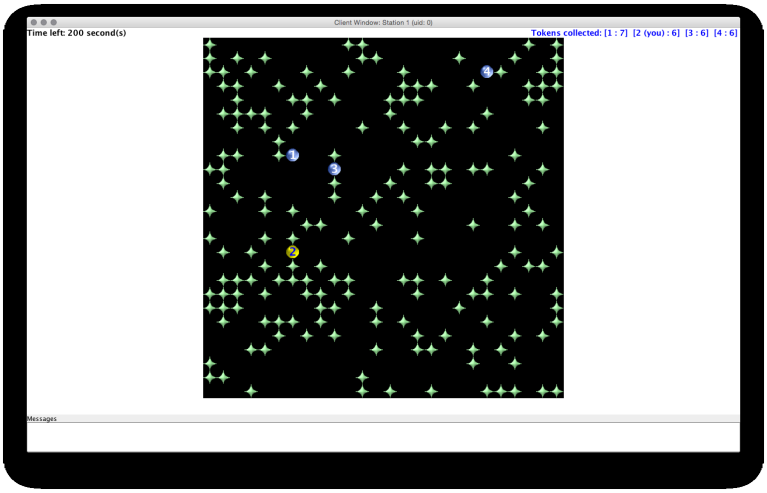
10–10 Rule. Collect tokens for 10 seconds, then wait 10 seconds before collecting again. Repeat this process until time runs out or the tokens are all gone.

Default. Everyone can do whatever they want.

We designed the rules based on prior CPR experiments that used the foraging task and allowed groups to design their own rules (Janssen, 2010, Janssen, et al., 2010). Thus, the current rules resemble ecologically valid solutions that prior groups have created under similar conditions. They also closely resemble solutions from many real-world CPR dilemmas (e.g., territorial plots; Ostrom, 1990).

[2]See Supplement Section A for optimization analyses under different constraints. Our experimental software is open-source and available online at https://bitbucket.org/virtualcommons/foraging.

Figure 1: Foraging task environment. Star-shaped tokens are the resource units ("plants"). Circles are participant avatars. Participants see their own avatar colored yellow (others are blue). Each person's tokens collected during the round are displayed in the upper right-hand corner. For example, group member 2 (with 6 tokens), is emphasized here ("[2 (you), 6]"). When individuals sanctioned one another, this information appeared in the "Messages" box.



Groups in the Imposed-Enforce or Imposed conditions were assigned a rule by the experimenter. The imposed rules were yoked with those in the voting conditions. For example, Group 1 in the Vote-Enforce condition elected the 60-Second rule, and this rule was therefore assigned to Group 1 in the Impose-Enforce condition, ensuring that the rules were equal across treatments. In addition, groups reviewed the rule list before having a rule imposed on them, to control for educational effects of seeing conservation strategies. Thirty percent (12) of the groups had the 60 Second Rule, 35% (14) had the Private Property Rule, 25% (10) had the 10–10 Rule, and 10% (4) had the 40 Token Rule.

Enforcement. Enforcement was announced at the beginning of Phase 2, and we presented this information only to the Voted-Enforce and Imposed-Enforce conditions. Individuals could spend one token ($0.02) to deduct any other group member's earnings for that round by $0.04 (two tokens). Participants made these costly economic sanctions in real-time during the round. In keeping with Ostrom's (1990, 2010) design principle of graduated sanctioning, participants could sanction someone multiple times. Participants pressed the number key (1, 2, 3, or 4) that corresponded to the targeted person's avatar; additional button presses increased the sanction. The sanctioning fees were immediately deducted from both participants (target and sanctioner), and both people received a text message informing them of the sanction (visible to all group members). We did not mention the concepts of "enforcement", "punishment", or "sanctions", or suggest when or why to use the sanctions. These procedures ensured that enforcement activity was up to the interpretation and discretion of each group member.

6.5 Cooperation

In addition to considering its impacts on overall conservation of the resource, we operationalized cooperation as percentage rule compliance. Each rule specified a particular time and/or location to harvest resources. Therefore, our unit of analysis was any time an individual harvested a token. We categorized each harvest as compliant (or a rule violation) based on the parameters specified in the rule (the default no-rule option was never elected, or assigned):

60 Second Rule. Harvests before the first 60 seconds of the round were categorized as rule violations.

40 Token Rule. We first determined when an individual had collected 40 tokens. We treated any tokens collected by that individual during the next 30 seconds as a rule violation. We repeated this procedure for each 40-token interval afterward.

Private Property Rule. To identify the "owner" for a particular segment (i.e., corner) of the resource field, we determined the individual who collected the most tokens in that corner. All other harvesting events within that area were classified as rule violations.

10–10 Rule. Participants should collect tokens during the first 10 seconds of the round; then wait 10 seconds. Harvests during the waiting periods were rule violations.

To measure compliance in Phase 2 and 3 of the experiment, we calculated each person's percentage rule compliance, averaged across the rounds for a particular phase.

6.6 Measures

We used three surveys to assess participants' motivations and perceptions at different points in the experiment (see Table 1). For example, Survey 1 measured reactions to voting and rule imposition. Survey 2 measured reactions to enforcement. The purpose of the measures was to identify potential social-psychological correlates of cooperative behavior. Each measure was based on existing, well-validated instruments in psychological science. However, we are aware of no prior research examining most of these specific psychological effects via self-report measures in CPR dilemma experiments (e.g., see Anderies et al., 2011). Therefore, we adapted each measure to fit the current experimental environment, in keeping with standard practices (see Colquitt, 2001; Vallerand & Ratelle, 2002). The measures performed well, exhibiting both good reliability and predictive validity consistent with prior research.

Participants answered each question privately on their own computer terminals, and were told that their responses would not be viewed by the experimenter, disclosed to other participants, or used to alter the ongoing experiment. The survey measures were presented to participants in the order shown here, and individual items were presented in the same random order to everyone. Unless otherwise noted, participants responded to each item on a 7-point Likert-type response scale, which ranged from 1 (strongly disagree) to 7 (strongly agree). See Supplement Section B for the instructions and complete list of items.

Survey 1. We administered Survey 1 immediately after the voting manipulation to assess the impacts of voting (or imposed rules) on each person's fundamental needs and rule acceptance. Participants also evaluated the anticipated effectiveness of each rule.

Rule acceptance. We assessed rule acceptance using three items (α=0.96, *M*=4.81, *SD*=1.70) adapted from Allen and Meyer (1990) and Colquitt (2001) (e.g., "I approve of the strategy"). Instructions clarified that the strategy (i.e., rule) was the one recently elected (voters) or assigned by the experimenter (non-voters), not an informal or personal strategy.

Social-psychological needs. We assessed a total of five candidate social-psychological needs, previously identified to be associated with participatory decision making and formation of internalized motivation and rule acceptance. These items referred specifically to the procedures used to elect the rule (voters) or assign it (non-voters). To emphasize each person's subjective perceptions, each item was introduced with the prompt, "The procedures used to select/decide the strategy today made me feel:".

Procedural Justice. We assessed perceptions of procedural justice using four items (α=0.80, *M*=4.43, *SD*=1.38). Two items (Colquitt, 2001) measured perceived decision influence (e.g., "as if I was able to influence what strategy was established"). Two additional items (van Prooijen, 2009) measured general perceptions of fairness (e.g., "as if the procedures were fair").

Self-Determination. We assessed perceptions of self-determination using eight items chosen to target three dimensions (α=0.91, *M*=4.14, *SD*=1.33). Four items (Sheldon et al., 2001) measured self-concordance (e.g., "free to do things that express, or exercise, my 'true self'"). Two items (Levenson, 1980) measured internal perceived locus of causality (e.g., "as if I could determine what to do"). Two additional items measured sense of choice (e.g., "a genuine sense of choice").

Belonging. We assessed perceptions of belonging using six items chosen to target two dimensions (α=0.91, *M*=3.52, *SD*=1.11). Three items (Leary et al., 2013) measured perceived social standing (e.g., "like I am seen as a valuable person"). Three items (Sheldon et al., 2001) measured social connectedness (e.g., "a sense of contact with people who care for me, and whom I care for").

Competence. We assessed feelings of competence using six items chosen to target two dimensions (α=0.86, *M*=4.27, *SD*=1.17). Three items (Ryan, 1982) measured intelligence (e.g., "intelligent"). Three additional items (Sheldon et al., 2001) measured mastery (e.g., "as if I was taking on and mastering important challenges").

Interpersonal Justice. We used four items (e.g., "like I was treated in a polite manner;" Colquitt, 2001) to assess perceived interpersonal justice (α=0.87, *M*=4.51, *SD*=1.18), which is thought to be primarily related to the way individuals (e.g., in a group) interaction with one another, rather than to institutional decision-making procedures.

Self-Other Merging. We used five items to assess self-other merging (α=0.91, *M*=3.05, *SD*=1.28). One item used circle pairs that overlap to different extents to assess each participant's felt closeness to the group (De Cremer et al., 2005; Karremans, 2002). One circle represented the participant, and the other represented the other group members. Participants saw six such diagrams, ranging from no overlap (1) to substantial overlap (6), and selected the diagram that reflected how they currently felt about their group. We adapted two items from Cameron's (2004) in-group affect subscale to assess participants' emotional feeling towards the group (e.g., "I feel positively towards the group").

Two items from Cameron's (2004) in-group ties subscale assessed individuals' sense of fit to the group (e.g., "I feel like I really 'fit in' with the other people in my group"). The complete measure of self-merging indicates how cohesive groups were in transitioning from an individual ("I") to a collective sense of self ("We").

Rule Effectiveness. Participants evaluated the anticipated effectiveness of each rule: "In your opinion, how effective would the following strategy be for managing the collection of tokens?" Participants saw the entire list of rules and their descriptions. We used these ratings as an indicator of personal outcome favorability, or rule desirability, in follow-up analyses. Thus, a rule rated as highly effective by a particular individual may also be considered more desirable.

On average, participants rated the 60-Second Rule (M=4.96, SD=1.58), 95% CI [4.72, 5.21] and Private Property Rule (M=5.00, SD=1.77), 95% CI [4.72, 5.28] as equally effective, and more effective than any other rule. They rated the 40 Token Rule (M=4.36, SD=1.54), 95% CI [4.12, 4.60] and 10–10 Rule (M=4.39, SD=1.58), 95% CI [4.15, 4.64] as less effective, and the default ("no rule") option as least effective (M=2.46, SD=1.92), 95% CI [2.16, 2.76].

Survey 2. We administered Survey 2 immediately after Phase 2. By this point, groups have completed three rounds of the CPR task with rules under different experimental conditions (e.g., voting with/without enforcement). During Survey 2 we reassessed participants' rule acceptance and self-other merging. We also assessed participants' reactions to the presence (or absence) of enforcement, and their self-reported reasons (i.e., motivations) for obeying the rule.

Rule Acceptance. We used the same items as before to measure participants' rule acceptance after Phase 2 (α=0.96, M=3.68, SD=1.96). This method of comparing rule acceptance before (Survey 1) and after Phase 2 (Survey 2) indicates how rule acceptance changed over time in each condition, in response to differences in experimental treatment (e.g., presence/absence of enforcement) and the behavior of each group.

Reasons for Compliance. Consistent with research in other domains, we assessed individuals' extrinsic and internalized motivations to comply with the rules (see Deci & Ryan, 2000; Sheldon & Elliot, 1998; Vallerand & Ratelle, 2002, for review). Participants rated five potential reasons for their behavior. Instructions emphasized that people may follow rules ("strategies") for different reasons. Each item was introduced with the prompt, "The reason I followed the strategy was because:" Items measuring social pressure, guilt, and internalized motivation were adapted from Sheldon and Elliot (1998), Sheldon and Houser-Marco (2001), and Soenens et al. (2009). Items measuring compliance due to security and anticipated earnings were adapted from Sheldon et al. (2001). Security is considered a basic need, not an intrinsic or extrinsic motivation, per se (Sheldon et al., 2001).

Social Pressure. Two items assessed social pressure, an extrinsically-motivated reason for behavior ("somebody else wanted me to"; "the situation seemed to require or compel it"; α=0.38; M=3.72, SD=1.45).

Anticipated Earnings. Two items assessed compliance due to the perceived earning potential of the rule, an extrinsically-motivated reason (e.g., "I felt that the strategy would help me get more tokens (more money)"; α=0.90, M=5.02, SD=1.83).

Guilt. Two items assessed compliance driven by guilt, a relatively internally-motivated reason (e.g., "I would have felt guilty if I did not follow it"; α=0.68, M=3.61, SD=1.66).

Internalized Motivation. Two items assessed more internalized reasons for compliance (e.g., "I felt that the strategy matched with my desires and values"; α=0.83, M=4.09, SD=1.74).

Security. Two items assessed compliance due to the rule's perceived impact on security, including structure/predictability and safety from uncertainty (e.g., "I felt the strategy made the token task more structured and predictable"; α=0.74, M=4.10, SD=1.68).

Self-Other Merging. Self-other merging was measured as before (α=0.94, M=2.99, SD=1.40), indicating self-merging after Phase 2 performance.

Social-Psychological Needs affected by enforcement. Finally, we measured need satisfaction as a result of the presence/absence of enforcement. We used the same social-psychological need scales as in Survey 1, except they now referred to enforcement: *Procedural Justice* (α=0.87, M=4.31, SD=1.40), *Self-Determination* (α=0.94, M=3.98, SD=1.33), *Belonging* (α=0.90, M=3.73, SD=1.22), *Competence* (α=0.89, M=4.02, SD=1.19), *Interpersonal Justice* (α=0.93, M=4.41, SD=1.55).

We first briefly described enforcement procedures without mentioning potentially biasing terms (e.g., "punish"). This description ensured that individuals who had not been exposed to enforcement (i.e., Voted and Imposed conditions) adequately understood the nature of these interventions and their presence/absence (e.g., "In these kinds of

situations sometimes individuals can use some of their tokens (money) to remove/subtract tokens from people in their group…" (see Supplement, Section B for complete description). Because individuals may perceive enforcement differently when they have been sanctioned, versus when they have not, we followed this information with a question about their sanctioning experience (e.g., "Did someone pay money (tokens) to subtract money (tokens) from you?…"). Individuals who indicated that they were sanctioned received the following prompt for each question about their needs: "How did it make you feel when the individual(s) in your group used their money (tokens) to subtract some of your money (tokens)?" Individuals who were not sanctioned responded to a different prompt: "How does it make you feel to know that the people in your group did not use their money (tokens) to subtract some of your money (tokens)?"

Demographics. Survey 3 measured participants' basic demographic information (e.g., age, gender, and socioeconomic status). However, there were no significant effects of these factors, so they will not be discussed further.

7 Results

7.1 Overview

We used group means to examine group harvesting behavior, because of correlated error between individuals in groups. We also used group means in ordinary least squares (OLS) regression to analyze the psychological effects (e.g., rule acceptance) associated with group harvesting patterns. Finally, when we examined individual's perceptions and behaviors in follow-up analyses (e.g., to see how the losing voters responded), we used OLS regression (Cohen et al., 2003). This is because the psychological predictors (e.g., procedural justice) were reported privately, and they did not exhibit significant correlated error. Alternative analyses using hierarchical linear regression (HLR) to control for group correlated error yielded the same pattern of results (Raudenbush & Bryk, 2003).

7.2 Resource conservation

Figure 2 shows how quickly groups depleted the resource in each four-minute (240 sec) round, during each phase of the experiment. Groups depleted the resource rapidly during Phase 1 (approximately 165 sec), when there was no conservation rule, voting, or enforcement. The resource lasted longer (approximately 216 sec) after we introduced voting and enforcement in Phase 2. This improvement was especially pronounced in the Voted-Enforce condition. During Phase 3, we removed the ability to enforce the rule (e.g., Voted-Enforce condition), so cooperation was strictly voluntary at that point. Groups depleted the resource only slightly faster (approximately 210 sec) in the Voted-Enforce, Voted, and Imposed conditions. In contrast, groups in the Imposed-Enforce condition rapidly depleted the resource, returning to Phase 1 (baseline) levels of performance (approximately 125 sec).

7.3 Group harvests

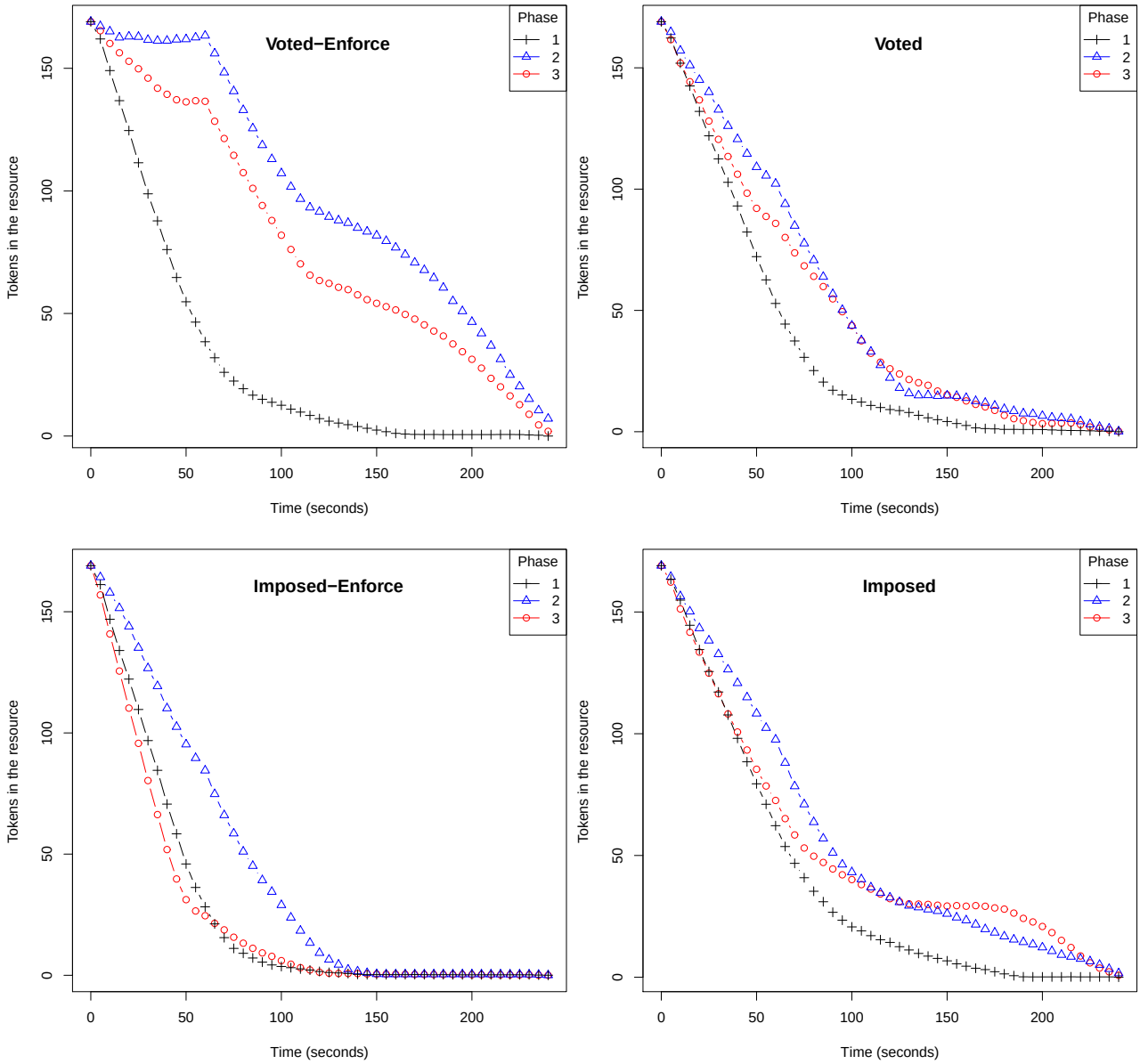
Overview. Figure 3 shows the mean number of tokens harvested by each group as a function of experimental condition. We assessed whether overall harvests improved by introducing rules, voting, and enforcement (Phase 2), relative to baseline (Phase 1). We also assessed whether these improvements were sustained (Phase 3).

Preliminary analyses indicated that the specific rules elected (or assigned) to conditions influenced group outcomes. To be certain that any voting or enforcement effects were not simply caused by the type of rule used, we included groups' rules as covariates in all analyses.

We also discovered that groups were initially different in their baseline harvest levels during Phase 1. Specifically, we conducted a 2 (Vote: voted, imposed) × 2 (Enforcement: can enforce, cannot enforce) between-subjects ANOVA on Phase 1 harvests and found a significant main effect of Enforcement, $F(1, 36)=5.38$, p=.026, $\eta^2=.13$ (all other Fs<1). Groups randomly assigned to an enforcement condition (i.e., Voted-Enforce or Imposed-Enforce) harvested fewer tokens than those in other conditions (see Figure 3). In subsequent analyses, controlling for Phase 1 harvests did not change the results, nor did this factor emerge as a significant predictor. Thus, reported effects of voting and enforcement occurred beyond any baseline differences among conditions. For simplicity, we therefore report results without controlling for this factor.

Phase 1 to Phase 2. To examine the effect of rules, voting, and enforcement on change in group harvests from Phase 1 to Phase 2, we conducted a 2 (Vote: voted, imposed) × 2 (Enforcement: can enforce, cannot enforce) × 2 (Phase: 1, 2) mixed-factorial ANOVA, with group rule as a covariate. There was a significant main effect of Phase: $F(1, 35)=17.95$, $p<.001$, $\eta^2=.34$. Group harvests improved from Phase 1 ($M=230.16$, $SE=3.79$) to Phase 2 ($M=265.64$, $SE=7.25$). There was also a significant Rule × Phase interaction: $F(1, 35)=6.23$, $p=.017$, $\eta^2=.15$. Groups with the 60 Second Rule performed marginally better ($M=285.61$ tokens; 95% CI [254.90, 316.32]) than groups with other rules (e.g., $M=244.70$ *10–10 rule*; $M=260.10$ *Private Property*). There was a significant Vote × Enforcement interaction: $F(1, 35)=6.22$, $p=.017$, $\eta^2=.15$. There was a significant Phase × Vote interaction: $F(1, 35)=5.83$, $p=.021$, $\eta^2=.14$. This effect was qualified by a significant Phase × Vote × Enforcement interaction: $F(1, 35)=4.41$, $p=.043$, $\eta^2=.11$. As shown in Figure 3, the Voted-Enforce condition improved

Figure 2: Mean number of resource units (tokens) left in the resource pool for each experimental condition, broken down by phase and time left in the round (0-240 seconds).



more than any other condition, followed by the Voted and Imposed conditions. The Imposed-Enforce condition did not improve significantly. No other effects were significant (Fs<1).

We confirmed these observations by analyzing the effects of rules, voting, and enforcement in an ANOVA examining group harvests during Phase 2. There was a main effect of Rule, $F(1, 35)$=4.81, p=.035, η^2=.12, main effect of Vote, $F(1, 35)$=5.37, p=.026, η^2=.13, and a Vote × Enforcement interaction, $F(1, 35)$=6.77, p=.013, η^2=.16. Group harvests were greatest in the Voted-Enforce condition and worst in the Imposed-Enforce condition, indicating that the combination of voting and enforcement is crucial.

Phase 2 to Phase 3. We used a similar mixed-factorial ANOVA to examine whether these effects were sustained from Phase 2 to Phase 3. There were significant main effects of Rule, $F(1,35)$=5.22, p=.029, η^2=.13, and Vote, $F(1,35)$=4.61, p=.039, η^2=.12. There was also a significant Vote × Enforcement interaction, $F(1, 35)$=7.17, p=.011, η^2=.17. There were no significant Phase effects or interactions with Phase (Fs<1.17), indicating that the pattern of results in Phase 3 did not differ significantly from Phase 2. A separate ANOVA examining Phase 3 revealed a significant main effect of Rule, $F(1, 35)$=4.16, p=.049, η^2=.11, and a Vote × Enforcement interaction, $F(1, 35)$=5.60, p=.024, η^2=.14 (all other Fs<1).

Table 2: Direct psychological effects of voting and enforcement.

A. Need Satisfaction (Voting)

	PJSD	IJ	Bel.	Comp.
Intercept	4.24(.09)	4.51(.09)	3.52(.09)	4.27(.09)
Vote	1.04(.19)***	0.28(.19)	0.17(.18)	0.52(.18)**

B. Need Satisfaction (Enforcement)

	PJSD	IJ	Bel.	Comp.
Intercept	4.09(.10)	4.40(.12)	3.73(.10)	4.02(.09)
Vote	0.13(.20)	0.36(.24)	0.19(.19)	0.12(.19)
Enforce	0.62(.22)**	0.51(.26)*	0.16(.21)	0.34(.21)
Vote×Enforce	0.09(.40)	0.46(.47)	0.31(.38)	0.28(.38)
§Sanctioned	−0.86(.32)**	−1.39(.37)***	−0.61(.31)*	−0.26(.30)

C. Motivations for Rule Compliance

	Pressure	Guilt	Ant. Earn.	Security	Internalized
Intercept	3.72(.12)	3.61(.13)	5.02(.14)	4.10(13)	4.09(.14)
Vote	0.31(.23)	0.32(.26)	0.39(.29)	0.54(.26)*	0.68(.27)*
Enforce	0.14(.23)	−0.07(.26)	0.38(.29)	0.33(.26)	0.36(.27)
Vote×Enforce	−0.02(.46)	0.41(.53)	0.56(.58)	1.21(.52)*	−0.13(.54)

D. Rule Acceptance

	Before Phase 2	After Phase 2
Intercept	4.82(.14)	3.68(.15)
Vote	0.06(.27)	0.64(.30)*
Enforce		0.65(.30)*
Vote×Enforce		0.68(.61)

E. Self-Other Merging

	Before Phase 2	After Phase 2
Intercept	3.05(.10)	2.99(.11)
Vote	−0.02(.20)	0.56(.21)**
Enforce		0.47(.21)*
Vote×Enforce		0.93(.43)*

Note: Slopes represent unstandardized regression coefficients (standard errors in parentheses). Predictors are effects coded (e.g., Vote: –1 rule imposed, 1 rule decided by vote). Vote = Predictor for voting. Enforce = Predictor for enforcement. Sanctioned = Predictor for effect of being sanctioned at least once. PJSD = Composite score for procedural justice and self-determination. IJ = Interpersonal justice. Bel. = Belonging. Comp. = Competence. Pressure = Social pressure. Ant. Earn. = Anticipated earnings. Internalized = Internalized motivation. §Being sanctioned had no other statistically significant effects (e.g., on motivations for rule compliance). * p<0.05. ** p<0.01. *** p<0.001.

7.4 Sanctioning patterns

Participants sanctioned one another infrequently across the Voted-Enforce (30 times) and Imposed-Enforce conditions (36 times). Sanctioning patterns did not differ by condition, or individual (e.g., level of rule acceptance) (Mann-Whitney *U*, *ns*). In a few instances, pairs of individuals retaliated

Figure 3: Mean number of resource units (tokens) harvested by groups during each phase (minus costly punishment). Error bars represent 95% Confidence Intervals.

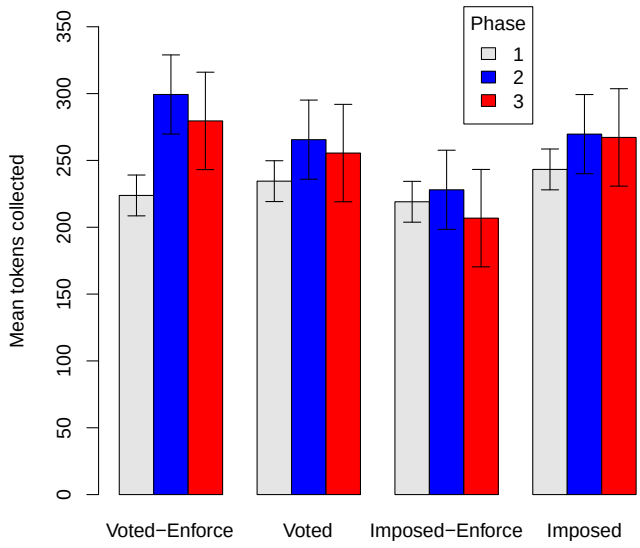
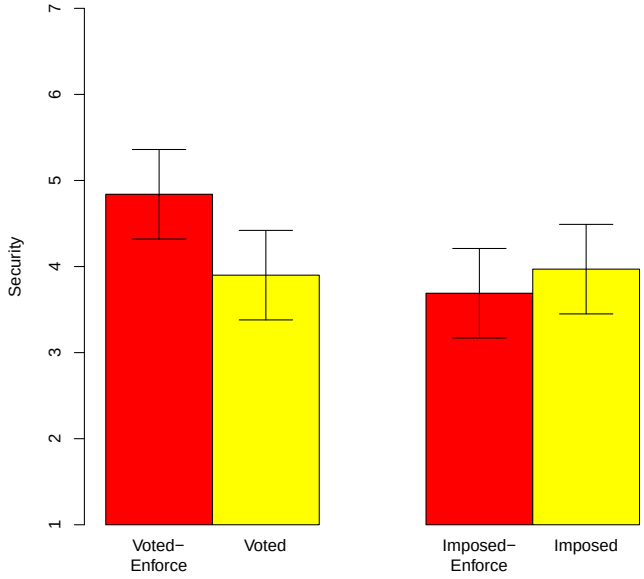


Figure 4: Perceptions of security. Error bars represent 95% confidence intervals.



against one another, but no clear patterns emerged.[3] Thus, consistent with similar studies (e.g., Ostrom et al., 1992; Janssen et al., 2010), the rarity of punishment events suggests that the mere presence, or threat, of enforcement influenced cooperation.

7.5 Direct psychological effects of voting and enforcement

We report the results for the direct effects of voting and enforcement on individuals for each of the psychological measures in Table 2.

Social-psychological need satisfaction (Voting, Survey 1). We combined procedural justice and self-determination into a single predictor (i.e., PJSD) because they were strongly correlated, $r(158)=0.79$, $p<0.001$ (Cohen et al., 2003), and theoretically similar (e.g., van Prooijen, 2009). On average, individuals who voted reported feeling more PJSD (M=4.75, SE=0.12) than those who had the rule imposed (M=3.71, SE=0.14; see Vote, Table 2A). Voting also increased feelings of competence (M=4.53 vs. M=4.01, SE=0.13). Voting had no significant effects on reported interpersonal justice or belonging. The enforcement factor is not included in these analyses, because it had not been introduced in the experiment.

[3]Theoretically, sanctioning patterns could be expected to differ by condition or an individual's level of rule acceptance. However, group members rarely punished one another, so there was insufficient data available to investigate these kinds of questions fully.

Social-psychological need satisfaction (Enforcement, Survey 2). On average, individuals who could enforce reported a greater sense of PJSD (M=4.40, vs. M=3.78, SEs=0.15) and interpersonal justice (M=4.66, vs. M=4.15, SEs=0.16) than those who could not enforce (see Table 2B). However, this finding was true primarily for individuals who were not sanctioned, because being sanctioned decreased participants' sense of PJSD (M=3.66 sanctioned, SE=0.32; see Sanctioned, Table 2B). Sanctioning also decreased participants' sense of interpersonal justice (M=4.66 vs. M=4.15, SEs=0.13) and belonging (M=4.04 vs. M=3.22, SEs=0.16).

Motivations for rule compliance (Survey 2). Next, we examined participants' self-reported reasons for obeying the rule. There were no significant effects of condition on social pressure, guilt, or anticipated earnings (see Table 2C), indicating that voting and enforcement did not exert their effects by influencing these motivations.

The Security results in Table 2C illustrate that there was a significant main effect of Voting, where voters (averaged across the Voted and Voted-Enforce conditions) reported higher levels of security than groups who had the rule imposed. However, there was also a significant Vote × Enforce interaction. As shown in Figure 4, the main effect was primarily driven by the Voted-Enforce condition (M=4.84; 95% CI [4.32,5.36]). The Voted, Imposed, and Imposed-Enforce conditions did not significantly differ from one another (Ms = 3.69 to 3.97, ps>.05). Thus, the Voted-Enforce condition showed the greatest perceived security.

There was also a significant main effect of voting on internalized motivation (see Vote, Table 2C). On average, indi-

Figure 5: Rule acceptance after Phase 2. Error bars represent 95% confidence intervals.

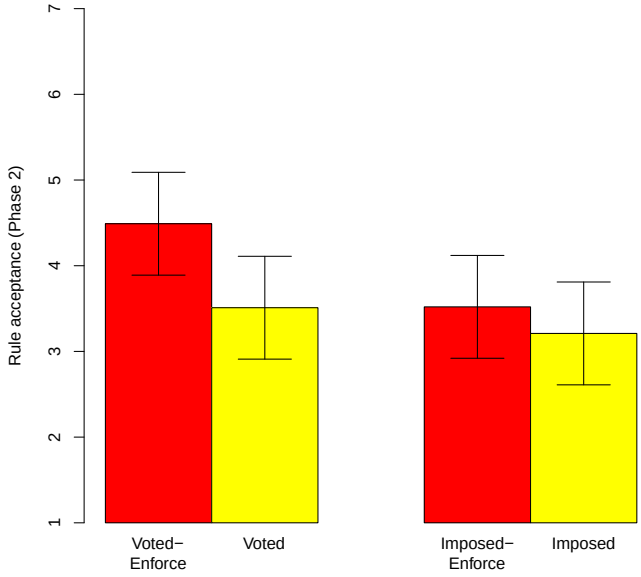
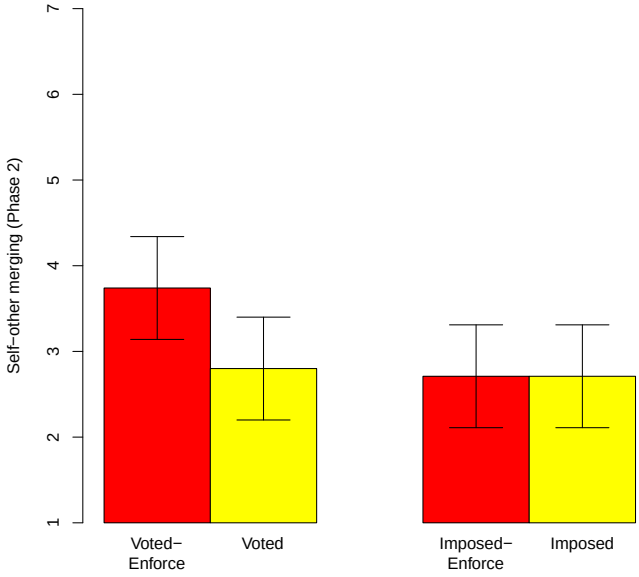


Figure 6: Self-other merging after Phase 2. Error bars represent 95% confidence intervals.



viduals who voted felt the rule better matched their personal interests and desires (M=4.43 voters, 95% CI [4.05, 4.80]; M=3.75 rules imposed), increasing their motivation to follow the rule.

Rule Acceptance (Surveys 1 and 2). Voting did not have a significant effect on participants' acceptance of the rule immediately after the vote (i.e., before Phase 2), contrary to what might be expected from a traditional social justice perspective (see Table 2D). Thus, at first, individuals who had the rule imposed (M=4.79) accepted the rule as much as those who voted (M=4.85, 95% CI [4.48, 5.23]). However, by the end of Phase 2, there were significant main effects of both voting and enforcement, but no interaction (Table 2D). As Figure 5 illustrates, the Voted-Enforce condition had the highest levels of rule acceptance after Phase 2 (M=4.49, 95% CI [3.89, 5.09]). The other conditions did not significantly differ from one another (Ms=3.21 to 3.51, ps>0.05).

Self-Other Merging (Surveys 1 and 2). There was no difference in self-other merging immediately after the vote (i.e., before Phase 2); Ms=2.99 to 3.14 (SEs=0.23) (see Table 2E). Thus, voting by itself was not sufficient to influence perceptions of self-other merging. However, by the end of Phase 2, there were significant main effects of voting and enforcement on merging, which were qualified by a significant Vote × Enforce interaction (Table 2E). As shown in Figure 6, this interaction was driven by a significant increase in merging in the Voted-Enforce condition (M=3.75, 95% CI [3.31, 4.16]) compared to the other conditions, which did not differ from one another (Ms = 2.71 to 2.81, ps>.05).

7.6 Psychological predictors of resource conservation

We next conducted a series of mediation analyses to assess the direct and indirect (mediated) effects of various psychological predictors on resource conservation. Depending on whether we were investigating the psychological correlates of group behavior or individual behavior (nested within groups), we used either OLS regression (Baron & Kenny, 1986; Kenny, Kashy & Bolger, 1998) or HLR (Luke, 2004; Zhang et al., 2009). These analyses build a model that describes the sequence of psychological events that may plausibly explain behavior.

During Part I of the analyses, we first used group means and OLS regression to assess the relationship among voting and enforcement, rule compliance, and the number of tokens harvested by groups, establishing the basic behavioral model to be described. Afterward, we added predictors for group rule acceptance and self-other merging, our two major candidate predictors for behavior. Thus, Part I assesses whether group rule acceptance and self-other merging may explain how voting and enforcement influenced resource conservation. During Parts II and III of the analyses, we used individual scores and HLR (and later, OLS) to assess the potential psychological predictors of individual rule acceptance and internalized motivation, completing the sequence.

We focused on Phase 3 of the experiment, which is when cooperation was strictly voluntary for every treatment condition. This approach matches our interest in understanding

Table 3: Predictors of Phase 3 group harvests (mean number of tokens collected).

	Step 1	Step 2	Step 3	Step 4
R2 (ΔR2)	27%	44% (17%)	54% (10%)	59% (5%)
Intercept	252.28(8.92)	252.28(7.30)	252.28(7.30)	252.28(6.99)
Vote	15.26(8.92)	7.73(8.26)	2.99(7.81)	−1.15(7.77)
Enforce	−9.09(9.14)	−3.60(8.29)	−11.61(8.20)	−13.58(7.93)
Vote × Enforce	21.11(8.92)*	14.48(8.19)	13.11(7.56)	8.77(7.56)
Rule	−16.05(7.87)*	−9.31(7.30)	−2.41(7.20)	1.45(7.17)
Phase 3 Compliance		106.90(33.20)**	60.85(35.11)	60.34(33.65)
Phase 2 Acceptance			25.07(9.41)**	15.65(10.19)
Phase 2 Merging				25.63(12.26)†

Note: Slopes represent unstandardized regression coefficients (standard errors in parentheses). Dichotomous predictors are effects coded (e.g., Vote: –1 rule imposed, 1 rule decided by vote). Continuous predictors (e.g., Phase 2 Acceptance) and Rule are grandmean centered. Vote = Predictor for voting. Enforce = Predictor for enforcement. Rule = Group's rule. Compliance = Group's rule compliance. Acceptance = Group's rule acceptance. Merging = Group's self-other merging. † p=0.056. * p<0.05. ** p<0.01.

the factors that contribute to voluntary cooperation. This approach also helps avoid potential temporal confounds that may arise by using predictors measured after Phase 2 (e.g., Phase 2 rule acceptance) to retrospectively explain Phase 2 behavior. For example, it would not be clear if rule acceptance influenced participants' compliance (i.e., Acceptance → Compliance) or if emergent levels of compliance during earlier rounds of Phase 2 caused individuals to accept the rule (i.e., Compliance → Acceptance).

Resource conservation. The results of this analysis are presented in Table 3. Step 1 quantifies the direct behavioral effects of experimental treatment: we used group means and OLS regression to examine the effect of voting (Vote), enforcement (Enforce), and their interaction (Vote × Enforce) on the average number of tokens collected by groups during Phase 3. We also controlled for the effect of specific rules. There was a significant Vote × Enforcement interaction. Harvests were greatest in the Voted-Enforce condition and lowest in the Imposed-Enforce Condition, as previously described.

Step 2 quantifies rule compliance's contribution to the group harvests: adding a predictor for Phase 3 group rule compliance weakened the previously significant Vote × Enforcement interaction, and compliance emerged as a significant predictor, accounting for an additional 17% of the variance in tokens collected. This pattern (weakening a previously significant predictor with the introduction of a new variable) indicates that compliance is a mediator (Baron & Kenny, 1968; Kenny et al., 1998). The Vote × Enforcement interaction likely influenced group harvests through corresponding changes in rule compliance (i.e., Vote × Enforce → Compliance → Harvests).

During Step 3, we added a predictor for group rule acceptance to the model. Group compliance and acceptance were correlated, $r(38)=0.53$, $p<0.001$. Rule acceptance mediated the relationship between voting/enforcement and compliance (i.e., Vote × Enforce → Acceptance → Compliance); the compliance predictor was weakened, and acceptance emerged as a significant predictor, accounting for an additional 10% of variance in harvests.

During Step 4, we added group self-other merging to the model. Group self-other merging was correlated with group harvests, $r(38)=0.40$, $p<0.001$, and compliance, $r(38)=0.60$, $p<0.001$. Self-other merging was a marginally-significant predictor, and accounted for an additional 5% of the variance. In addition, the previously significant effect of rule acceptance dropped to non-significance. Thus, rule acceptance appears to have contributed to better conservation and cooperation by enhancing group self-other merging (i.e., Vote × Enforce → Acceptance → Merging → Compliance → Harvests).

Rule Acceptance. Next, we used individual scores and OLS regression to examine the psychological processes associated with individuals' Phase 2 rule acceptance. We initially used HLR (*SPSS 22™*) to test these effects to control for correlated error caused by group context. However, as previously reported, there was no significant correlated error for these measures, so these analyses did not differ from standard OLS regression (Raudenbush & Bryk, 2003; Zhang et al., 2009). Results are presented in Table 4.

Table 4: Predictors of Phase 2 individual Rule Acceptance.

	Step 1	Step 2	Step 3	Step 4
R2 (ΔR2)	6%	13% (7%)	46% (33%)	53% (7%)
Intercept	3.68(.15)	3.68(.15)	3.68(.12)	3.68(.11)
Vote	0.64(.30)*	0.18(.32)	0.07(.26)	0.03(.24)
Enforce	0.65(.30)*	0.58(.29)*	0.36(.23)	0.34(.22)
Vote $\times$ Enforce	0.68(.61)	0.81(.59)	0.02(.48)	0.49(.46)
PJSD Vote		0.44(.13)***	0.20(.10)*	0.10(.10)
Anticipated earnings			0.28(.09)**	0.06(.10)
Security			0.46(.10)***	0.20(.11)
Internalized Motivation				0.55(.12)***

Note: Slopes represent unstandardized regression coefficients (standard errors in parentheses). Dichotomous predictors are effects coded (e.g., Vote: –1 rule imposed, 1 rule decided by vote). Continuous predictors (e.g., PJSD Vote) are grandmean centered. Vote = Predictor for voting. Enforce = Predictor for enforcement. PJSD Vote = Predictor for felt procedural justice and self-determination from voting (or having a rule imposed). * p<0.05. ** p<0.01. *** p<0.001.

Step 1 quantified the effect of voting and enforcement on individual rule acceptance. As previously reported (Table 2D), there were significant main effects of voting and enforcement and no interaction; individuals in the Voted-Enforce condition had higher levels of rule acceptance (Figure 5).

During Step 2, we entered the predictor for the PJSD (i.e., procedural justice and self-determination) individuals felt from voting (versus rule imposition). As expected, PJSD was a significant predictor of rule acceptance, accounting for 7% of the variance. Moreover, the previously significant main effect of Vote dropped to non-significance. This finding suggests that individuals where more likely to accept the rule when they voted, in part because voting better satisfied their need for procedural justice and self-determination (i.e., Vote, Enforce $\rightarrow$ PJSD $\rightarrow$ Acceptance). Enforcement remained significant in this analysis, indicating that enforcement exerted effects on rule acceptance via a different psychological pathway. We also tested the potential contributions made by other psychological needs (i.e., belonging and competence). However, neither emerged as significant, and including these variables produced poor model fits.

During Step 3, we added predictors for security and anticipated earnings. Previously, we showed that there was a significant Vote × Enforcement interaction effect on security (Table 2C) and that the Voted-Enforce condition had the highest security (Figure 4). We also showed that voting and enforcement did not impact anticipated earnings (Table 2C), but we included it as a theoretically-important control variable. As shown in Table 4, security and anticipated earnings were significant predictors of rule acceptance, accounting for an additional 33% of the variance. Moreover, the previously significant effect of enforcement dropped to non-significance. PJSD was also weakened but remained significant.

The results of Step 3 indicate that voting and enforcement improved rule acceptance by satisfying needs for procedural justice and self-determination and by enhancing group members' sense of security (Vote, Enforcement $\rightarrow$ PJSD + Security $\rightarrow$ Rule Acceptance). Individuals were more likely to accept rules when governance interventions satisfied social-psychological (PJSD, security) and material needs (anticipated earnings) hypothesized to be especially pertinent in social dilemma situations. Voting was primarily mediated by PJSD, whereas enforcement was mediated by perceptions of security. We also tested the potential contributions made by the other psychological needs of enforcement (i.e., interpersonal justice and belonging), with and without a predictor representing the effect of actually being sanctioned. However, none of these emerged as significant, and including them in the analyses produced poor model fits, perhaps because sanctions were so infrequently used.

During Step 4, we added internalized motivation to the model (Table 4). Internalized motivation was a significant predictor of rule acceptance, accounting for 7% of the variance. Moreover, the predictors for PJSD, security, and anticipated earnings all dropped to non-significance, indicating that need satisfaction was associated with improved internalized motivation, which further contributed to rule acceptance (i.e., Vote, Enforcement $\rightarrow$ PJSD + Security $\rightarrow$ Internalized Motivation $\rightarrow$ Rule Acceptance). We examined the factors associated with internalized motivation to understand this relationship more clearly.

Table 5: Predictors of Phase 2 Internalized Motivation.

	Step 1	Step 2	Step 3
R2 (ΔR2)	5%	15% (10%)	72% (57%)
Intercept	4.09(.14)	4.09(.13)	4.09(.07)
Vote	0.68(.27)**	0.19(.28)	0.08(.16)
Enforce	0.36(.27)	0.29(.26)	0.03(.15)
Vote×Enforce	−0.13(.54)	0.02(.52)	−0.85(.31)
PJSD Vote		0.47(.11)***	0.18(.07)*
Anticipated earnings			0.40(.06)***
Security			0.47(.07)***

Note: Slopes represent unstandardized regression coefficients (standard errors in parentheses). Dichotomous predictors are effects coded (e.g., Vote: –1 rule imposed, 1 rule decided by vote). Continuous predictors (e.g., PJSD Vote) are grandmean centered. Vote = Predictor for voting. Enforce = Predictor for enforcement. PJSD Vote =Predictor for felt procedural justice and self-determination from voting (or having a rule imposed). * p<0.05. ** p<0.01. *** p<0.001.

Internalized Motivation. Results of Step 1 are presented in Table 5. As previously reported (Table 1C), there was a significant main effect of Vote on internalized motivation: on average, individuals who voted reported higher internalized motivation. Steps 2 and 3 (Table 5) revealed that this effect was mediated by perceived PJSD and perceptions of security, controlling for the motivation associated with anticipated earnings (i.e., Vote → PJSD + Security → Internalized Motivation). Thus, individuals may be more likely to recognize the inherent importance of the rule (a) if they elected the rule and (b) they perceived the rule as able to increase security and their anticipated earnings.

Summary. These mediational analyses help explain the psychological factors involved in voting and enforcement's impact on Phase 3 resource conservation. Groups with higher levels of rule acceptance were more likely to comply, conserving the resource (Table 3). Rule acceptance was higher when individuals' fundamental needs were satisfied (Table 4), and this was strongest in the Voted-Enforce condition, which beneficially combined interventions. Specifically, voting satisfied procedural justice and self-determination (see also, Table 2A), and the combination of voting plus enforcement satisfied security (see Figure 4). Satisfying these needs collectively promoted internalized motivation, rule acceptance, and self-other merging (Table 3). Neither intervention—voting or enforcement—produced these effects by itself. Voting and enforcement appear to promote effective CPR governance synergistically.

Two more observations emerge from these results. First, rule acceptance and voluntary cooperation may not be motivated purely by internalized motivation, as commonly hypothesized (e.g., Moller et al., 2006). According to our results, internalized motivation accounted for 7% of the variance in rule acceptance, whereas security and anticipated earnings together accounted for 33% (Table 4). Voting and enforcement may, therefore, promote a beneficial set of intrinsic and extrinsic motivations needed for sustained cooperation.

Second, the current results do not fully explain why the Voted condition, which used an apparently fair decision-making procedure, did not outperform the Imposed condition (Figure 3). To investigate this question, we examined how individuals reacted to losing the vote. As described next, we found that voting fractured the group, undermining the cooperation of the losing voters. The upcoming analyses clarify the psychological effects involved and further demonstrate the synergistic relationship between voting and enforcement.

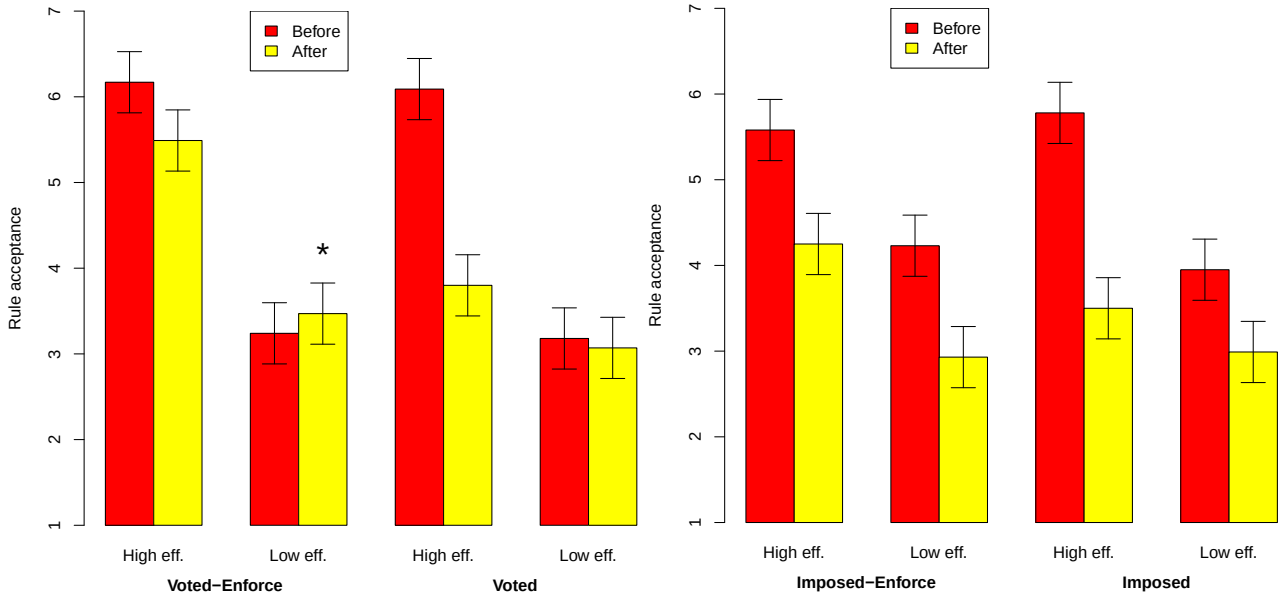
7.7 Winning or losing the vote

We investigated the fuller impacts of voting and enforcement by examining how individuals responded when they won or lost the vote. The rule was elected by two nominations in 95% (19) of the groups in the Voted-Enforce and Voted conditions. Thus, most groups consisted of two individuals who won the vote (*winning voters*) and two individuals who lost (*losing voters*). There was a correlation between each participant's chosen rule and how effective they thought that rule would be, $r(78)=0.67$, $p<0.001$. Thus, perceived rule effectiveness can be used as an indicator of outcome favorability, or rule desirability. By chance, approximately two individuals in each group within the Imposed-Enforce and Imposed conditions received a rule that they rated as highly effective. Thus, for comparison, we can also consider how individuals in the Imposed-Enforce and Imposed conditions responded when they were assigned a rule that they perceived as more or less effective.[4] For succinctness, we present the summarized results of this analysis (see Supplement, Section C for complete results).

Rule Acceptance. To compare the impact of winning (or losing) the vote (Voted-Enforce, Voted conditions) to having a desirable (or undesirable) rule imposed (Imposed-Enforce, Imposed conditions), we examined individuals' rule acceptance as a function of condition (Vote, Enforcement, Vote × Enforcement interaction) and anticipated rule effectiveness

[4]Rule effectiveness is an imperfect proxy for actual or revealed preferences, but it is useful here to allow us to compare effects across conditions, especially the Imposed and Imposed-Enforce conditions where self-reported judgments of anticipated rule effectiveness provide our only a-priori indicator of underlying preference.

Figure 7: Change in rule acceptance before and after phase 2 as function of anticipated rule effectiveness. (A) Voted-Enforce and Voted conditions. (B) Imposed-Enforce and Imposed conditions. High Eff. = High anticipated rule effectiveness (+1 SD). Low Eff. = Low anticipated rule effectiveness (–1 SD). Error bars represent 95% confidence intervals. * $p = 0.001$ when tested using actual winning/losing instead of its proxy, rule effectiveness.



(Effectiveness). We were interested in how rule acceptance may have changed over time in each of the conditions, so we compared rule acceptance before and after Phase 2 (Time). As previously reported, correlated error was not significant for rule acceptance. We nevertheless used HLR to analyze the results for consistency with subsequent results (e.g., individual harvests were correlated within groups), and because HLR allows us to properly treat Effectiveness as a continuous predictor.

The results are reported in Supplement, Section C (Table C1). Numerous effects emerged in this analysis, as illustrated in Figure 7. First, there was a main effect of Effectiveness and a significant Vote × Effectiveness interaction. On average, participants accepted the rule more highly when they thought the group's rule would be effective, especially when they voted to decide the rule.[5] Second, there was a main effect of Time and a significant Time × Effectiveness interaction. Rule acceptance declined over time, most likely because individuals observed that the rules were less effective than expected. The decline was stronger for individuals who originally thought the rule would be effective. Third, these effects were qualified by significant Time × Vote and Time × Enforce × Effectiveness interactions. The decline in rule acceptance was less pronounced in the Voted-Enforce condition. The Voted-Enforce condition was also the only condition where rule acceptance increased, albeit marginally (p = .075), among the individuals who felt they received an ineffective rule.[6] These effects coincided with individuals' rule compliance and harvesting patterns.

Individual harvests. Next, we examined the association between anticipated rule effectiveness and individuals' harvesting behavior (see Supplemental Table C2 for results). We highlight the significant Phase × Vote × Enforce × Effectiveness interaction (see Figure 8). In the Voted-Enforced condition, average predicted harvests increased significantly for individuals who believed the rule would be effective (Highs) and individuals who believed it would be ineffective (Lows). Thus, individuals in the Vote-Enforce condition benefitted from the rule regardless of anticipated effectiveness and despite the fact that the losing (i.e., Low) voters did not accept the rule initially. In contrast, in the Voted condition, introducing the rule disproportionately benefitted the Lows (i.e., losing voters). Lows also disproportionately benefitted in the Imposed-Enforce condition.

Rule compliance. To better understand why individuals benefitted differentially from the introduction of rules, we examined their rule compliance (see Supplemental Table

[5]Participants also felt more PJSD when they deemed the rule more effective. For example, voters whose preferred rule was elected (high effectiveness) felt more PJSD than voters whose preferred rule was not elected (low effectiveness).

[6]This effect is significant when it is examined using actual winning/losing (i.e., whether individuals' chosen rule was elected) instead of its imperfect proxy, rule effectiveness: $F(1,38)=13.74$, $p<0.001$, $\eta^2 = 0.27$ (M=3.25 before, 95% CI [2.71, 3.79]; M=3.88 after).

Figure 8: Mean predicted number of tokens harvested by individuals across phases as a function of anticipated rule effectiveness. (A) Voted-Enforce and Voted conditions. (B) Imposed-Enforce and Imposed conditions.

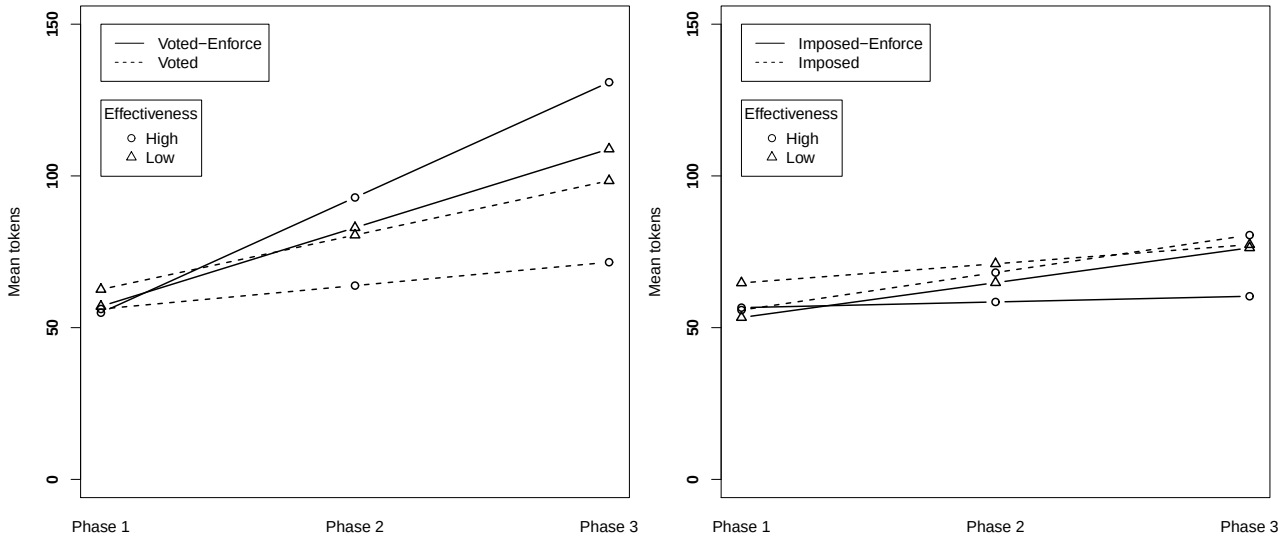
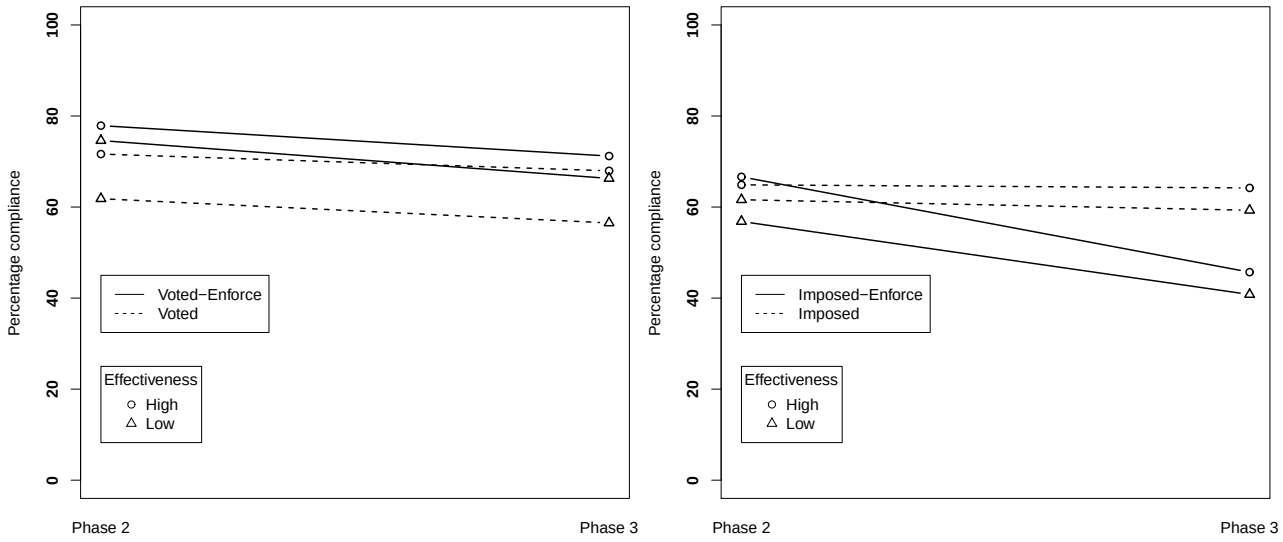


Figure 9: Mean predicted percentage individual rule compliance across phase 2 and 3 as a function of anticipated rule effectiveness. (A) Voted-Enforce and Voted conditions. (B) Imposed-Enforce and Imposed conditions.



C3). The compliance results coincided with the aforementioned harvesting patterns (Figure 9). There was a marginal main effect of Rule Effectiveness (p=.069), in which lower anticipated rule effectiveness was associated with lower compliance. There was also a marginal Vote × Enforce × Effectiveness interaction (p=.100). Specifically, there was a significant Enforce × Effectiveness interaction among the voters (b=–0.02, *SE*=.01, p=.039), such that Lows defected in the Voted condition but complied in the Voted-Enforce condition (Figure 9). There was no Enforce × Effectiveness interaction when rules were imposed (b=0.02, *SE*=.02, p=.454). Thus, Lows defected in the Imposed-Enforce condition, even when enforcement was present (Phase 2), and the Highs eventually joined them (Phase 3), contributing to a substantial (18%) drop in overall compliance (Phase 3). Compliance did not differ significantly among Lows and Highs in the Imposed condition.

Summary. The current results may help explain why the Voted and Imposed conditions performed relatively equally. In the Voted condition, the majority vote was fracturing. Individuals who did not receive the rule they initially desired (low anticipated effectiveness) rejected it and pillaged the resource, while their counterparts complied. In the Imposed condition, approximately half of the individuals received a

rule that they believed would be effective; these individuals accepted it, and complied moderately well (their counterparts complied slightly less). Thus, the Voted condition performed similarly to the Imposed condition, because the low compliance of the losing voters counteracted the high compliance of the winning voters, yielding moderate levels of compliance overall.

These results illustrate the importance of combining voting and enforcement in the Voted-Enforce condition. Enforcement ensured the groups' success after they were fractured by the majority vote. During Phase 2, Lows complied even though they did not accept the rule. After Phase 2, they accepted the rule more and continued to comply, even when we removed enforcement (Phase 3). This apparently buttressed the winning voters' acceptance of the rule (Phase 2), helping them sustain their commitment (Phase 3). Thus, initial enforcement (Phase 2) seems to have deterred the losing voters from defecting long enough to demonstrate the rule's benefits and grow their acceptance and solidify the group (i.e., self-other merging). These results are consistent with a positive reputation effect, in which successful cooperation (Phase 2) creates confidence in others, encouraging future cooperation (e.g., Abele & Stasser, 2008; Miliniski et al., 2002).[7]

8 Discussion

A well-functioning society requires an engaged, self-governing citizenry capable of addressing difficult collective action problems (Ostrom, 1998, 2010a). The answers to society's most pressing environmental problems are unlikely to materialize if we cannot overcome significant obstacles to cooperation (Parks et al., 2013). Among these challenges is the fact that widespread interventions, such as enforcement, do not always perform as planned or yield beneficial results (Agrawal & Ribot, 2014; Ostrom, 2007). Many conservation policies fail because they are demotivating or rejected (DeCaro & Stokes, 2013). Successful cooperation requires deeper understanding of human motivation and decision making to avoid these pitfalls (e.g., Cornforth, 2009; Kinzig et al., 2013; Poteete et al., 2010). Interdisciplinary laboratory experiments may help achieve this goal by integrating insights from multiple fields (Anderies et al., 2011).

In the current experiment, we asked how participatory decision making (voting) and enforcement (graduated sanctions) influence cooperation in a CPR dilemma. We used psychological measures to help reveal underlying perceptions and motivations that may explain behavioral outcomes. We were guided by converging (and sometimes diverging) theories from multiple disciplines (e.g., Deci & Ryan, 2000; Becker, 1974). To integrate perspectives, we focused on fundamental psychological processes of need satisfaction (e.g., procedural justice, security), internalized motivation, institutional acceptance, and self-other merging.

We hypothesized that voting and enforcement have synergistic effects, functioning differently when used together. For example, voting and enforcement may legitimize and reinforce one another, overcoming the fundamental dilemma of coordinating rational agents without stifling their fundamental needs for procedural justice/self-determination and security, or undermining internal motivations for cooperation. To test the configurative effects of voting and enforcement, we introduced then removed enforcement among voters (Voted-Enforce condition) and non-voters (Imposed-Enforce condition). We also compared voting and enforcement alone. The current approach helps clarify apparently contradictory effects of voting and enforcement, while improving our understanding of voluntary cooperation.

8.1 Voting with enforcement

Voting on rules combined with enforcement (i.e., Voted-Enforce condition) was superior to using either of these interventions alone (e.g., Voted condition). Cooperation was higher in the Voted-Enforce condition (Phase 2) and more sustainable, persisting even when we removed enforcement (Phase 3). The results for this treatment group argue against a strong crowding-out effect of enforcement (e.g., Deci et al., 1999; Moller et al., 2006, Bowles, 2008). Enforcement in the context of ostensibly fair institutional decision-making procedures may actually facilitate, or empower, long-term cooperation (see Ostrom, 2000 for a similar argument).

With important caveats, the current findings are generally consistent with theories that describe the relationship between (a) participatory decision making (e.g., Deci & Ryan, 2000; Tyler, 1988, 1990) and enforcement (e.g., Hardin, 1968), and (b) internalized motivation and institutional acceptance. As a result of voting, individuals in the Voted-Enforce condition reported the highest levels of procedural justice and self-determination; and as a result of enforcement, they reported the greatest sense of security. These perceptions were associated with improved internalized motivation and rule acceptance, and individuals also had positive attitudes towards the group (i.e., self-other merging), facilitating norm adoption. Collectively, these social-psychological processes mediated the effect that voting and enforcement had on cooperation in Phase 3, when cooperation was strictly voluntary. These results support and extend prior work that emphasizes the importance of internalized social norms in sustainable cooperation (e.g., Kerr et al., 1997; Sutinen & Kuperan, 1999).

[7] A negative reputation effect may help explain why cooperation faltered in the Imposed-Enforce condition. Initial enforcement (Phase 2) did not deter the Lows from defecting, potentially creating a reputation of non-cooperation that convinced both Lows and Highs to defect when enforcement was removed (Phase 3). See Mulder et al. (2006) and Tenbrunsel and Messick (1999) for a similar argument.

8.2 Enforcement with imposed rules

The results for the Imposed-Enforce condition support predictions that sanctions may crowd-out internal motivations for cooperation (e.g., Bowles, 2008; Deci et al., 1999; Frey & Jegen, 2001; Moller & Deci, 2006), demonstrating an important caveat on the nature of enforcement. Specifically, the critical deciding factor was whether conservation strategies were exogenously imposed or decided by group vote. In the Imposed-Enforce condition, enforcement did not improve cooperation (Phase 2). Contrary to the general deterrence model of enforcement (e.g., Becker, 1974; Hardin, 1968),[8] group members felt no more secure (and cooperated no better) than the Voted and Imposed conditions, which entirely lacked enforcement. Furthermore, cooperation declined sharply after we removed enforcement. Thus, enforcement was detrimental without participatory rule choice, crowding out voluntary cooperation.

These findings replicate prior CPR experiments in which experimenters exogenously imposed rules and sanctions, and found a crowding effect (e.g., Cardenas et al., 2000; Ostrom et al., 1992; Janssen et al., 2010). The current experiment helps to explain these effects using social-psychological measures. Individuals in the Imposed-Enforce treatment group reported lower levels of procedural justice and self-determination, internalized motivation, and institutional acceptance.

The current results are also consistent with experiments where group members became dependent on enforcement, losing faith that others will voluntary cooperate (e.g., Chen et al., 2009; Mulder et al., 2005; Tenbrunsel & Messick, 1999). In those experiments, participants attributed other's cooperation to fear of enforcement, so when enforcement ceased, cooperation declined. We do not have psychological measurements (e.g., attributions) to confirm that this occurred in the current study. However, we suspect that it contributed. In the Imposed-Enforce condition, the rule was imposed by the experimenter. Thus, in the presence of enforcement, it would be difficult for participants to assume that others are obeying the rule because of internal motivations, such as the rule's inherent importance. In contrast, in the Voted-Enforcement condition, participants may attribute other's cooperation both to external enforcement and internal motivations because some individuals clearly voluntarily voted for that particular rule. This may have helped safeguard internalized motivation in the Voted-Enforce condition, even though enforcement existed.

It is interesting that sanctions were not sufficient to increase security and improve cooperative outcomes in the Imposed-Enforce condition. The foundational work by Hardin (1968), which partly inspired widespread use of sanctions in environmental governance, acknowledged the importance of fair process in enforcement, e.g., "mutual coercion, mutually agreed upon," (Hardin, 1968, p. 1247). However, this insight is often overlooked in contemporary treatments of enforcement.[9] As Hardin writes:

> To many, the word coercion implies arbitrary decisions of distant and irresponsible bureaucrats; but this is not a necessary part of its meaning. The only kind of coercion I recommend is mutual coercion, mutually agreed upon by the majority of the people affected. (p. 1248)

Hilbe et al. (2014) recently confirmed that a majority vote to establish a sanctioning system can support lasting cooperation in a public goods dilemma. Many other experiments have shown that enforcement is more effective when chosen by a large majority (e.g., Ostrom et al., 1992; Sutter et al., 2010; Tyran & Feld, 2006; Vollan, 2008; Vyrastekova & van Soest, 2003).

A participatory process, such as voting, may therefore be essential, legitimizing sanctions (e.g., Grossman & Baldassarri, 2012) in a way that enhances security without undermining institutional acceptance, as more generally hypothesized in theories of law enforcement and procedural social justice (Gibson, 1989; Tyler, 1990, 2006). Thus, the Imposed-Enforce condition may be seen as the worse-case from a motivational standpoint. For instance, in the Imposed condition, participants felt a deficit to procedural justice and self-determination because they could not vote to decide the rule. However, because there was no enforcement, they experienced no further injustice, and any cooperation (however slight) must be attributed to other's internal motives to cooperate (e.g., Chen et al., 2009; Mulder et al., 2005; Tenbrunsel & Messick, 1999).

However, we are careful not to overgeneralize the results, because many factors could alter this balance. For example, Jenny et al. (2006) found that, even though they had no say in creating the rules, a community in Cuba obeyed conservation rules to share a solar power system because the mayor was trustworthy and knowledgeable (i.e., an electrician). We based the current research on several studies, which used different types of enforcement.[10] However, other enforcement factors, such as visibility (Janssen, 2013; Kamei & Putterman, 2013), cost/benefit ratio (Nikiforakis & Normann, 2008), or probability of sanction (e.g., Dai et al. 2014), could potentially yield different results.

[8] See Bowles (2008) and Mulder et al. (2006) for theoretical discussion.

[9] Ostrom's (1990, 2010a) Design Principles allude to the connection somewhat, with both participation and enforcement appearing as beneficial factors, but the connection is not fully developed (e.g., Ostrom, 2000, 2010b).

[10] For example, Janssen et al. (2010) used graduated sanctions; Vollan (2008) used rewards and punishments; Vyrastekovia and van Soest (2003), Mulder et al. (2005), Tenbrunsel and Messick (1999) used weak versus strong punishments; and some used centralized enforcement (e.g., Vyrastekovia & van Soest, 2003), whereas others used self-enforcement (e.g., Janssen et al., 2010), or both (e.g., Tyran & Feld, 2006).

8.3 Voting without enforcement

Our data also replicate and further extend prior observations that participatory decision making is not always beneficial (e.g., Chess & Purcell, 1999; Irvin & Stansbury, 2004). In our experiment, majority vote was a necessary but insufficient condition for success. Voters in both the Voted-Enforce and Voted conditions felt less procedural justice and self-determination when they lost the vote and did not get the rule they wanted (this coincided with the rule's anticipated effectiveness). As a result, they did not accept the rule highly.

In the Voted condition, in which defectors could not be sanctioned, losing voters were more likely to pillage the resource. Overall, these groups did no better than the Imposed condition. This finding replicates many other experiments (e.g., Janssen et al., 2008; Rauchdobler et al., 2010; Vollan, 2008; Vyrastekova & van Soest, 2003). However, our study reveals perceptions and motivations associated with this behavior. In the Vote-Enforce condition, institutional acceptance remained strong over time, and even improved among losing voters. It appears that enforcement stopped the losing voters from defecting long enough to see the rule's benefits and grow their support for it. In the Voted condition, there was no enforcement, so individuals who initially disliked the rule could not be as readily convinced otherwise, leading to worse levels of acceptance and performance.

Overall, the results are consistent with the emergence of reputation effects (e.g., Abele & Stasser, 2008; Milinski et al., 2002) facilitated (or thwarted) by condition. For example, in the Voted-Enforce condition, voting and enforcement ensured cooperation during earlier stages of coordination (Phase 2), helping to establish norms of cooperation, and positive group identity (self-other merging), that carried over into Phase 3. But this was not fully possible in the Voted condition, because they lacked enforcement.

8.4 Why examine social-psychological mechanisms?

Speaking more broadly, our findings suggest that institutional decision makers need to carefully consider the social-psychological consequences of their interventions, especially as determined by context. Voting and enforcement had different effects when they were combined, versus when they were used individually. These effects may further depend on broader social context (DeCaro & Stokes, 2013). For example, Vollan (2008) found that voting combined with punishments undermined cooperation of groups with high prior trust and existing norms of voluntary cooperation (Namibians), but facilitated cooperation of groups with little trust or cooperative norms (Namaqualand, South Africans). Thus, our results may pertain primarily to groups with low prior trust, such as undergraduates randomly assigned to treatment groups, or communities with a history of poor cooperation.

The specific type of participatory decision making may also be crucial. In our experiment, the majority vote essentially created a political "zero-sum" game, in which winning voters held more influence (see also, Gelman, 2003). This aspect of majority vote decreased perceptions of fairness and self-determination. Other methods may avoid counterproductive effects (Fung, 2006). Communication and iterated decision making may help group members air their concerns and reach common understanding about group preferences (Caripini et al., 2004; Fung, 2006), further supporting individual justice and autonomy (Moller & Deci, 2006). Indeed, Ostrom et al. (1992) found that groups deciding CPR rules by communication plus a consensus vote outperformed even those groups that additionally had enforcement (see also, Cardenas et al., 2000; Janssen et al., 2010). These outcomes may further depend on cross-cultural preferences for particular forms of governance. For example, Vollan et al. (2014) found that individuals who valued authoritarian leadership (e.g., Chinese students) preferred top-down decision-making procedures and cooperated well even when they disagreed with the rules.

Our results have implications for human governance more broadly, as they suggest that it is important to balance fundamental social-psychological needs (e.g., self-determination) with important economic and strategic needs (e.g., security and economic earnings). Thus, as with prior work, both decision-making procedures (procedural utility) and their outcomes (outcome utility) mattered (Frey et al., 2004), lending further support to a growing body of research that claims cooperation is energized by multiple motivations (Ramcilovic-Suominen & Epstein, 2012; Sutinen & Kuperan, 1999). In a complex society, it is highly unlikely that everyone will wholeheartedly agree with chosen conservation strategies, or strongly internalize important rules and norms. In our study, the losing voters did not strongly internalize the rule. However, in the Voted-Enforce condition, they did eventually grow to accept (or tolerate) it. Both sources of motivation, (a) internalization among wholeheartedly invested citizens and (b) general acceptance, or tolerance, among citizens who are less invested, are vital for democratic governance. Participatory decision making seeks to promote widespread cooperation by justifying and legitimizing chosen decisions so that a sufficient number of citizens accept (or tolerate) the governance system (Brehm & Brehm, 1981; Lawrence et al., 1997; Tyler, 1988, 1990). We believe that the Voted-Enforce condition provided this opportunity, helping to galvanize the group (self-other merging).

Finally, the current study pertains to a CPR dilemma, whereas many experiments examine public goods (PG) and prisoner's dilemmas (Dawes, 1980; Kerr, 2013; Parks et al., 2013). The core findings of our experiment should be

similar across dilemmas insofar as they tap fundamental problems in cooperation (Ostrom, 2006).[11] However, there may also be important psychological differences that warrant attention (Apesteguia & Maier-Gaud, 2006; Sell & Son, 1997): for example, their competitiveness (Halevy et al., 2011), degree of loss aversion (Brown, 2006), and how individuals judge fairness of their payoffs (van Dijk & Wilke, 2000). Many differences stem from contextual variations, such as group size, framing, and resource characteristics (Weber et al., 2004). Future studies may wish to explore these potential differences (see DeCaro & Stokes, 2013 for general discussion).

8.5 Conclusion

By focusing on central social-psychological processes, the current research approach accounts for complex nuances in cooperative behavior across different CPR governance scenarios. Similar approaches have been used to explain decisions in markets, families, education, work, healthcare, law, religion, and other domains (Deci & Ryan, 2008; Frey et al., 2004). This approach may therefore be applicable to a large range of social-ecological dilemmas where sustained cooperation is essential. The current results suggest that design principles for effective CPR governance (e.g., Ostrom 2010a) function as a configuration, helping stakeholders address fundamental needs while overcoming multiple personal, social, and interdependent obstacles to cooperation.

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[11] For example, individuals react to uncooperative behavior in PGs and CPRs with similar emotions (Cubitt et al., 2011); a majority vote (without enforcement) can fracture groups in CPRs (e.g., Janssen et al., 2008) and PGs (e.g., Bo et al., 2010; Kamei, 2014), causing the losing voters to defect; and voting to use enforcement often improves cooperation, compared to when enforcement is exogenously imposed (e.g., Markussen et al., 2014 Sutter et al., 2010; Tyran & Feld, 2006).

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