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RESEARCH ARTICLE

Evolution of cooperation in the indefinitely repeated collective action with a contest for power

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Abstract

Social and political inequality among individuals is a common driving force behind the breakdown in cooperation. In this paper, we theoretically and experimentally study cooperation among individuals facing a sequence of collective-action problems in which the benefits of cooperation are divided according to political power that is obtained through a contest. We have three main results. First, we find that cooperation predictably responds to the fundamental parameters of the collective-action problem. Specifically, it is increasing in the benefit to cooperation and how much benefit is gained from partial group cooperation, and decreasing in the number of players. Second, we find that when players are unrestricted in their expenditures in the contest, cooperation is much lower than when expenditures are set to a specific proportion of earnings. Finally, we find that individual norms and beliefs account for a substantial proportion of explained variance in individuals' decisions to cooperate.

Keywords Dynamic Coordination Games · Beliefs · Norms · Cooperation · Contest

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1 Introduction

The 21st century has seen considerable social unrest across the developed and developing countries (e.g., Black Lives Matter Movement in the U.S., the Umbrella Movement in Hong Kong). Among the major driving forces behind these conflicts is political inequality between different ethnic, regional, or religious groups. The aim of our paper is to understand how human decision-makers cooperate when the benefits to cooperation are divided according to political power that is obtained through a contest. In particular, we develop a theoretical model that connects two famous, but largely disconnected problems. The first is a collective-action problem in which individuals face a decision on whether to undertake a risky collective action or an individual action that guarantees a safe payoff. For example, consider a stag-hunt game (Rousseau 1754) or a public-goods game (Samuelson 1954; Hirshleifer 1983). The second is the contest for "political power" in which players face a decision on how much to spend to gain greater representation, which, in turn, translates into a more beneficial division of benefits from the collective action.[1] Building on earlier work (Houle et al. 2022; Tverskoi et al. 2021), we connect the two problems by assuming the benefits from the collective action are split based on the dynamically changing political power of the individuals. We further integrate the two problems by assuming interactions are indefinitely repeated, which creates opportunities for accumulation of power and cooperation breakdown over the long horizon that may not be present in the short run.

Our approach for deriving theoretical predictions for the decisions in the collective-action problem is twofold. First, we use a measure of strategic uncertainty developed for one-shot coordination games (Dal Bó et al. 2021) to serve as a guideline for the choices during the initial interaction. Second, we use a model of myopic best-response to derive theoretical predictions for the long-run outcomes that incorporate the contest for power. Both approaches are consistent regarding the impact of the fundamental parameters of the decision to cooperate. Specifically, players are more likely to cooperate as the benefit to (partial) cooperation increases or the number of players decreases. The main theoretical results of the paper pertain to the long-term impact of the contest for power on the players' decision to cooperate. In particular, we show that when players do not have a choice regarding how much to spend in the contest, the cooperation is much higher than when they are unrestricted in their expenditure in contests for power.

To test our theoretical predictions, we design and run a controlled lab experiment. The experiment achieves three main objectives. First, we establish that human decision-makers respond to the fundamental parameters of the collective-action problem according to the theoretical predictions. Second, the results of our experiments

[1] For example, in models of electoral competition (e.g., Baron 1994; Grossman and Helpman 1996), political parties use campaign spending to influence the voting behaviors to achieve more favorable outcomes. In the context of rent-seeking (e.g. Tullock 1967; Krueger 1974; Brock and Magee 1978; Findlay and Wellisz 1982), special interest lobbies compete for more favorable policies in areas with government restrictions such as taxes, subsidies, tariffs, and quotas.

also confirm that when human subjects are free to choose their expenditure in the contest, cooperation in the collective-action stage breaks down. Finally, as part of the experiment, we elicited individual beliefs as well as individual and social norms. We then use the data on elicited beliefs and norms to estimate a behavioral model of choice (Gavrilets 2021; Tverskoi et al. 2021, 2022). Specifically, we show that in a dynamic setting in which individuals face an indefinite sequence of collective-action problems and contests for power, individual beliefs and norms play a prominent role in explaining individual behavior. Our experimental results on the effects of inequality in power, conformity and norms on cooperation complement an earlier test of the model predictions using country-level data linking economic inequality with social unrest in 75 countries between 1991 and 2016 (Houle et al. 2022).

Our paper contributes to several strands of literature. First, we contribute to the vast experimental literature on coordination games.[2] Early works in this stream include Van Huyck et al. (1990) and Cooper et al. (1992), who show that in a coordination game, human subjects tend to coordinate on the risk-dominant equilibrium.[3] More recently, Dal Bó et al. (2021) show that coordination in the experimental setting is better explained by a continuous measure of risk associated with choosing a cooperative action. We use this measure to make predictions in a much more complex dynamic setting. Specifically, in our experiments, subjects interact in a sequence of games whereby payoffs start with a stag-hunt coordination game but then evolve endogenously based on the resulting payoffs and the decision to invest in a contest for power. From this perspective, the most relevant papers are Cooper and Van Huyck (2018), who show that subjects are able transfer conventions between related coordination games presented in a sequence, Bornstein et al. (2002), who show that in the presence of inter-group competition, more efficient outcomes can be achieved, and Cooper et al. (2018), who show that endogenous assignment to higher payoffs to coordinating on risky action leads to greater efficiency.

Second, we contribute to the experimental and theoretical literature that studies proportional-prize contests (Cason et al. 2020). Whereas the most famous theoretic and experimental analyses consider the winner-take-all lottery contests of Tullock (1980), a smaller stream considers proportional-prize contests (Cason et al. 2010).[4] One of the most relevant papers is Savikhin and Sheremeta (2013), who study simultaneous decisions in a contest and public-goods game. The authors find that the contest does not affect contributions to the public-goods game, whereas the (sub optimal) overbidding in the contest decreases, indicating a positive spillover effect of the cooperative game on the competitive one. Our theory and experiment focus on a different combination of games integrated in a new, dynamic way. In particular, we consider the impact of the contest for power on the individual's decision to cooperate when the benefits to cooperation are split according to the power earned in the contest. Both theoretically and experimentally, we find that an unrestricted contest for power leads to significantly lower cooperation.

2 For a recent survey of experiments on coordination games, we refer the reader to Cooper and Weber (2020).

3 In a two-player two-action coordination game, risk dominance is defined as a best response to the other player choosing 50–50 (Harsanyi and Selten 1988).

4 See Dechenaux et al. (2015) for a review of experimental literature on winner-take-all Tullock contests.

The third stream of literature that we contribute to studies dynamic repeated games. Work in this field has focused on behavior in common-pool resources games (Gardner et al. 1990; Stoddard et al. 2014; Vespa 2020), dynamic Prisoner's dilemma games (Vespa and Wilson 2019; Rosokha and Wei ming), and dynamic public good games (Noussair and Soo 2008; Rockenbach and Wolff 2017; Gächter et al. 2017). The closest among these are Cadigan et al. (2011) and Rockenbach and Wolff (2017), who study dynamic public good games with carryover. In particular, in their setting, players' endowments in a period are determined by payoffs obtained in the previous period. Our work is unique in that we study a dynamic game that is a combination of two games – collective action and contest – such that endowment in a contest is determined by payoffs in the collective action, and payoffs in the collective action depend on the power obtained in the contest (see Sect. 2 for more details).[5]

In addition, we contribute to a growing literature that links behavior of individuals with changes in their personal norms and empirical and normative expectations (d'Adda et al. 2020; Górges and Nosenzo 2020; Andreozzi et al. 2020; Szekely et al. 2021; Tverskoi et al. 2023). Our work integrates these approaches by accounting for changes in individual beliefs and norms as the individual's power evolves during social interactions. In particular, we estimate a behavioral model that combines expected payoffs given beliefs with social and personal norms elicited within the experiment. Our results suggest that although expected payoffs and best responding are fundamental drivers, social norms explain substantial variation in cooperative choices.

The rest of the paper is organized as follows: in Sect. 2, we formalize the environment. In Sect. 3, we develop three main hypotheses. Next, in Sect. 4, we present details of the experimental design. We then present results of the experiment in Sect. 5. Finally, we conclude in Sect. 6.

2 Environment

We consider a society composed of $I = \{1, \ldots, n\}$ individual decision-makers interacting over an indefinite sequence of rounds. Each round, $t \in \{1, 2, 3, \ldots\}$, the decision-makers are engaged in a collective-action game (stage 1) and a contest for power (stage 2). Specifically, in stage 1 of period t, each player i chooses whether to cooperate ($a_{i,t} = 1$) or not ($a_{i,t} = 0$) in the production of a club good. The cost of cooperation, $c > 0$, is the same across all players and is constant across time. Let $a_t = (a_{i,t}, a_{-i,t}) = (a_{1,t}, \ldots, a_{n,t})$ denote the action profile in period t, with $a_{-i,t}$ denoting an action profile of all players excluding i. The production amount $F(\bar{a}_t)$ is an S-shaped function of the proportion of players who decide to cooperate,

[5] Some of the elements of our environment have been studied separately in the experimental and theoretical literatures. For example, on the experimental side, Schmitt et al. (2004) study a multi-period contest with carryover and Swope (2002) study public goods game with exclusion, while on the theory side Petkov (2023) study infinite-horizon multi-stage contests with dynamically determined prizes that are split according to the effort exerted in a stage.

$\bar{a}_t = \frac{\sum_{i \in I} a_{i,t}}{n}$, as follows:

$$F(\bar{a}_t) = b \frac{(\bar{a}_t)^\kappa}{(\bar{a}_t)^\kappa + (a_0)^\kappa}, \tag{1}$$

where $b > 0$ is the maximum benefit to cooperation, $a_0 \in (0, 1)$ is the "half-effort" parameter that determines the proportion of the group required to produce half of the maximum benefit, $(\frac{b}{2})$, and $\kappa \geq 1$ is the parameter that determines the steepness of the production function (Gavrilets 2015).

Unlike the widely studied collective-action problems, such as stag-hunt or public-goods games, in our environment, the share of the production that player i gets in period t depends on how much expenditure, e_{t-1}, players spent in stage 2 of period $t-1$ on obtaining "political power" over the division. Specifically, the division in a round is determined according to the proportional-prize contest among all cooperators based on the total expenditure. Thus, player i's payoff in stage 1 is

$$\pi_i^1(a_t, e_{t-1}) = R_0 + a_{i,t}\left(\frac{e_{i,t-1}}{a_t \cdot e_{t-1}} F(\bar{a}_t) - c\right), \tag{2}$$

where $a_t \cdot e_{t-1} = \sum_{i \in I} a_{i,t} e_{i,t-1}$ is the dot product of the two vectors equal to the sum of all expenditures by cooperating players, and $R_0 > c$ is an endowment.[6] In each round t, the expenditure $e_{i,t}$ a player i can spend should not exceed the stage 1 payoff, $0 \leq e_{i,t} \leq \pi_i^1(a_t, e_{t-1})$. We initialize that $e_{i,0}, 0 = 0\ \forall\ i$ so that all cooperators share the production equally in round 1. Then, the payoff in round t is

$$\pi_i(a_t, e_{t-1}, e_t) = \pi_i^1(a_t, e_{t-1}) - e_{i,t}. \tag{3}$$

In this paper, we aim to achieve three main goals. First, we would like to establish that human decision-makers respond to the fundamental parameters of the collective-action problem (b, n, a_0). Second, we would like to understand how the contest for power interacts with the decision to cooperate in the collective production. Finally, we consider an individual's beliefs and norms about cooperation to provide insights into the forces that may drive decisions to cooperate or defect in this highly dynamic environment.

2.1 Parameters

As mentioned above, our first goal is to establish that decision-makers in this environment respond to the fundamental parameters in a predictable way. To this end, we vary three fundamental parameters—$b \in \{109, 218\}$, $n \in \{2, 4\}$, and $a_0 \in \{0.406, 0.819\}$—and fix $R_0 = 60, c = 20.4, \kappa = 12,$and $e_{i,0} = 0,\ \forall i \in I$ across all treatments. Summary of the resulting treatment parameters, including collective production, are presented in Table 1. In addition, Table 2 presents the stage-game

[6] In the case of $a_t \cdot e_{t-1} = 0$ and $a_t \cdot \mathbb{1} \neq 0$ (where $\mathbb{1}$ is a vector of ones), we define $\pi(a_t, e_{t-1}) = R_0 + a_{i,t}\left(\frac{1}{a_t \cdot \mathbb{1}} F(\bar{a}_t) - c\right)$. In the case of $a_t \cdot \mathbb{1} = 0$, we define $\pi(a_t, e_{t-1}) = R_0$.

Table 1 Summary of Treatment Parameters

Treatment		Parameters						Production function, $F(\bar{a})$				
		b	a_0	n	R_0	c	κ	$\bar{a}=0$	.25	.5	.75	1
T1	EXO	109	.812	2	60	20.4	12	0		0		100
T1	END	109	.812	2	60	20.4	12	0		0		100
T2	EXO	109	.812	4	60	20.4	12	0	0	0	30	100
T3	END	218	.812	2	60	20.4	12	0		0		200
T4	EXO	218	.812	4	60	20.4	12	0	0	0	60	200
T4	END	218	.812	4	60	20.4	12	0	0	0	60	200
T5	END	109	.406	2	60	20.4	12	0		100		108
T6	EXO	109	.406	4	60	20.4	12	0	0	100	108	108
T6	END	109	.406	4	60	20.4	12	0	0	100	108	108

Production function, $F(\bar{a})$, is given by equation (1). b denotes the maximum benefit to cooperation; n denotes the number of players in the environment; a_0 denotes the "half-effort" parameter, which determines proportion of the group that is required to achieve half of b. EXO denotes a treatment with an exogenously specified proportion of earnings in stage 1 that are contributed in stage 2. END denotes a treatment in which players make decisions in stage 2. Table D-5 in the Online Appendix presents a summary of the nine treatments

Table 2 Stage-Game Payoffs when All Players Have the Same Power

Parameters	$n=2$			$n=4$				
b = 109	T1	0	1	T2	0	1	2	3
a_0 = 0.812	C	40	90	C	40	40	50	65
	D	60	60	D	60	60	60	60
b = 218	T3	0	1	T4	0	1	2	3
a_0 = 0.812	C	40	140	C	40	40	60	90
	D	60	60	D	60	60	60	60
b = 109	T5	0	1	T6	0	1	2	3
a_0 = 0.406	C	140	94	C	40	90	76	67
	D	60	60	D	60	60	60	60

Payoff for choosing C(cooperate) and D(defect) when all players have equal power. Columns denote how many other players choose C (out of $n-1$). Players always have equal power in Round 1 of a match, but may have equal power in other rounds depending on players' choices in prior rounds

payoffs in round 1 of a supergame. We choose the parameters so that payoffs in the first round of interaction are comparable to previously studied two-player stag-hunt games (Dal Bó et al. 2021; Schmidt et al. 2003). For example, the payoffs in one of the games studied in Dal Bó et al. (2021) are the same as in round 1 of the T1 parameter combination with the exception that the payoff to (D,C) in T1 is 60, whereas the payoff to (D,C) in Dal Bó et al. (2021) is 65.

Our second goal is to understand how the contest for power influences the decisions to cooperate. To this end, in some of the treatments, we restrict the investment in the contest to be a constant fraction of the earnings from the collective action. We use abbreviations EXO and END to differentiate between an exogenous and an endogenous contest treatment (see Table 1). Specifically, in the exogenous treatment, players are restricted to invest a fixed proportion (10%) of their stage 1 earnings in the contest for the next round's power. By contrast, in the endogenous treatment, the only restriction on players' spending is the intrarounds budget constraint (i.e., in stage 2 of a given round, subjects may not exceed what they earned in stage 1). Finally, our third goal is to understand how norms and beliefs influence behavior. To this end, we elicit subjects' round-by-round beliefs and norms. We then test whether the belief and norm data help better explain subjects' observed behaviors.

3 Hypotheses

Theoretical analysis of the indefinitely repeated coordination games does not provide a clear prediction regarding whether decision-makers will cooperate or defect. On the one hand, any sequence of stage-game Nash equilibria (NE) is supported as a subgame perfect equilibrium (SPE) and given that both cooperation and defection are stage-game NE, either could be played. On the other hand, infinitely many trigger strategies could be supported as an SPE as well. For example, consider a strategy that prescribes cooperating in stage 1 and a contribution of a fixed fraction of stage 1 earnings to stage 2 contest as long as the other cooperates in stage 1 and contributes the same fraction in stage 2. Any deviation, either by defecting in stage 1 or by changing the amount in stage 2, will trigger punishment of defections forever. Therefore, for theoretical guidance, we rely on two behaviorally grounded approaches. First, we consider the *size of the basin of attraction of cooperation* (henceforth, $SizeBC$) of the stage game as a predictor of the behavior in rounds 1 of a supergame. Focusing on the behavior in round 1 has several advantages: (i) It is an important determinant of how the interaction unfolds, because behavior in later rounds is not independent of previous rounds; (ii) in round 1 of each supergame, all players have the same power, and thus conditional on parameters of the collective-action problem, play the same game; and (iii) in round 1, subjects have not yet participated in the contest for power, which may add an additional layer of complexity to the analysis. The second approach we take focuses on the long-term outcomes. In particular, we use a model of *myopic best response* that has been widely used among economists (Kandori et al. 1993; Young 1993; Kandori and Rob 1995; Hopkins 1999) and evolutionary game theorists (Smith 1982; Matsui 1992; Sandholm 1998; Alós-Ferrer 2003; Roca et al. 2009; Szolnoki and Perc 2014; Tverskoi et al. 2021; Houle et al. 2022). Notably, the approach has found recent empirical support in economics experiments on repeated coordination games (Mäs and Nax 2016). In addition, Offerman et al. (2001) note that subjects tend to be adaptive and less strategic in complicated experimental environments, as is the case in our experiment.

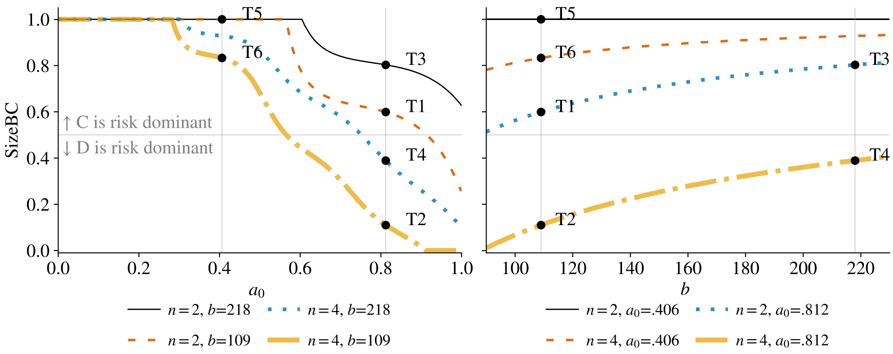


Fig. 1 Basin of Attraction and Behavior in Round 1. *Notes* The figure presents the size of basin of attraction of cooperation ($SizeBC$) assuming the power is equally distributed. The left panel shows how $SizeBC$ changes with a_0. The right panel shows how $SizeBC$ changes with b. • denotes treatment parameters chosen for the experiment

3.1 Size of Basin of Attraction of cooperation in round 1

To predict behavior in round 1, we focus on a measure of strategic uncertainty developed for one-shot games by Dal Bó et al. (2021). In particular, for the two-player version of the game, we define $SizeBC$ of the stage game as the maximum probability of the other subject playing defect that still makes cooperation a best response. Specifically, let θ_{-i} be the probability that the other player chooses to cooperate. Then, to calculate the $SizeBC$, we find the maximum value of $(1-\theta_{-i}) \in [0, 1]$ such that

$$\theta_{-i}\pi_i^1((1,1), e_0) + (1-\theta_{-i})\pi_i^1((1,0), e_0) \geq R_0$$
$$\Rightarrow SizeBC = \begin{cases} 1, \text{ if } a_0 \leq 0.5\left(\frac{b}{c} - 1\right)^{\frac{1}{\kappa}}, \\ \frac{(2c+2ca_0^\kappa - b)(1+2^\kappa a_0^\kappa)}{b(1+2a_0^\kappa - 2^\kappa a_0^\kappa)}, \text{ otherwise.} \end{cases}$$

In Online Appendix A.1, we show that for the parameters chosen for the experiment, $SizeBC$ is increasing in b and decreasing in a_0. Note that if $SizeBC$ is greater than one-half, then cooperation is risk dominant (Harsanyi and Selten 1988). Furthermore, the higher $SizeBC$, the more robust cooperation is to strategic uncertainty and the more cooperation we expect to see in the experiment. To adapt this measure to games with $n > 2$ players, we follow Kim (1996), Morris et al. (1995), and Peski (2010) in assuming that all other $n-1$ players have the same probability of cooperation, θ_{-i}.[7] Figure 1 presents how $SizeBC$ changes with the treatment parameters.

The comparison between treatments T3 and T1 as well as between T4 and T2 shows that $SizeBC$ increases with the maximum benefit to cooperation (b). The comparison

[7] Kim (1996) generalizes the risk-dominance concept of Harsanyi and Selten (1988) to an N-player coordination game using the same approach. A similar approach is adopted for the p-dominant equilibrium by Morris et al. (1995) and the GR-dominance by Peski (2010). In a concurrent paper, Boczoń et al. (2023) experimentally validate the assumption of independence-based extension of strategic uncertainty in the context of indefinitely repeated Prisoner's Dilemma.

between treatments T1 and T2, T3 and T4, as well as T5 and T6 shows that $SizeBC$ is decreasing in the group size (n). Finally, the comparison between T1 and T5 as well as T2 and T6 shows that $SizeBC$ is decreasing in the proportion (a_0) required to achieve half of the possible benefit to cooperation. We summarize the resulting predictions with Hypothesis 1:

Hypothesis 1 *Cooperation responds to the parameters of the collective-action problem:*

(a) *Cooperation is increasing in the maximum benefit to cooperation (b),*
(b) *Cooperation is decreasing in the group size (n),*
(c) *Cooperation is decreasing in the proportion of the group (a_0) required to achieve half of the maximum benefit to cooperation.*

3.2 Myopic best response, contest for power, and the long-term outcomes

To understand how the contest for political power interplays with decisions to cooperate, we consider two versions of the environment. In particular, in addition to the environment in which players freely choose how much to spend on the contest for power in stage 2 (which we denote as END), we also consider a baseline, denoted as EXO, in which we exogenously restrict expenditures on the contest for power to be a fixed proportion of the earnings in stage 1 (i.e., players have to spend a specific amount in the contest as in Tverskoi et al. 2021; Houle et al. 2022). By comparing the two models (and resulting treatments), we have a better understanding of the reasons cooperation may break down. Next, we introduce the best-response functions for both versions of the model and characterize the myopic best-response equilibria.

3.2.1 Exogenous power revision

For the model of exogenous power revision, we restrict expenditure in stage 2 to be a fixed proportion, $\gamma \in (0, 1)$, of the payoff in stage 1:

$$e_{i,t} = \gamma \pi_i^1(a_t, e_{t-1}), \forall i \in I. \tag{4}$$

We assume that in stage 1 of period $t+1$, player i decides whether to cooperate, by best responding to the choices in period t. That is, in stage 1 of period $t+1$, player i chooses

$$a_{i,t+1} = BR_i^a(a_{-i,t}, e_t) = \underset{a_i \in \{0,1\}}{\text{argmax}}\ \pi_i^1((a_i, a_{-i,t}), e_t). \tag{5}$$

Definition 1 An action profile a^* is a myopic-best-response equilibrium in the exogenous version of the model if

$$a_i^* = BR_i^a(a_{-i}^*, \hat{e}), \forall i \in I, \tag{6}$$

where

$$\hat{e}_i = \gamma \pi_i^1(a^*, \hat{e}), \forall i \in I. \tag{7}$$

In Online Appendix A.2, we provide further details. In particular, we show that all equilibria are symmetric in that all cooperators (if exist) spend the same and all defectors have the same expenditure. As a result, no more than $n + 1$ equilibria (with 0, 1,.., or n cooperators, respectively) can exist. Moreover, we provide conditions for the existence of these equilibria. Notably, because γ affects all payoff combinations in the same way, the outcomes do not depend on the actual proportion.

3.2.2 Endogenous power revision

For the model of endogenous power revision, in addition to the decision to cooperate in stage 1, players must decide on the expenditure to spend in the contest for power in stage 2, $e_{i,t} \in [0, \pi_i^1(a_t, e_{t-1})]$. Note, however, the expenditure spent in stage 2 of period t directly affects not only the current payoff, but also the next-period payoff (which also depends on $a_{i,t+1}$). Therefore, to make the analysis manageable, we assume the individual simultaneously chooses the expenditure $e_{i,t}$ in stage 2 of period t and the action $a_{i,t+1}$ in stage 1 of period $t + 1$ to maximize her expected total earnings by best responding to the previous choices (a_t, e_{t-1}). That is, if $a_{-i,t} \cdot e_{-i,t-1} \neq 0$ or $a_{-i,t} = 0$ in stage 2 of period t, player i chooses

$$\begin{aligned}(a_{i,t+1}, e_{i,t}) &= BR_i^{a,e}(a_t, e_{t-1}) \\ &= \underset{a_i \in \{0,1\}, e_i \in [0, \pi_i^1(a_t, e_{t-1})]}{\text{argmax}} \Big\{ -e_i + \delta \pi_i^1((a_i, a_{-i,t}), (e_i, e_{-i,t-1})) \Big\},\end{aligned} \tag{8}$$

where $a_{-i,t} \cdot e_{-i,t-1} = \sum_{j \in I \setminus \{i\}} a_{j,t} e_{j,t-1}$ is the total expenditure of all cooperating players except i, and $\delta \in (0, 1)$ is the probability of continuing the game to the next round (for more details, see Online Appendix A.2).

Definition 2 A strategy profile (a^*, e^*) is a myopic-best-response equilibrium in the endogenous version of the model if

$$(a_i^*, e_i^*) = BR_i^{a,e}(a^*, e^*), \forall i \in I. \tag{9}$$

Proposition 1 *All equilibria in the endogenous version of the model are symmetric, in that all* $n_C^* \in \{0, 1, .., n\} \setminus \{1\}$ *cooperators (if they exist) spend the same* $e_C^* = \delta \left(1 - \frac{1}{n_C^*}\right) \frac{F(n_C^*/n)}{n_C^*}$, *and all* $n - n_C^*$ *defectors (if they exist) have the same expenditure* $e_D^* = 0$.

The conditions for equilibrium existence as well as the proof of Proposition 1 can be found in Online Appendix A.2. In addition, as a corollary, we show that no more than n equilibria (with $n_C^* \in \{0, 1, \ldots, n\} \setminus \{1\}$ cooperators, respectively) can exist.

3.2.3 Endogenous versus exogenous comparison

Figure 2 presents the summary of the theoretical results. The figure shows parameter regions for which a particular symmetric equilibrium (denoted by the number of cooperators) exists. In the figure, we also mark the treatments of the experiment that we run. The main takeaway from the theoretical results is that allowing players to compete for power leads to lower cooperation. The most stark example is that the T4 parameter combination with the endogenous scenario is predicted to have no cooperation, whereas for the same parameter combination in the exogenous scenario, full cooperation (all four players) can be supported in equilibrium. The intuition behind the above result is as follows. First, under the myopic best-response framework, the defectors are not motivated to invest in the competition if they have a choice. However, if they are forced to do so exogenously, they have an extra incentive to switch to cooperation. Second, if the power is revised endogenously, cooperators are motivated to cooperate if their share of the jointly produced resource exceeds individual costs plus individual investments in competition as compared with just their share of the jointly produced resource if power is revised exogenously.

In addition to the theoretical considerations, which show the existing equilibria are symmetric, an additional channel exits that may lead to cooperation breakdown. Namely, subjects in the experiment may have difficulty coordinating on the specific value of expenditure e^*, which will lead to inequality in the division of surplus in the collective-action stage. Because inequality aversion has been shown to be an important factor in a number of settings (e.g., Fehr and Schmidt 1999, 2001, 2004; Fehr et al. 2007; Yang et al. 2016), we expect that this channel will further exacerbate the difference between the EXO and END treatments.

We summarize the above considerations with the following hypothesis:

Hypothesis 2 *Cooperation is lower in endogenous-power-revision treatments than in exogenous-power-revision treatments.*

In addition to the results on cooperation in the collective-action stage, Fig. 3 presents a summary of the theoretical predictions regarding the average equilibrium expenditure in the endogenous version of the model. The figure shows the equilibrium expenditure in the contest for power as the average proportion of the payoff from stage 1, $\overline{e^*/\pi^{1*}} = \frac{1}{n}\sum_{i=1}^{n}\frac{e_i^*}{\pi_i^{1*}}$. The main takeaway is that for the treatments of the experiment that we run, the average proportion of the payoff an individual spends in the contest responds similarly to the fundamental parameters of the collective-action problem as the cooperation described in Hypothesis 1.

3.3 Beliefs, norms, and within-supergame interactions

A distinct feature of our environment is that subjects face payoffs that depend on the political power over the division obtained through a contest. That is, a contest for power introduces additional considerations, such as unequal payoffs and subjective evaluations of what others will or should do given a particular power distribution. To help sort through the myriad of outcomes, we consider beliefs and norms that

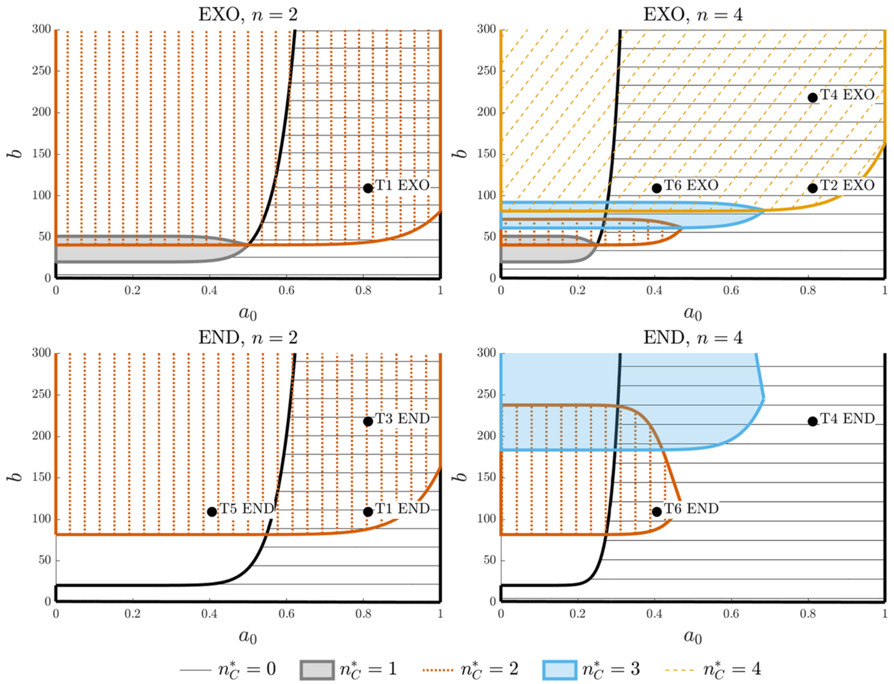
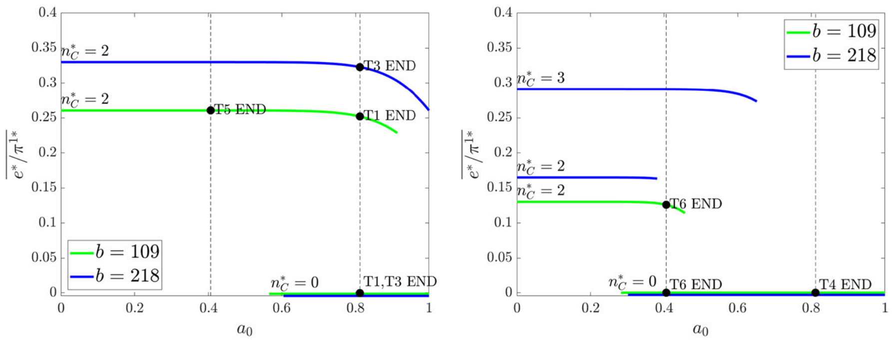


Fig. 2 Myopic-Best-Response Equilibria. *Notes* Shaded regions correspond to symmetric equilibria with $n_C^* \in \{0, .., n\}$ cooperators and $n - n_C^*$ defectors. b denotes the maximum benefit to cooperation. a_0 denotes the proportion of the group that is required to produce $\frac{b}{2}$. • denotes experimental treatments. For example, the T4 EXO treatment supports two symmetric equilibria: (i) full-cooperation, $n_C^* = 4$ cooperators (area shaded with 45-degree dashed orange lines); (ii) full-defection, $n_C^* = 0$ cooperators, (area shaded with horizontal black lines). By contrast, the T4 END treatment supports only one full-defection symmetric equilibrium, $n_C^* = 0$ cooperators



(a) END, $n = 2$ (b) END, $n = 4$

Fig. 3 Contest Expenditures in Equilibrium. *Notes* The figure presents an average proportion of the payoff earned at stage 1 that an individual spends in the contest at stage 2, $\overline{e^*/\pi^{1*}} = \frac{1}{n}\sum_{i=1}^{n} \frac{e_i^*}{\pi_i^{1*}}$. When multiple equilibria exist, all are shown using the same color. For example, three equilibria for the case of $n = 4$ and $b = 218$ are in blue (top blue, middle blue, and bottom blue). • denotes the experimental treatments subjects hold. In particular, we follow Gavrilets (2021) in assuming that the behavioral utility function has four components: expected payoffs given beliefs, conformity with the behavior of others, social norms about appropriateness of behavior, and personal norms about appropriateness of behavior. Next, we elaborate on each component.

A number of experimental studies have found evidence of best responding to beliefs in one-shot coordination games (Harsanyi and Selten 1988; Cooper et al. 1990; Heinemann et al. 2009; Bosworth 2017) as well as in more complicated repeated games (Nyarko and Schotter 2002; Davis et al. 2016; Gill and Rosokha ming; Aoyagi et al. 2020). To capture an individual's tendency to best respond to beliefs, the behavioral utility function will include the expected payoff given the belief about the behavior of others in the group: $\pi_i^1(a_{i,t}, e_{t-1}, \theta_{-i,t}) = \mathbb{E}[\pi_i^1((a_{i,t}, a_{-i,t}), e_{t-1})|\theta_{-i,t}]$.

Although many subjects tend to best respond to the beliefs, previous studies have also found that a substantial fraction fail to do so (Nyarko and Schotter 2002; Costa-Gomes and Weizsäcker 2008; Heinemann et al. 2009). To help explain why subjects may not best respond, we consider three types of norms: (1) descriptive social norms, (2) injunctive social norms, and (3) personal norms.

Following Bicchieri (2005, 2016), we define a *descriptive social norm* as a behavioral rule that individuals are willing to conform with, provided that most people conform to it. That is, descriptive norms are based on the first-order beliefs of what others will do. To operationalize how descriptive social norms enter the utility function, we define $C(a_{i,t}, \theta_{-i,t}) = -\mathbb{E}\big[(a_{i,t} - \bar{a}_{-i,t})^2 \big| \theta_{-i,t}\big]$ as the expected disutility associated with not conforming with the expected actions of others. That is, we need to compare each subject's choice with what they expect others will do, and say that subjects conforms with others if their own actions match their expectations about others.

Following Krupka and Weber (2013), we define *injunctive social norms*, $IN(a_{i,t}, e_{t-1})$, as collective perceptions regarding the appropriateness of action $a_{i,t}$ given a particular power distribution (determined by e_{t-1}). Thus, the injunctive social norms differ from descriptive social norms in that they focus on society's evaluation of the appropriateness of behavior instead of conforming with others.[8] Finally, following Burks and Krupka (2012), we define the *personal norm*, $PN(a_{i,t}, e_{t-1})$, as a individual's own perception of the appropriateness of an action $a_{i,t}$ given a particular power distribution (determined by e_{t-1}). Both social norms and personal norms have been found to be important drivers of individual behaviors and decision-making, including cooperation (Camerer and Fehr 2004; Fehr and Fischbacher 2004a; Fehr and Schurtenberger 2018), prosocial behavior (Bénabou and Tirole 2006; Andreoni and Bernheim 2009; Bénabou et al. 2020), and punishment (Fehr and Gächter 2000; Fehr and Fischbacher 2004b).[9]

[8] To help differentiate between injunctive social norms and descriptive social norms, consider the following scenario from Krupka and Weber (2013). "Suppose you are at a local coffee shop near campus and notice that someone has left a wallet at one of the tables." An injunctive social norm about the "take the wallet" action could be "very socially inappropriate." That is, you believe that most people agree taking the wallet is inappropriate. A descriptive social norm about the "take the wallet" action could be that you believe that someone will take the wallet and therefore you are willing to take it because others would do the same. That is, you do what you expect others to do and not what you expect others think is appropriate.

[9] The literature on the effect of personal and social norms is vast and includes the public-goods game (Fischbacher and Gächter 2010; Kölle and Quercia 2021; Reuben and Riedl 2013), the collective-risk

To summarize, we propose that an individual i makes her decision regarding cooperation in the collective action in round t based on the utility function (for more details, see Online Appendix A.3):

$$\begin{aligned} & u_i(a_{i,t}, e_{t-1}, \theta_{-i,t}) \\ & \quad = \beta_{1,i}\pi_i^1(a_{i,t}, e_{t-1}, \theta_{-i,t}) + \beta_{2,i}C(a_{i,t}, \theta_{-i,t}) + \beta_{3,i}IN(a_{i,t}, e_{t-1}) \\ & \quad\quad + \beta_{4,i}PN(a_{i,t}, e_{t-1}), \end{aligned} \tag{10}$$

and we put forward the following hypothesis:

Hypothesis 3 *Beliefs and norms explain cooperative behavior in the collective-action stage.*

4 Experimental design and administration

To establish that individuals' decision to cooperate and compete responds to the main parameters of the environment, we designed a between-subjects experiment that systematically varies (i) the benefit to full cooperation, b, (ii) the number of subjects in each group, n, and (iii) the proportion of subjects that is required to achieve half of the maximum payoff to cooperation, a_0. To show that the nature of the contest over political power – exogenous versus endogenous – has a substantial impact on cooperation in the collective action, we included treatment pairs for the same parameter combinations. Finally, to understand whether behavioral factors may influence individuals to cooperate in our environment, we elicited beliefs about other group members' choices, personal and social norms, and measures of risk aversion, loss aversion, social preference, and cognitive ability.

4.1 Indefinitely repeated collective action with contest for power

To implement the infinitely repeated interactions in the lab, we follow Roth and Murnighan (1978) with subjects interacting in fixed groups for a random number of decision rounds. In particular, at the end of each decision round, the supergame ends with a 0.1 probability and continues with a 0.9 probability. Thus, on average, each supergame lasts 10 rounds; however the actual realizations vary.[10] At the end of each supergame, subjects are randomly rematched to avoid a long-term reputation effect. Each decision round contains two stages: collective action and the contest for power. Next, we describe each stage in more detail.

social dilemma (Szekely et al. 2021), the dictator game (d'Adda et al. 2020), the common-pool resource game (Tverskoi et al. 2023), Bertrand games (Krupka et al. 2017), trusting games (Krupka et al. 2020), and a set of different games (dictator game, dictator game with tax, ultimatum game, and third-party punishment game) (Bašić and Verrina 2021).

[10] Table D-4 in the Online Appendix presents supergame length sequences used in our experiment. As is typical in the literature on repeated games, we chose to pay participants based on performance in all rounds of all supergames. An alternative approach would have been to implement a last-round payment mechanism (Sherstyuk et al. 2013; Chandrasekhar and Xandri 2023).

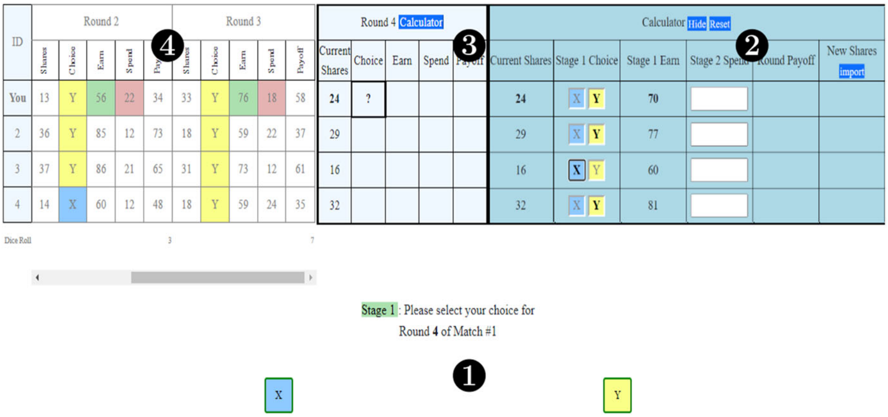


Fig. 4 Stage 1 Interface Screenshot. *Notes* The screenshot shows the decision screen in the T6 END treatment. The neutral action names *X* and *Y* correspond to *D* (defect) and *C* (cooperate). The screenshot shows (1) decision entry, (2) hypothetical payoff calculator, (3) current-round summary with power distribution in the first column (neutral "current shares" was used instead of "power") and a question mark denoting current decision, and (4) scrollable history

4.1.1 Stage 1: Collective-action decision

In stage 1, subjects simultaneously decide whether to cooperate in the production of a collective good. Figure 4 presents the decision screen for stage 1 of the T6 END treatment. Given the complexity of the environment and the dynamic consequences of decisions, we provide a hypothetical calculator (2 in Fig. 4). Using the calculator, subjects could enter a hypothetical scenario and see the resulting payoffs for the round as well as a consequence on the power in the following round.

4.1.2 Stage 2: Contest for power

After all subjects make their stage 1 decisions, the experiment proceeds to stage 2. Figure 5 presents the screenshot of the stage 2 interface for the T6 END treatment. In the END treatment, subjects need to decide how many points to spend in the contest for power. In particular, we use neutral phrases such as "shares" when referring to power (see 2 in Fig. 5). The points they spend in stage 2 cannot exceed their earnings in stage 1. In the EXO treatment, subjects don't have the option to specify how many points to spend. Instead, the screen notifies them that 10% of their stage 1 earnings (rounded to the nearest integer) are spent in stage 2.

The order (whether the contest occurs in stage 1 or 2 within each round) does not affect our main theoretical predictions regarding the long-term outcomes because of the indefinite horizon. Therefore, our choice to start with the collective action in stage 1 was driven by the following three consideration. First, starting with the collective action allows for a clean analysis of round 1 cooperation decisions. Round 1 decisions are important because they indicate the intent to cooperate before any interaction has taken place. Round 1 decisions have been shown to be highly predictive of the subsequent behavior within the repeated-games literature (e.g., Dal Bo and Frechette,

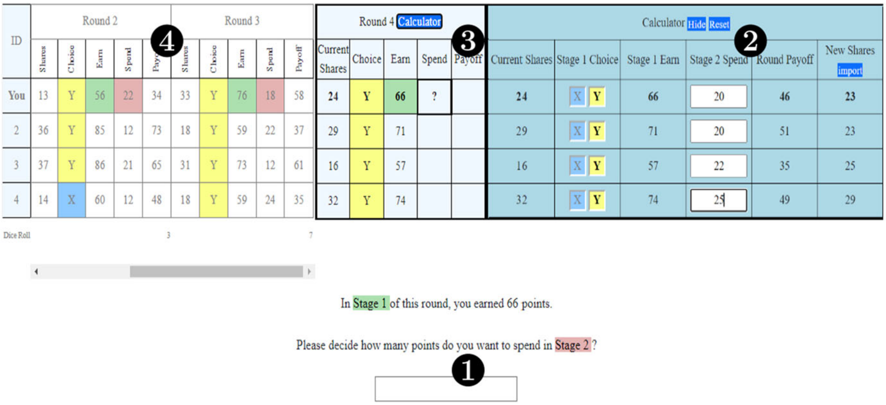


Fig. 5 Stage 2 Interface Screenshot. *Notes* The screenshot shows the decision screen in the T6 END treatment. The neutral action names X and Y correspond to D (defect) and C (cooperate). The screenshot shows (1) stage 2 decision entry (for endogenous case), (2) hypothetical payoff calculator, (3) updated current-round summary with power distribution in the first column (neutral "current shares" was used instead of "power"), stage 1 decisions in the second column, stage 1 earnings in the third column (self stage 1 earn is highlighted with green cell, and a question mark denoting current decision, (4) scrollable history

2018). Second, round 1 coordination games were initialized with equal power and linked to the existing literature on symmetric coordination games (e.g., Dal Bó et al. 2021). Third, our approach eliminates the need to provide endowments for the initial contest, and therefore, all money earned within the experiment comes from decisions in the two stages.

4.2 Elicitation of beliefs, norms, and individual characteristics

In the first and 10th match of the END treatment and in the first, 10th, and 20th match of the EXO treatment, we elicit subjects' beliefs and norms.[11] The belief and norm elicitation is done in every round of a supergame immediately following the stage 1 decision. Specifically, we ask subjects three elicitation questions. The first question uses a binarized scoring rule (Hossain and Okui 2013; Erkal et al. 2020) to elicit subjects' beliefs about other subjects' choices.[12] With the second question,[13] we elicit how appropriate their two actions are on a 4-point Likert scale (1 = inappropriate, 2 = somewhat inappropriate, 3 = somewhat appropriate, and 4 = appropriate). In particular, the aim is to elicit subjects' personal ethical norms, which cannot be financially incen-

[11] As part of the main dataset, we include data from the pilot experiment, which had some variation in the timing and number of elicitations. See Online Appendix B for details.

[12] Following the suggestions from Danz et al. (2021), we provide the full details of the incentive mechanism upon request. Subjects needed to actively click a button to go over the mathematical details.The question about beliefs is worded as "What do you think the chance are that the other participant will choose X or Y?". Conformity is assessed based on the elicited beliefs, with more details in Online Appendix A.3. More details about the instruction and experimental layout can be found in Online Appendix C.2.8.

[13] The personal question is worded as "How appropriate do YOU think your actions in this round are?", as shown in Online Appendix C.2.9. The social norm question is worded as "How socially appropriate will MOST PEOPLE agree your actions are?", as shown in Online Appendix C.2.10.

tivized (as discussed in Young 1998; Bicchieri and Chavez 2010; Burks and Krupka 2012). With the third question, we elicit injunctive social norms by describing the task as a coordination game. We follow Krupka and Weber (2013) in the elicitation structure, except we decided not to incentivize the answers given the time constraints, the complexity of the compensation procedure, and the complexity of the environment.[14] Note that whereas we elicit injunctive social norms directly, we construct a measure of descriptive social norms, termed conformity, using the elicited beliefs as described in Sect. 3.3.

We were concerned that round-by-round belief and norms elicitation may influence the behavior in the experiment; therefore, we ran 13 pilot sessions (6 without elicitation and 7 with elicitation) for three parameter combinations T1, T2, and T6. Comparing subjects' behaviors across these three parameter combinations in Online Appendix B, we find no impact of elicitation on subjects' decision-making. Therefore, we summarize this design check with Remark 1:

Remark 1 Belief and norm elicitation did not impact subjects' decisions to cooperate and compete.

4.3 Elicitation of individual characteristics and demographic variables

Before the main experiment, we ask subjects to complete five individual tasks: (i) risk-aversion elicitation, (ii) loss-aversion elicitation, (iii) elicitation of social preferences for advantageous inequality, (iv) elicitation of social preferences for disadvantageous inequality, and (v) cognitive ability. The first four tasks are organized as multiple price lists following Holt and Laury (2002), Rubin et al. (2018), and Kerschbamer (2015). The fifth task is composed of 11 matrix-reasoning questions (Condon and Revelle 2014). We incentivized subjects' decisions by randomly picking one of the four tasks to pay. If the picked task was a multiple-price-list task, we randomly pick one of the decisions and paid subjects based on their choice. If the cognitive ability task was picked, we paid subjects a flat rate of $4. In Online Appendix C, we provide screenshots with more details for each task.

4.4 Experimental protocol and administration

For the experiment, we recruited 388 subjects and ran 26 sessions at the Vernon Smith Experimental Economics Laboratory at Purdue University between February and April 2022. Table D-5 in the Online Appendix presents a summary of the nine treatments. Each treatment contained at least two sessions and at least 40 participants across sessions. On average, subjects earned $22.16 (including the $5 show-up fee) in our experiment.

Given the complexity of the environment, we took extra steps to ensure subjects understood the interface and the consequences of the cooperation and competition decisions. First, we developed an interactive interface to engage subjects throughout

[14] For example, subjects could face different power distributions after round 1, making having enough people to evaluate the same scenario for each answer infeasible.

the instructions (see Online Appendix C). Second, to facilitate a better understanding of how earnings and new shares are determined in stages 1 and 2, subjects had to go through five examples with step-by-step calculations. To eliminate any bias, we generated the power distribution and the choices at random.[15] Third, subjects had to answer seven comprehension questions. Although the questions were not incentivized, participants could only proceed if the answer was correct. Lastly, throughout the experiment, including the waiting pages, they had access to the payoff calculator.

5 Experimental results

The results section is organized as follows. First, in Sect. 5.1, we focus on the impact of fundamental parameters of the collective-action problem on the decisions of human subjects to cooperate. Next, in Sect. 5.2, we explore the endogenous power revision and how it affects the proclivity to cooperate. Finally, in Sect. 5.3, we estimate a behavioral model that takes into account an individual's beliefs and norms.

5.1 Effect of the parameters of the collective-action problem

Figure 6 presents the average cooperation rate across matches observed in our experiment. The three panels in the figure present the comparison of treatments based on n, b, and a_0, respectively. In particular, to make the comparison easier, we use the same color for a pair of treatments that have the same parameters other than the varied parameters. For example, treatments T1 EXO and T2 EXO in the left panel are presented in the same color (green) to indicate that all parameters with the exception of the number of participants are the same. The solid line with solid circles corresponding to T1 EXO is clearly higher than the dashed line with empty triangles corresponding to T2 EXO, indicating the strong negative impact of increasing the number of players in the group.

The raw data in Fig. 6 suggest subjects respond to the game parameters as the theory predicts.[16] These results are confirmed by random-effects regressions presented in Table 3. In particular, the regressions show that the effects are highly significant whether we focus on round 1 or all rounds, and whether we control for preferences and demographics.[17] We summarize results on the role of parameters with Result 1.

Result 1 *Hypothesis 1 is supported: the decision to cooperate in the collective-action stage responds to the fundamental parameters:*

(a) *Cooperation is increasing in the maximum benefit to cooperation (b),*

[15] For stage 1, subjects see five randomly generated power distributions and random choices made by each subject. They then see how their earnings in stage 1 are calculated step by step. For stage 2, in the END treatment, they see randomly generated spending, whereas in the EXO treatment, they see how the randomly generated choices from stage 1 determine the spending in stage 2.

[16] Summary statistics of average cooperation rate across treatments are reported in Table D-6 of Online Appendix D.

[17] In Table D-7 of Online Appendix D, we provide a full set of estimates including preferences and demographics.

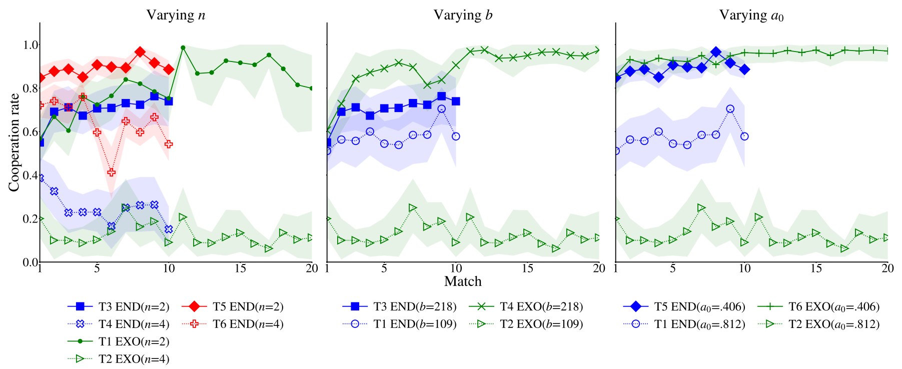


Fig. 6 Impact of Fundamental Parameters on Cooperation. *Notes* The cooperation rate is the fraction of rounds in which an individual cooperated in a match. From left to right, the three panels show the impact of varying n, b, and a_0. In each panel, colors indicate pairs of treatments to be compared. For each pair, a solid line with filled markers indicates the treatment with greater cooperation. The shaded areas show the 90% bootstrapped confidence interval, treating a group in a match as one observation unit

(b) *Cooperation is decreasing in the group size* (n),
(c) *Cooperation is decreasing in the proportion of the group* (a_0) *required to achieve half of the maximum benefit to cooperation.*

A notable observation is that round 1 cooperation rates in T1 and T3 treatments are comparable to previous one-shot stag-hunt experiments that employed similar stage-game payoffs. For example, in a game with the same payoffs as T1 for three out of four action profiles, Dal Bó et al. (2021) report an average cooperation rate of 78.57%, whereas the average cooperation rate is 79.2% in T1 EXO and 67.6% in T1 END treatments, respectively. In addition to the similar levels of cooperation, the upward trend across matches is present in both instances. Moreover, Dal Bó et al. (2021) find that increasing the size of the basin of attraction of stag (which is equivalent to the $SizeBC$) increases the prevalence of cooperation. In our experiment, such an increase corresponds to the comparison of T1 to T3. Our data are consistent with their finding because the average cooperation rate increases from 67.6 % in T1 END to 72% in T3 END (p-value < 0.01).

5.2 Endogenous power revision

In this section, we focus on the impact of contests for power on individuals' decisions to cooperate in the collective-action problem. In particular, we compare the END treatments with the EXO treatments and show that cooperation indeed decreases in the endogenous-power-revision treatment, as the theory in Sect. 3.2 predicts. Recall, in a symmetric equilibrium, we expect the cooperation to be higher in EXO treatments because exogenously restricted spending provides additional motivation for defectors to switch to cooperation. In addition, off equilibrium, coordination difficulties, and power inequality are substantially smaller in the EXO than in the END treatment. We then take a closer look at the END treatment to see how well the theory predicts the

Table 3 Cooperation in Stage 1

	All rounds			Round 1		
	(1)	(2)	(3)	(4)	(5)	(6)
Greater n (n=4)	−0.47***	−0.33***	−0.33***	−0.38***	−0.30***	−0.31***
	(0.07)	(0.07)	(0.07)	(0.08)	(0.07)	(0.06)
Greater b (b=218)	0.45***	0.41***	0.41***	0.36***	0.26***	0.27***
	(0.11)	(0.10)	(0.10)	(0.11)	(0.08)	(0.08)
Greater a0 (a0 = 0.812)	−0.65***	−0.52***	−0.53***	−0.61***	−0.40***	−0.40***
	(0.09)	(0.09)	(0.09)	(0.11)	(0.08)	(0.08)
Choose effort (endogenous)	−0.44***	−0.31***	−0.31***	−0.22***	−0.20***	−0.20***
	(0.08)	(0.08)	(0.08)	(0.08)	(0.07)	(0.06)
Power Inequality		−0.35***	−0.35***			
		(0.05)	(0.05)			
My power (%)		0.36***	0.36***			
		(0.06)	(0.06)			

Table 3 continued

	All rounds			Round 1		
	(1)	(2)	(3)	(4)	(5)	(6)
Own R1 coop in Match 1		0.14***	0.13***		0.28***	0.27***
		(0.03)	(0.03)		(0.03)	(0.03)
Others' R1 coop in Match t-1		0.04***	0.04***		0.14***	0.14***
		(0.01)	(0.01)		(0.02)	(0.02)
(Length of Match t-1) / 100		0.12*	0.12*		0.07	0.07
		(0.06)	(0.06)		(0.07)	(0.07)
Constant	1.41***	1.00***	1.11***	1.32***	0.90***	1.09***
	(0.08)	(0.09)	(0.13)	(0.09)	(0.09)	(0.14)
Observations	42,392	39,912	39,912	5,088	4,700	4,700
Number of subjects	388	388	388	388	388	388
Preferences	No	No	Yes	No	No	Yes
Demographics	No	No	Yes	No	No	Yes

The table reports results from random-effects regressions using data across all nine treatments. The dependent variable is 1 if subjects chose "Y"(cooperation) in stage 1, and 0 otherwise. Preference measures include risk aversion, loss aversion, other-regarding preference in disadvantageous and advantageous inequality, and cognitive ability. Demographics include age, gender, major, and subjects' high school location (US or not). Standard errors are clustered at the session level. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

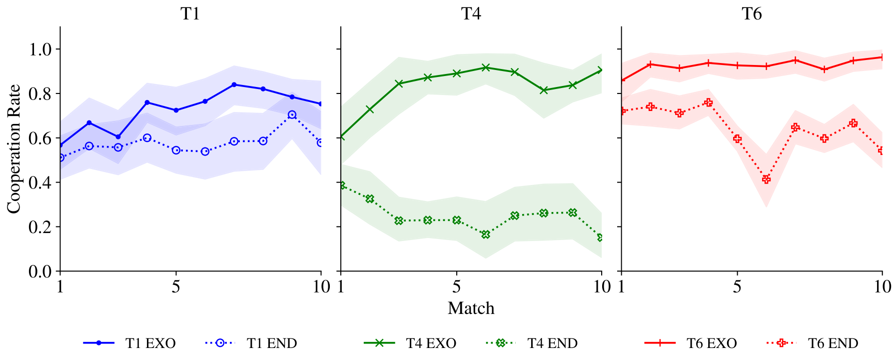


Fig. 7 Impact of Endogenous Power Revision on Cooperation. *Notes* The figure presents the average cooperation rate for all rounds over 10 matches. Each panel contains one treatment pair of EXO and END treatments. For each pair, a solid (dotted) line indicates the EXO (END) treatment. The shaded areas show 90% bootstrapping confidence intervals, treating a group in a match as one observation unit

competition in the contest for power. In addition, we note several observations regarding the interplay between cooperation in the collective-action stage and competition in the contest for power.

Figure 7 presents the average cooperation rate for the three pairs of treatments that isolate the impact of the contest for power in stage 2. In particular, across the three pairs, consistent with the theoretical predictions derived in Sect. 3.2, EXO treatments have significantly higher cooperation rates. The regressions presented in Table 3 confirm the strong significance of these results.

Result 2 *Hypothesis 2 is supported: cooperation in the collective-action stage is significantly lower when subjects compete in the contest for power.*

Figure 8 presents the average cooperation rate in the stage 1 collective-action problem (left panel) and the average spending rate in the stage 2 contest for power (right panel) across the five END treatments of our experiment. The ranking of cooperation rates among the two-player settings (T1, T3, and T5) and four-player settings (T4 and T6) are as the theory in Sect. 3.1 predicted. Regarding the spending in the contest for power, the highest proportion spent is in the T5 treatment, followed by T3, T6, T1, and lastly T4. Generally, these results are consistent with the theoretical predictions discussed in Sect. 3.2. In particular, Fig. 3 shows that T5 was unambiguously predicted to have higher proportions of spending than T1, T6, and T4, all of which held. The theoretical comparison of T5 and T3 is less clear because of the multiplicity of equilibria in the T3 case (with one equilibrium higher and one lower than T5).

Although the theory had accurate comparative-static predictions, the actual level and the symmetry rarely hit the mark. In particular, our theoretical predictions based on myopic best-response generated symmetric equilibria with all cooperators spending the same amount in the contest and all defectors spending zero. In the experiment, we see a considerable degree of heterogeneity within cooperators as well as expenditures by the defectors. For example, Table 4 shows a regression of subjects' spending in stage 2 on metrics capturing the state of the game in a round. Negative trends across matches

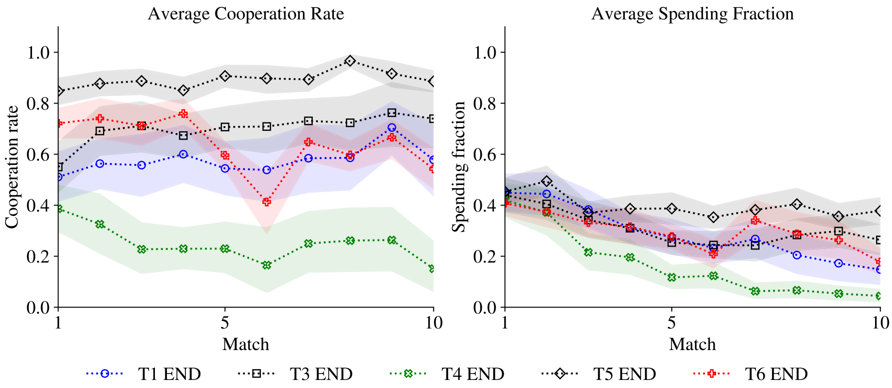


Fig. 8 Cooperation and Spending across END Treatments. *Notes* The figure presents the average cooperation rate and spending fraction for all rounds over 10 matches for the five END treatments. In each figure, different marker symbols indicate different treatments. The shaded areas show the 90% bootstrapping confidence interval, treating a group in a match as one observation unit

and increased expenditures based on the payoff from stage 1 confirm observations from Fig. 8. More interestingly, however, are results that are not directly observable from the raw data. In particular, the strong negative impact of power inequality indicates that we observe more competition in the contest when the powers are close but unequal.[18]

5.3 Beliefs and norms

In this section, we focus on the individual's beliefs and norms that were elicited as part of our experiment to help explain cooperative (and non-cooperative) behavior by the human participants. Specifically, our goal is to understand whether and to what extent our measures of beliefs and norms can predict an individual's choice to cooperate given that a certain situation has been reached.

The descriptive statistics of beliefs, personal norms, and injunctive norms are presented in Tables D-10, D-11, and D-12 of the Online Appendix. In particular, we find that beliefs and norms respond to the environmental parameters (b, n, a_0) as well as to the nature of the power-revision contests (endogenous vs. exogenous) similarly to the cooperation decision (see Tables D-15 and D-16 in the Online Appendix). In addition, we find that the round-by-round beliefs are relatively accurate, with the average accuracy rate of 78.2% across the whole experiment and a minimum accuracy rate of 49.4% that was observed in the T3 END treatment.[19] Finally, we find an average best-response rate of 77.8% in match 1 and an average best-response rate of 88.0% in match 10.[20] Thus, best responding is relatively prevalent.

18 Note the interpretation of the "My Power" term is not straightforward, because the "Power Inequality" term contains the linear "My Power" term as well. The 'Power Inequality' is constructed as standardized power variance, $\frac{\sum_{i=1}^{n}(p_i - \frac{1}{n})^2}{V_{max}}$, where $V_{max} = 0.5$ when $n = 2$, and $V_{max} = 0.75$ when $n = 4$.

19 Summary statistics of average belief deviations can be found in Table D-13 of the Online Appendix.

20 Summary statistics of best response rate can be found in Table D-14 of the Online Appendix.

Table 4 Spending in Stage 2

	All		Defectors Only		Cooperators Only	
	(1)	(2)	(3)	(4)	(5)	(6)
Money at Hand	0.18***	0.18***			0.16***	0.18***
	(0.04)	(0.04)			(0.03)	(0.03)
Power Inequality		−0.06***		−0.03***		−0.09***
		(0.01)		(0.01)		(0.02)
My power (%)		−0.05*		0.03*		−0.10***
		(0.03)		(0.01)		(0.03)
Match number		−1.53***		−1.25***		−1.58***
		(0.36)		(0.31)		(0.50)
Length of Match t-1		−0.13*		−0.09		−0.13**
		(0.08)		(0.08)		(0.07)
Constant	7.05**	21.83**	14.55***	19.00**	11.70***	24.45*
	(3.48)	(11.07)	(2.15)	(8.23)	(2.80)	(13.06)
Observations	16,104	14,664	6,590	6,005	9,514	8,659
Number of subjects	216	216	212	207	212	210
Preferences	No	Yes	No	Yes	No	Yes
Demographics	No	Yes	No	Yes	No	Yes

Notes: The table reports results from random-effects regressions using data from the five END treatments. The dependent variable is the stage 2 spending. Columns (1)-(2) show estimates based on all individuals. Columns (3)-(4) show individuals who choose to defect in the current round. Columns (5)-(6) show individuals who choose to cooperate in the current round. Power inequality is calculated as the group variance over the maximal variance a group can obtain (when $n = 2$, the maximal variance is 0.5; when $n = 4$, the maximal variance is 0.75). In both cases, the maximal variance happens when one person has 100% power and the rest have 0%). Preferences include risk aversion, loss aversion, other-regarding preference in disadvantageous and advantageous inequality, and cognitive ability. Demographics include age, gender, major, and the subjects' high school location. The full set of results are presented in Table D-8 of the Online Appendix. Standard errors in parentheses are clustered at the session level. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

Table 5 Effects of Beliefs and Norms on Cooperation

	(1)	(2)	(3)	(4)	(5)	(6)	R^2-dec
Intercept	0.57**	0.58***	0.51	0.54*	0.11	1.51**	–
	(0.26)	(0.20)	(0.34)	(0.30)	(0.14)	(0.64)	
Expected payoffs	0.12***	–	–	–	0.06***	0.06***	0.32
	(0.01)				(0.01)	(0.01)	
Conformity	–	2.79***	–	–	1.49***	1.49***	0.22
		(0.15)			(0.19)	(0.19)	
Injunctive norms	–	–	1.37***	–	0.19*	0.21**	0.15
			(0.09)		(0.10)	(0.10)	
Personal norms	–	–	–	1.67***	1.24***	1.25***	0.31
				(0.10)	(0.11)	(0.11)	
Preferences	No	No	No	No	No	Yes	–
Demographics	No	No	No	No	No	Yes	–
Observations	8100	8100	8100	8100	8100	8100	–
AIC	4979	5434	5697	5126	4116	4122	–
BIC	5014	5469	5732	5161	4235	4297	–
marginal R^2_{Nak}	0.49	0.36	0.29	0.45	0.64	0.64	–
conditional R^2_{Nak}	0.86	0.73	0.78	0.82	0.88	0.88	–

Notes: The table reports results from the mixed-effects logistic regression using data from matches 1, 10, and 20 (if available) across all treatments. The dependent variable is a dummy variable $a_{i,t}$ indicating whether a subject i in round t chooses to cooperate. To capture heterogeneity among individuals, we assume random intercepts and random slopes (slopes vary among individuals). To capture the session-level effects, we assume that an intercept varies among sessions and among participants of the sessions. The marginal Nacagawa's R-squared shows a proportion of the variance explained by fixed effects, whereas the conditional Nacagawa's R-squared shows a proportion of the variance explained by both, fixed and random effects. The last column shows the results of the hierarchical partitioning of the marginal Nacagawa's R-squared. Preferences include risk aversion, loss aversion, other-regarding preference in disadvantageous and advantageous inequality, and cognitive ability. Demographics include age, gender, major, and the subjects' high school location. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

Although approximately 40% of subjects always best responded to their beliefs in every round of match 1 and approximately 50% of subjects always best responded to their beliefs in match 10, a significant proportion of subjects best responded at a much lower rate. For example, approximately 50% of participants in Match 1 and 25% of participants in Match 10 best responded in less than 80% of the rounds they faced (see Figure D-3 in the Online Appendix for the full distribution). To help explain why human subjects may not best respond all the time, we estimate a behavioral model that incorporates normative factors into the random-utility framework. In particular, we estimate model 10 using a logistic mixed-effects regression.[21] The results are presented in Table 5.

[21] We performer mixed-effects regression analysis using R 3.6.6. We use the "performance" package to compute pseudo R-squared metrics (Lüdecke et al. 2021), the "lme4" package for the mixed-model estimation (Bates et al. 2015), the "DHARMa" package for the residuals diagnostics (Hartig and Hartig 2017), and the "glmm.hp" package for hierarchical partitioning to calculate the individual contributions of each predictor to marginal R-squared (Lai et al. 2022).

Results of the regression analysis show that the expected payoffs ($p < 0.01$), personal norms ($p < 0.01$), and conformity with perceived actions of others ($p < 0.01$) are associated with individual decisions to cooperate. The effect of injunctive norms ($p = 0.06$) is less salient. The less important effect of injunctive norms is well in line with the previous research (Tverskoi et al. 2023). A possible explanation is that individuals did not know each other, and were randomly reshuffled every match. In addition, we found that the expected payoffs and personal norms have the highest contributions to the marginal R-squared among all the predictors, whereas the contribution of conformity is higher than that of the injunctive norms. We summarize the role of beliefs and norms with Result 3.

Result 3 *Hypothesis 3 is supported: beliefs and norms explain cooperative behavior in the collective-action stage.*

We perform several diagnostics of our model and robustness checks of the results. In particular, the share of the variance explained by fixed effects is 0.64 (marginal R-squared), whereas the share of the variance explained by both fixed and random effects is 0.88 (conditional R-squared) indicating a good overall fit. The variance inflation scores range from 1.16 to 1.56, indicating that we did not detect multicollinearity. In addition, the Kolmogorov-Smirnov test ($p = 0.45$) and bootstrap outlier test ($p = 0.32$) indicate no evidence of an incorrect specification of the model. Regarding the robustness of results, we check various regression models (e.g., linear, logistic) and various assumptions on the correlation structure (see Tables D-17 and D-18 in the Online Appendix). We find that our main conclusions on the strong significant effects of the three variables (expected payoffs, conformity, and personal norms) and their contributions toward the R-squared hold. We also check results when splitting the endogenous and exogenous treatments. The results support our conclusions on the significance of expected payoffs, conformity, and personal norms. The difference between the treatments is that expected payoffs contribute more, whereas conformity and injunctive norms contribute less to the marginal R-squared in the endogenous treatments than in the exogenous treatments (see Table D-19 in the Online Appendix).

6 Conclusion

In this paper, we study a model of cooperation and competition in which players split the benefits of cooperation according to the political power obtained in a contest. Our main contributions are threefold. First, we provide a theoretical foundation based on the framework of myopic best-response to show that the contest for power introduces additional considerations that decrease cooperation of the players in the cooperation stage. Second, we design and conduct an experiment to test our theoretical predictions. Finally, we estimate a behavioral model of cooperation in which a decision is based on subjective beliefs and norms regarding the appropriateness of behavior in a particular situation.

Our experimental results show that human subjects predictably respond to the main parameters of the collective-action problem. For example, an increase in the benefit to cooperation results in a greater frequency of subjects cooperating, as well as greater expenditures in the contest for power. The most novel result of the paper, however, is the comparison of the endogenous and exogenous contest for power. Specifically, in the exogenous contest, we restrict players to contribute a fixed proportion of earnings from the collective-action problem, whereas in the exogenous case, they are free to choose the amount of their contribution. We find both the theory and experiments are consistent in that players significantly reduce cooperation in the collective action when the contest is not restricted. These results provide insight into the design of institutions in which cooperation is desired, but that also include a competitive stage (e.g., elections).

From the data obtained in the experiment, we estimate a behavioral model based on beliefs and norms elicited from human subjects (Gavrilets 2021; Tverskoi et al. 2021; Houle et al. 2022; Tverskoi et al. 2022). We find that beliefs matter in two ways. First, they matter as a determinant of the expected payoffs of available actions. Thus, choosing actions with higher expected payoffs captures best-responding behaviors. Second, they matter as a measure of descriptive social norms. These norms allow us to specify a measure of conformity. In our estimation exercise, we find that expected payoffs account for 32% of the explained variance in cooperation. The remaining variance is due to personal norms (31%), conformity (22%), and injunctive social norms (15%). Overall, our results show that understanding human cooperation is hardly possible without accounting for the effects of inequality in power, conformity, and norms (Gavrilets 2015, Houle et al. 2022).

Our study opens a number of interesting avenues for future research. First, we focused on societies composed of individual decision-makers. In the real world, political power is often held by groups or factions. Thus, studying whether groups would act differently would be interesting (e.g., Cooper and Kagel 2005). Second, given the complexity of the experiment and some of the elicitation procedures, we did not elicit beliefs in every interaction. Understanding the evolution of beliefs both within and across interactions (e.g., Szekely et al. 2021) would be important. To this end, adding elicitations throughout the experiment and in the contest stage would be interesting. Third, the contest for power introduced the second layer of coordination. Future research can investigate the degree to which coordination in the contest could be increased through various institutions and communication mechanisms (e.g., Aoyagi 2005) and whether this would lead to greater cooperation in the collective action. Finally, many real-world collective-action problems are subject to unexpected shocks (e.g., flood impact on the public infrastructure); therefore, establishing the degree to which such uncertainties affect the outcomes of collective-action problems would be interesting.

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