Morally Monotonic Choice in Public Good Games*

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Abstract. Consequentialist rational choice theory, including models of (unconditional) social preferences, is challenged by decades of robust data from *payoff-equivalent* public good games with provision or appropriation as well as by robust data showing contributions to public goods, funded by lump-sum taxation, do *not* crowd out voluntary contributions on a one-for-one basis. This paper offers an extension of rational choice theory that incorporates *observable* moral reference points. This morally monotonic choice theory is consistent with robust data in the literature and has idiosyncratic features that motivate new experimental designs that introduce nonbinding quotas on appropriations or floors on provisions. Data, from three previous experiments and our new experiment, favor moral monotonicity over alternative theoretical models including rational choice theory, prominent belief-based models of kindness, and popular reference-dependent models with loss aversion.

JEL Classifications: C91, D03, H41

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1. Introduction

Theory and behavior for private provision of public goods is a central topic in economics. Despite extensive research on modeling behavior in public good games,[1] two robust experimental findings have continued to be anomalous to theory. They are: (a) public good games with provision elicit higher allocations to the public account than *payoff-equivalent* public good games with appropriation[2] and (b) contributions to public goods, funded by lump-sum taxation, do *not* crowd out voluntary contributions on a *one-for-one* basis[3].

Consequentialist rational choice theory[4] including (unconditional) social preferences

[1] For reviews of experimental studies see the early work by Ledyard (1995) and the selective survey by Chaudhuri (2011). Our Text Appendix 1 provides another selective survey.
[2] See Andreoni (1995) and the large literature surveyed in Text Appendix 1.
[3] See, for examples: Abrams and Schmitz (1978, 1984); Clotfelter (1985); Kingma (1989); Andreoni (1993); Bolton and Katok (1998); Khanna and Sandler (2000); and Ribar and Wilhelm (2002). For incomplete crowding out with distortionary taxes see Bernheim (1986).
[4] By "rational choice theory" we mean the general model of consequentialist rational choice (e.g., Samuelson 1938; Chernoff 1954; Arrow 1959; Sen, 1971, 1986, 1993) and its prominent special cases including conventional preference

models, can account for limited free-riding behavior and other stylized facts in public good games (Ledyard 1995; Cox and Sadiraj 2007). But such models also predict: (i) *absence* of (provision vs. appropriation) game-form effect in payoff-equivalent games; and (ii) *presence* of one-for-one crowding out of voluntary contributions by tax-financed contributions or quotas. Both predictions (i) and (ii) are at odds with robust data (see references in footnotes 2 and 3).

What about popular alternative theories? A prominent belief-based model of kindness/reciprocity (Dufwenberg and Kirchsteiger 2004), applied to quotas or lump-sum-tax-financed contributions, makes the data-inconsistent prediction of crowding out of voluntary contributions on a *higher* than one-for-one basis. Implications of reference-dependent models with loss aversion (e.g. Tversky and Kahneman 1991; Kőszegi and Rabin 2006) depend on specification of the reference point. If the reference point is conditional on others' allocations then the prediction is that the provision game elicits *smaller* allocations to the public account than the appropriation game, the opposite of the robust empirical pattern.[5]

In this paper we present morally monotonic choice theory[6] that extends the fundamental axiom of rationality, the consistency property (Arrow 1959), by advancing the idea of choice monotonicity with respect to *observable* moral reference points. In tests of empirical validity, we use data from previous experimental studies (Andreoni 1995, Reuben and Riedle 2013, Khadjavi and Lange 2015) and a new experiment. The new experiment includes payoff-equivalent game forms with contributions or extractions or both and elicits first-order beliefs in addition to choices. A central feature of the design is implementation of endogenous contractions of feasible sets that discriminate between morally monotonic choice and existing alternative theories. The contractions implemented in the new experiment take the simple form of non-binding lower bounds on permissible allocations to the public account.[7] The paper makes several contributions. First, we offer a choice theory that agrees with conventional rational choice theory when the moral reference point is preserved but monotonically diverges otherwise. We demonstrate existence of a reference-

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theory (e.g., Hicks 1946; Samuelson 1947; Debreu 1959; textbooks), revealed preference theory (e.g., Afriat 1967; Varian 1982; textbooks) and (unconditional) social preferences models (e.g., Fehr and Schmidt 1999; Bolton and Ockenfels 2000; Andreoni and Miller, 2002; Cox and Sadiraj 2007). Of course, rational choice is *not* equivalent to its special case of self-regarding or *homo economicus* choice.

[5] These and other implications of these models are explained in sections 2 and 3.

[6] See Cox, List, Price, Sadiraj, and Samek (2019) for applications to dictator games (non-strategic environments).

[7] A lower bound is non-binding if it is smaller than observed allocation choices of both players in the full game as well as their reported beliefs about the other's choice.

dependent choice function for this moral monotonicity theory that can be used in applied work. Second, we propose *observable* moral reference points that incorporate two features of the environment: (game) initial endowments and (set-conditional) minimal expectations payoffs (Roth 1977). Third, we show that moral monotonicity theory can explain the two challenging patterns: provision vs. appropriation game form effects; and absence of one-for-one crowding by minimum required provision. Fourth, we use data from three previous experimental studies to inform on empirical validity of moral monotonicity of choices. Fifth, we report a new experiment with three game forms and non-binding contractions of feasible sets that discriminate between implications of morally monotonic choice and alternative theories including conventional rational choice theory, a prominent belief-based model (Dufwenberg and Kirchsteiger 2004), and popular reference-dependent models of loss aversion (Tversky and Kahneman 1991; Kőszegi and Rabin 2006).

2. Theories of Choice and Their Implications for Allocations

Theory of play in *n*-player strategic games depends on models of individual decision making. In this section we report on conventional rational choice, two alternative models (belief-based kindness and reference-dependent with loss aversion) and a new model, morally monotonic choice. Popular models of (consequentialist) social preferences belong to conventional rational choice theory because they are characterized by utility functions defined over final (monetary) payoffs that provide complete and transitive orderings in the payoff space. Such models can explain cooperation and other stylized facts in linear public good games (Cox and Sadiraj 2007) but they fail to capture data patterns such as (provision vs. appropriation) game form effects and absence of one-for-one crowding out of contributions by lump-sum-tax-financed provision. Moral monotonicity aims at dealing with this deficiency.

We report the divergent testable implications for contractions of feasible sets of conventional rational choice theory (section 2.1) and morally monotonic choice theory (section 2.2). We illustrate the implication of conventional rationality (Example 1), moral monotonicity (Examples 2.b and 3.b), as well as two alternative models: belief-based model of kindness

(Example 2.a), and reference-dependent model of loss aversion (Example 3.a) for allocations in two-player public good games (as in our new experiment).[8]

It is useful for clarity in discussion to use the word "token" to refer to discrete units of the scarce resource, that can be transferred between private accounts and the public account, because this resource has different dollar values in the two types of accounts. It is also useful to distinguish between the "action space" in which tokens can be transferred and the "payoff space" which reports the payoff implications of final token allocations to public and private accounts. Throughout the paper, "feasible set" refers to a set of available n-vectors of payoffs whereas "choice set" refers to the n-vectors of payoffs an agent chooses from the feasible set by allocating tokens in the action space.[9] The domain of feasible sets consists of all nonempty finite sets of payoffs in $\mathbb{R}^n$, and choice sets are nonempty.

2.1 Conventional Choice Theory

The fundamental axiom of rationality is the Consistency property. It is equivalent to existence of a complete and transitive order (Arrow, 1959; Sen 1971, 1986) for finite sets. Let T and S denote two nonempty finite feasible sets in $\mathbb{R}^n$. Let $T^* \subseteq T$ and $S^* \subseteq S$ denote an agent's (non-empty) choice sets, that is, the sets of elements chosen from T and S. Rational choice theory (Arrow 1959) states that choice sets satisfy[10]

Consistency. For all feasible sets $T \subseteq S$: $S^* \cap T \neq \emptyset \;\Rightarrow\; T^* = S^* \cap T$

In words, the Consistency property states that if some chosen element from the larger set, S is available in the smaller set, T (that is, the intersection of S^* and T is not empty) then the choice set, T^* contains all elements of S^* that are available in T and no others.

Example 1 provides an illustration. Section 3.1 of the paper provides general implications of the Consistency property (in the payoff space) for allocations in our public good games.

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[8] The scarce resource in our experiment consists of 10 tokens that can be allocated between private and public accounts, with each token worth \$1 in the private account and \$1.5 in the public account that is equally shared (i.e., the marginal per capita return (mpcr) is 0.75).

[9] In the provision game, with endowments of 10 tokens in each private account, if the other player contributes 5 then my *feasible* set, in (own payoff, other's payoff)-space, is $X = \{(10 - x + .75(5 + x), 10 - 5 + .75(5 + x)) : x \in \{0, \cdots, 10\}\}$. If I contribute 7 to the public account then my *choice* set is the singleton $X^* = \{(12,14)\}$. Generally, an agent's choice set may not be a singleton; for simplicity, in all examples in this section we work with singleton choice sets.

[10] See also Samuelson 1938; Chernoff 1954; Sen 1993.

Example 1. Consider a two-player provision game, as in our experiment (described above, and in more detail in section 5).

Full game. Permissible contributions are from $\{0,1,\cdots,10\}$. Suppose that player 2 contributes 8 (or player 1 believes so) to the public account. In this case, player 1's feasible set, *S* in the payoff space is

$$S = \{\pi(g_1 \mid 8) = (10 - g_1 + .75g_1 + .75(8), 10 - 8 + .75g_1 + .75(8)) : g_1 \in \{0,1,\cdots,10\}\}.$$

When player 1 contributes 8 to the public account, she reveals that the vector of payoffs (14,14) from *S*, is in her (assumed-to-be-singleton) choice set, $S^* = \{(14, 14)\}$.

Contraction game. Suppose, in the contraction game, the smallest permissible contribution is 8; that is, each player's contributions must be selected from $\{8,9,10\}$. Now, when player 2 contributes 8 (or player 1 believes so), player 1's feasible set in the payoff space contracts to

$$T = \{\pi(g_1 \mid 8) = (10 - g_1 + .75(g_1 + 8), 10 - 8 + .75(g_1 + 8)) : g_1 \in \{8,9,10\}\}$$

which is a subset of *S* that contains (14,14); hence, $S^* \cap T \neq \varnothing$. What can we say about player 1's choice in *T*? Consistency requires, $T^* = S^* \cap T = \{(14,14)\}$. In this way, if player 2 contributes 8, player 1 also contributes 8 in the contraction game. This example may be transparent; it is stated here to illustrate a direct application of the Consistency property (no need for any special case utility specification) and to provide a basis of comparison with Examples 2 and 3, where we look at alternative models.

2.2 Moral Monotonicity Theory

As in subsection 2.1, let *T* and *S* be two nonempty finite feasible sets in $\mathbb{R}^n$. Let t^z and s^z denote moral reference points for sets *T* and *S*, from the perspective of agent *z*. Reference points may depend on features of the decision environment such as the status quo (Tversky and Kahneman 1991), disagreement point (Nash 1953), or disagreement and minimal expectations payoffs (Roth 1977), or maximal payoffs (Kalai and Smorodinsky 1975), or, the equitable payoff (the average of the minimum and maximum payoffs) as in belief-based kindness (Rabin 1993; Dufwenberg and Kirchsteiger 2004). In section 3, we will propose reference points dependent on the initial endowed payoffs (at the beginning of the game) and (set-conditional) minimal expectation payoffs. In this section, we are agnostic about the specific identification of the reference point. We do postulate how choices of payoffs respond to changes in reference points by proposing two basic properties: M-Consistency and M-Monotonicity.

An intuition about these properties can be conveyed by considering a special case of singleton (one-element) choice sets, two agents, and two-dimensional reference points. Begin with agent 1. Let t^* and s^*, respectively, denote agent 1's choices from feasible sets T and S in $\Re^2$. Suppose T is a subset of S that contains the choice s^* from S. Let t^1 and s^1 be the reference points from agent 1's perspective for sets T and S. M-Consistency has the same implication as Consistency when T and S have the same reference point: $t^1 = s^1$. More generally, M-Consistency and Consistency have the same implication for choice by agent 1 when the difference between reference points for the two sets does not favor either agent: $t_1^1 - s_1^1 = t_2^1 - s_2^1 = 0$. [11] Analogous statements hold for the reference points and choices of agent 2.

The implications of moral monotonicity theory diverge from conventional rational choice theory when the change between reference points favors one of the agents. We continue with a special case example. Let T and S contain the same elements: $T = S$. For the special case, M-Monotonicity states that, compared to the choice from S, agent 1's choice from T will favor agent 1 (resp. agent 2), if $t_1^1 - s_1^1 > 0 = t_2^1 - s_2^1$ (resp. $t_1^1 - s_1^1 = 0 < t_2^1 - s_2^1$). Analogous statements hold for the reference points and choices of agent 2. In this way, choice points are assumed to monotonically track reference points.

Writing the formal statements that define the theory will require some additional notation: $N = \{1, \cdots, n\}$ denotes the set of players; (X, x^z) denotes the "feasible problem" of agent z where $X \subset \Re^n$ is a nonempty finite set in the payoff space, and the moral reference point is $x^z = \{x_i^z \in \Re^m : i \in N\}$ [12]; $X^*(x^z) \subseteq X$ denotes the nonempty choice set of agent z; $X_i^*(x^z) \subset \Re$ denotes the set of payoffs that agent z's choice set $X^*(x^z) \subset \Re^n$ allocates to agent $i \in N$; $\delta_i(t^z, s^z) = \sum_{j=1..m} (t_{ij}^z - s_{ij}^z), i \in N$ denotes agent i's total change for reference points t^z and s^z;

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[11] If the moral reference point has four dimensions (i.e., two dimensions for each player), then $t^1, s^1 \in \Re^4$ and the expression is $(t_{11}^1 - s_{11}^1) + (t_{12}^1 - s_{12}^1) = 0 = (t_{21}^1 - s_{21}^1) + (t_{22}^1 - s_{22}^1)$.

[12] Here, the moral reference point has m dimensions per player. If it has only one dimension per player, as in the special case in the paragraph above, then $m = 1$.

$K = \{k \in N : \delta_k(t,s) = \max_{i \in N} \delta_i(t^z, s^z) > 0\}$, is the set of players most favored by t^z over s^z; $\triangleright$ denotes a partial order of feasible sets on $\mathbb{R}$ defined as: for all $Z, Y \subset \mathbb{R}$, $Z \triangleright Y$ means $\min(Z) \geq \min(Y)$ and $\max(Z) \geq \max(Y)$.

The M-Consistency property is a modification of the conventional Consistency property to incorporate reference points.

M-Consistency. For all feasible problems (T, t^z) and (S, s^z) such that $T \subseteq S$, and $\delta_{i \in N}(t^z, s^z) = 0$:

$$S^*(s^z) \cap T \neq \varnothing \;\Rightarrow\; T^*(t^z) = S^*(s^z) \cap T$$

In words, M-Consistency says that if for all agents from *N* the total change from reference point t^z to reference point s^z is 0 then choice sets satisfy the conventional Consistency property. A special case includes sets having the same reference point, $t^z = s^z$.

The M-Monotonicity property postulates choice monotonic response to changes in reference point when the feasible set does not change.

M-Monotonicity. For all feasible problems (T, t^z) and (S, s^z) if $T = S, K \neq \varnothing$ and $\delta_{i \notin K}(t^z, s^z) = 0$ then there exists a nonempty set of agents $K^* \subseteq K$ such that

$$T_k^*(t^z) \triangleright S_k^*(s^z) \text{ for all } k \in K^*;\; z \in K^* \;\; if \;\; K = N$$

This property states that agent *z*'s choice set becomes more favorable for some of the agents who are most favored by moral reference point t^z over s^z; meaning agent *z*'s smallest and largest payoffs chosen for such agents are both (weakly) larger in choice set $T^*(t^z)$ than in choice set $S^*(s^z)$. Furthermore, if the moral reference point becomes equally more favorable for all players (i.e., *K* = *N*) then player *z*'s choice in *T* must favor oneself.

M-Consistency postulates what happens to payoff choices when the feasible set contracts while preserving the moral reference point whereas M-Monotonicity postulates what happens to choices when moral reference point changes but the feasible set remains the same. The first inquiry relates to implications of moral monotonicity for choice sets when both the feasible set contracts and the moral reference point changes. Our first result (Proposition 1 below) provides an answer. A second immediate question concerns existence of a reference-dependent choice function that satisfies M-Consistency and M-Monotonicity (Proposition 2 below provides an answer.)

Scenario A. Consider an agent *z* who faces two feasible problems, (S, s^z) and (T, t^z) such that: (1) *T* is a subset of *S*, $T \subseteq S$; (2) the choice set, S^* of *S* and the feasible set *T* intersect, i.e., there exists $s^* \in S^*(s^z) \cap T$.

Proposition 1. Refer to Scenario A. If $\delta_{-k}(t^z, s^z) = 0$, and $\delta_k(t^z, s^z) \neq 0$ for some agent *k*, then there exists $t^* \in T^*(t^z)$ such that $(t_k^* - s_k^*)\delta_k(t^z, s^z) \geq 0$.

Proof: See Online Appendix O.1.

Proposition 1 says that the pattern of agent *z's* payoff choices follows the pattern of changes in moral reference point. So, if t^z is more favorable to agent *k* than s^z then some choice by agent z in problem (T, t^z) leaves agent *k* with larger payoff than *k* gets from s^*. The opposite happens if t^z is less favorable to agent *k*. A straightforward corollary for the special case of Pareto-efficient singleton choice sets and n = 2 is:

Corollary 1. Refer to Scenario A and suppose that choice sets are from $\Re^2$, singleton and Pareto efficient. If $\delta_{-k}(t,s) < 0 < \delta_k(t,s)$ then $t_{-k}^* - s_{-k}^* \leq 0 \leq t_k^* - s_k^*$.

The corollary states that if the change in moral reference point favors *k* (one of the two players) and disfavors the other, then agent z will choose a larger payoff for agent *k* (and a smaller one for the other).

Our next result, on existence of a choice function is stated in Proposition 2.

Proposition 2. There exists a reference-dependent choice function that satisfies M-Consistency and M-Monotonicity.

Proof. See Online Appendix O.1.

The proof uses choice function, $U(\pi \mid r)$ defined over payoff vectors, $\pi \in \Re^n$ for a given reference point, $r \in \Re^{mn}$, written (without any loss of generality) for agent 1 as

$$U(\pi \mid r)=\sum_{k=1}^{n} w_k(r)u(\pi_k) \text{ with weights } w_k(r)=\theta(\sigma_k \sum_{j=1}^{m} r_{kj})/\sum_{i=1}^{n}\theta(\sigma_i \sum_{j=1}^{m} r_{ij}),\ \sigma_1>1=\sigma_{k>1},$$

for some increasing concave function, $u(\cdot)$ and increasing function, $\theta(\cdot)$ such that $\theta(y+z)=\theta(y)\theta(z)$. An idiosyncratic feature of the choice function is that the reference points are in the $w_k(\cdot)$ weights rather than the $u(\cdot)$ values. Parametric special cases of the choice function are tractable for applications.[13]

2.3 Examples Illustrating Differences Between Three Alternatives to Rational Choice Theory

The following two examples offer a preview of general implications of alternative models to conventional rationality by comparing implications of moral monotonicity to implications of a belief-based model of kindness and a model of reference-dependence with loss aversion. We apply moral monotonicity using reference points *from the other models* so as to make clear that differences between models do not come solely from different definitions of reference points.[14]

Example 2. *Contraction and two alternative models to conventional rationality*. We refer to Example 1 (Contraction game) and ask: what are the implications of the belief-based model of kindness or moral monotonicity? To answer these questions, we need to know how contraction affects the reference point. We here use equitable payoff as the reference point (Dufwenberg and Kirschteiger 2004) and illustrate that for contraction the prediction of the belief-based model of kindness for allocations is the opposite of the prediction of moral monotonicity.

a. *Belief-based model of kindness*. In our linear public good (Example 1) game, the kindest action a player can adopt is to allocate 10 and the least kind is to allocate the minimum permissible level, *c*. The reference point, the average maximum and minimum payoffs, is reached at contributions of 5 in the full game (c=0) and 9 in the contraction game (c = 8). If player 1 believes player 2 contributes 8 (first order-belief), then player 2 is perceived to be kind in the full game (8

[13] In Text Appendix 4, we apply a parametric special case of $U(\cdot)$ − where the weights $w_k(\cdot)$ are normalized natural exponential functions of the moral reference point − to data from two previous experiments (Andreoni 1995; Khadjavi and Lange 2015) and data from a new experiment reported herein.

[14] We will explain our specification of moral reference point in Section 3.

> 5) but unkind in the contraction game (8 < 9), and therefore player 1 contributes less in the contraction game than in the full game.[15]

b. *Moral Monotonicity*. Use the same definition of reference point, but assume that player 1's choice sets satisfy M-Consistency and M-Monotonicity. At player 2's contribution of 8, the reference point − the average of the maximum and minimum payoffs − in sets *S* and *T* (as in Example 1) are: $s = (14.75, 11.75)$ corresponding to player 1's allocation of 5 (average of 10 and 0) and $t = (13.75, 14.75)$ corresponding to player 1's allocation of 9 (average of 10 and 8). Compared to *s*, reference point *t* is more favorable to player 2 (but not to player 1). Moral monotonicity (Corollary 1)[16] requires player 1 to leave player 2 with a larger payoff in the game with contraction, which player 1 can do by contributing more than 8 (the contribution in the full game), which is the opposite prediction of the belief-based model of kindness.

Example 3. *Game form effect and two alternative models to conventional rationality*. What are implications of reference-dependence with loss aversion (Tversky and Kahneman 1991, Koszegi and Rabin 2006) and moral monotonicity for allocations in provision and appropriation games? Again, to answer the question we first need to specify the reference point. In this example, let the reference point be the "status quo" payoffs when no player alters the initial position (that is, contributes nothing in the provision game and appropriates nothing in the appropriation game.) So, the reference points in the provision and appropriation game are given by the endowments, $s^p = (10,10)$ and $s^a = (15,15)$. Using this definition of reference point in both models, we illustrate how the two models' predictions differ.

a. *Reference dependence with loss aversion*. Assume that player 1's preferences are defined over final payoffs (utility of consumption) and changes from the reference point. When player 2 allocates 8 to the public account (i.e., contributes 8 in the provision game, or appropriates 2 in the appropriation game), the feasible set of player 1 is *S* (as in example 1) in both games. In the provision game, set *S* is in the gain domain (i.e., both players' payoffs are larger than 10) for all

[15] Let b_2 and c_1 denote player 1's first- and second- order beliefs. For the Dufwenberg and Kirschteiger (2004) model, player 1's utility in the full game is $\pi_1(g_1, b_2) + Y\gamma^2(g_1 - 5)(b_2 - 5)$, and $\pi_1(g_1, b_2) + Y\gamma^2(g_1 - 9)(b_2 - 9)$ in the contraction game with contribution low bound of 8, where $\gamma = .75$ and g_1 is player 1's contribution. A player 1 with sensitivity parameter, $Y > 0.15$, first-order belief, b_2=8 (and any second order belief) is a full contributor (g_1=10) in the full game but a "free rider" (g_1=8) in the contraction game.

[16] Corollary 1 applies, as all points from sets T and S are Pareto efficient, so will be in the choice sets.

player 1's allocations larger than 2. Suppose that player 1 allocates 3 in the provision game, resulting in payoffs (15.25, 10.25). [17] In the appropriation game, compared to (15,15), when player 1 allocates 3 to the public account (i.e., appropriates 7) she experiences a gain of 0.25 in own payoff dimension but a loss of 4.75 in other's payoff dimension. A loss-averse, reference-dependent player 1 would prefer contributing 4 (over 3) as she gives up (0.25) gain in one dimension to reduce the loss in the other's dimension by three times as much (0.75). Hence, when player 2 allocates 8, our player 1's allocation in the appropriation game is larger than 3, the allocation in the provision game.

b. *Moral Monotonicity*. Assume that player 1's choice sets satisfy M-Consistency and M-Monotonicity. Comparing $s^p = (10,10)$ and $s^a = (15,15)$, we see that both players are favored by the reference point in the appropriation game, that is, they both belong to set *K*. So by M-Monotonicity, player 1's choice leaves herself with a larger payoff in the appropriation game, which player 1 can do by allocating less to the public account in the appropriation game. Hence, when player 2 allocates 8, moral monotonicity predicts that the appropriation game will elicit *smaller* allocation from player 1 than in the provision game, which is opposite of the prediction of the reference-dependence with loss aversion model.

3. Play in Provision, Appropriation, and Mixed Games

Here we derive implications for (best response) *allocations* of tokens in the public account in two-player, payoff-equivalent provision, appropriation and mixed games with and without restrictions on chosen allocations. The discussion will be informal and for two-player games. Formal arguments for *n*-player games for conventional rational choice and morally monotonic choice are reported in Text Appendix 2 and online appendices.

In linear public good game, each player , *i* chooses how much, g_i of an amount W of a

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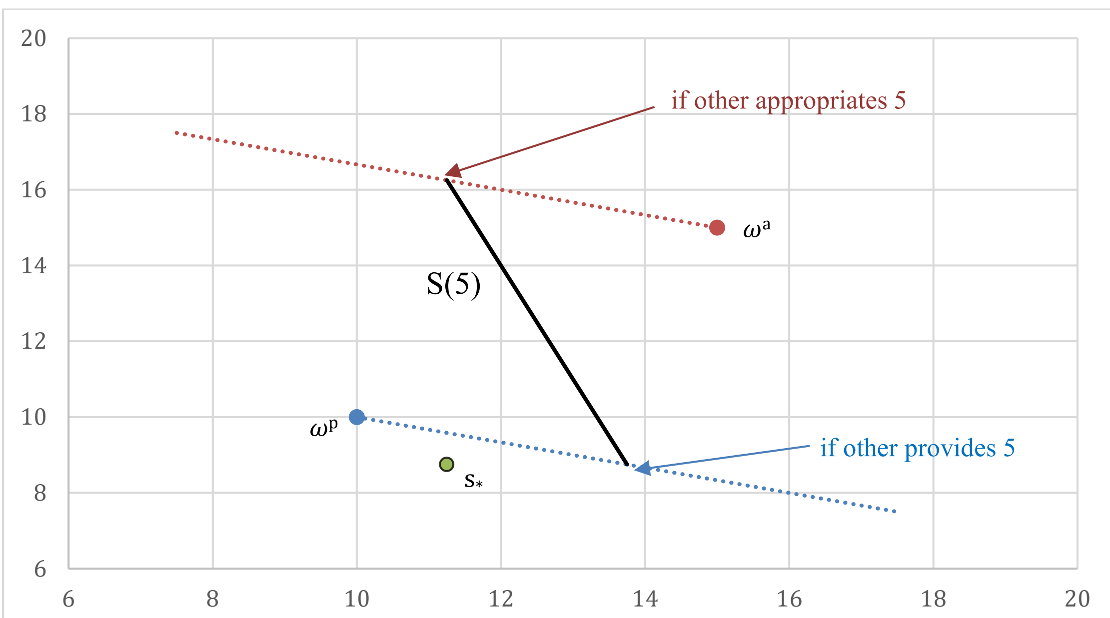
[17] Assume additively separable preferences, with utility of consumption $v(\pi) = \sum u_i(\pi_i)$, and for each dimension *i*, gain/loss utility is $(\pi_i - r_i)$ for gains, and $\lambda(\pi_i - r_i)$ for losses (i.e. $\lambda > 1$). A player 1 that allocates 3 in the provision game, reveals (*) $(v_1+1)(\gamma-1)+(v_2+1)\gamma = 0.25(-v_1+3v_2+2) = 0$. In the appropriation game, her marginal utility at allocation 3, is $(v_1+1)(\gamma-1)+(v_2+\lambda)\gamma = 0.25(-v_1+3v_2+3\lambda-1) = 0.25(3\lambda-3) > 0$ where the second equality follows form (*) and the inequality follows from loss aversion, $\lambda > 1$. Hence, player 1's allocation in the appropriation game must be larger than in the provision game.

scarce resource to allocate to a public account shared with others. Let $\gamma \in (0.5,1)$ denote the marginal per capita rate of return from the public account. When the other's allocation to the public account is g_{-i}, player *i*'s money payoff, π_i is the sum of returns from the private account, $w_i = W - g_i$ and the public account, $\gamma(g_i + g_{-i})$.

The initial *per capita* endowment of tokens, $g^e \in [0, W]$ in the public account uniquely identifies the g^e-game. Special cases include: provision game $(g^e = 0)$, where a public good can be provided; appropriation game $(g^e = W)$, where a public good can be appropriated; and mixed games $(g^e \in (0, W))$, where both provision and appropriation of a public good are feasible.

Without any loss of generality we focus on player 1. Player 2's allocation of tokens, g_2 to the public account determines the feasible set, $S(g_2)$ of player 1 (in the money payoff space).

Figure 1. Player 1's Feasible Set in Payoff Space



Notes: Player 1 and player 2 payoffs are on the horizontal and vertical axes in a two-player public good game with mpcr of 0.75 and per capita token endowment $W = 10$. In the provision game, the token endowment is 0 in the public account and 10 in each private account, so each player's endowed payoff is 10, shown by ω^p. In the appropriation game, the token endowment is 20 in the public account and 0 in each private account, so each player's endowed payoff is 15, as shown by ω^a. Discrete points on the dotted "lines" correspond to player 2's possible allocations in provision (lower blue dotted "line") and appropriation (upper orange dotted "line") games. If player 2 "appropriates 5" in appropriation, or "provides 5" in provision, then player 1's feasible set in the payoff space is (the set of discrete points on) the solid (black) line, *S*(5).

For a concrete illustration, consider the two-player public good game in our experiment (described in section 5) with parameterization $W = 10$ and $\gamma = 0.75$. If player 2 allocates 5 tokens to the public account, player 1's feasible set in payoff space, $S(5)$ consists of discrete points on the solid line in Figure 1. Note that set $S(5)$ is the same whether the initial per capita allocation, g^e is 10 (as in the appropriation game) or 0 (as in the provision game). Suppose player 1's desired final allocation in $S(5)$ is, say, 13 for oneself and 11 for the other; that is, (13,11) is from player 1's choice set, $S^*(5)$. Player 1 can implement it by allocating, $g_1^*(5) = 3$ to the public account, which corresponds to contributing 3 in the provision $(g^e = 0)$ game or extracting 7 in the appropriation $(g^e = 10)$ game or appropriating 5 in the mixed $(g^e = 8)$ game. Thus, if player 1 cares only about monetary payoff for player 2 and herself then she allocates 3 to the public account in any of these g^e-games to realize the desired (13,11) payoffs. This takes us to our first generalized observation in section 3.1.

<u>*3.1 Implications of Conventional Rational Choice Theory*</u>

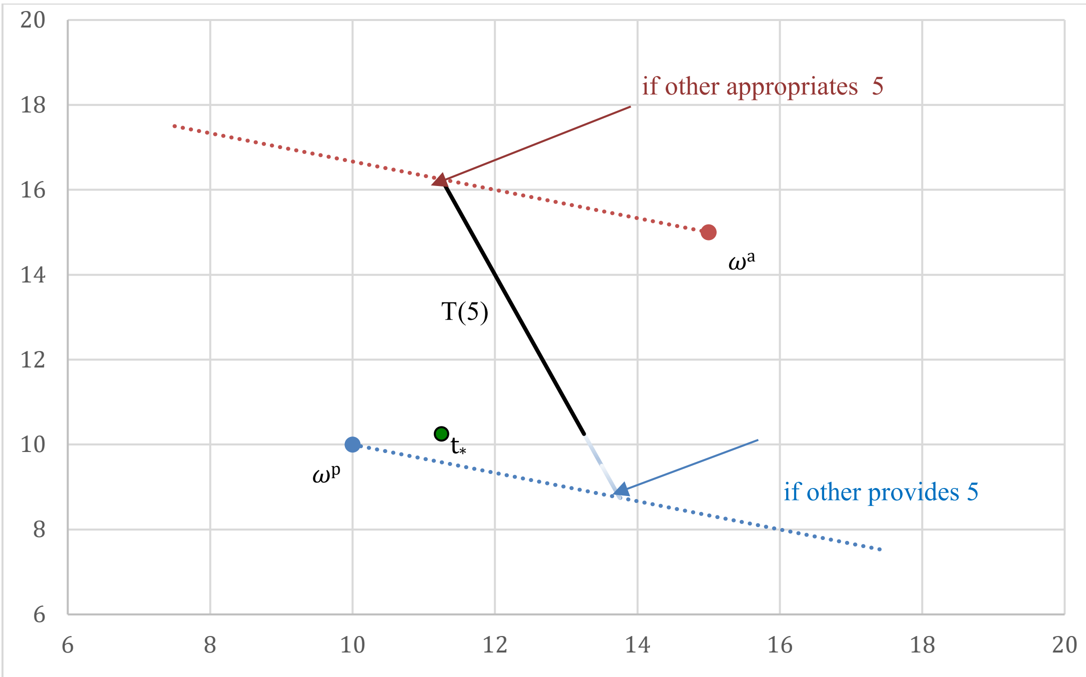
The first observation is that the Consistency property in the payoff space requires that player *i*'s (best response) allocations, $S^*(g_{-i})$ are not affected by initial (the endowed per capita) allocation, g^e in the public account (see Online Appendix O.2) because the feasible set in the payoff space, $S(g_{-i})$ remains the same for all g^e. This illustrates why, for any given vector of allocations of others, g_{-i} , player *i*'s set of best response allocations, $W^*(g_{-i} \mid g^e)$ is the same regardless of whether the per capita initial allocation to the public account g^e is 0 (provision game) or W (appropriation game) or some amount in $(0, W)$ as in mixed games.

A second observation (see Online Appendix O.2) is that the Consistency property in the payoff space implies that player *i*'s set of best response allocations, $W^*(g_{-i} \mid g^e)$ remains the same if, instead of $B = \{0, \cdots, W\}$, player *i* faces some subset, [18] C that contains all choice allocations of both players. We call these C subsets "nonbinding contractions". In our example, a low bound

[18] In a provision game, a required minimum contribution, $c > 0$, produces a contraction. Government contribution to a public good financed by lump sum taxation is one way of implementing such a contraction. In an appropriation game, a contraction corresponds to a quota on maximum extraction, $t > 0$. The two types of contractions are payoff equivalent when $c = W - t$.

of 2 on allocations to the public account is a non-binding contraction C because it contains the other's allocation 5 as well as player 1's allocation 3 (her best response to 5).

Figure 2. Player 1's Contracted Feasible Set in Payoff Space



Notes: Notation is the same as reported in the note below Figure 1. When a quota of 8 in the appropriation game or a required minimum contribution of 2 in the provision game is introduced, and the other's allocation is 5, then the feasible set includes discrete points on the solid line $T(5)$, which is a subset of $S(5)$ in Figure 1.

In the payoff space, the feasible set, $T(5)$ for this (contraction) game is shown in Figure 2. If player 2 allocates 5 to the public account in the full game, player 1's feasible set (in the payoff space) is $S(5)$. In the contracted game, allocations are constrained to C={2,3,…,10}, mapping to $T(5)$ in the payoff space, which is a subset of $S(5)$ that contains the pair of payoffs (13, 11). Consistency then requires (13,11) to be in the choice set, $T^*(5)$. The implication in terms of allocations to the public account is $C^*(5\,|\,g^e) = W^*(5\,|\,g^e)$.

Implications of the two observations are summarized in the following proposition (see Online Appendix O.2 for a formal derivation). [19]

[19] Note that if the lower bound, c is binding then by construction individual allocations are weakly increasing in c. For example, c=2 (as in our illustration) is binding for player 1 if she chooses to allocate 1 in the public account absent contraction, but cannot contribute less than 2 in the contraction game.

Proposition 3. If choice sets in the payoff space satisfy the Consistency property then for any given g^e-game and vector of others' allocations g_{-i}:

a. $C^*(g_{-i} \mid g^e) = W^*(g_{-i} \mid g^e),$ for all nonbinding[20] contractions C

b. $W^*(g_{-i} \mid g^e) = W^*(g_{-i} \mid 0)$, for all initial allocations $g^e \in [0, W]$

Proposition 3 says that, for any given vector of allocations to the public account by others, agent *i*'s (best response) allocations to the public account are invariant to: (a) non-binding contractions of the feasible set; and (b) provision, appropriation, or mixed game form.

A straightforward implication, is that if g^* is an equilibrium in the provision game, it is also an equilibrium in all g^e-games as well as for all non-binding contracted games. Two much-studied theoretical properties are among the applications of Proposition 3. A (non-binding) contraction of the feasible set can be implemented by imposition of a lump sum tax in amount $\tau = c$ and use of the tax revenue to finance the public good. Part a implies invariance of the *total* allocation to the public good: voluntary allocations in amount τ are crowded out one-for-one by this public policy. Among interpretations of Part b is another much-studied theoretical property of invariance of allocations to game form (provision or appropriation or mixed) in payoff-equivalent games. Summarizing:

Corollary 2. Conventional rational choice theory implies:

a. One-for-one crowding out of voluntary contributions by (nonbinding) lump-sum-tax-financed contributions to a public good;

b. Equal allocations to a public good in provision, appropriation, and mixed games that are payoff equivalent.

3.2. Implications of Models of Belief-based Kindness and Reference Dependence with Loss Aversion

Reference dependent models build on the assumption that material payoff is not the only motivator of individual choice. Payoffs exceeding (or falling short) of equitable payoffs matter in the belief-

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[20] Here $C = \{c, \cdots, W\}, c > 0$ is non-binding if $0 < c < \min(g_i^b, \min(g_{-i}))$ where g_i^b is the smallest best response allocation choice of player *i*.

based kindness (reciprocity) model whereas gains or losses from a reference point matter in the models of loss aversion. We here look at predictions of these two alternative models for behavior in our two-player linear public good games.

3.2.1 Belief-based Kindness

Player 1's utility (Dufwenberg and Kirchsteiger 2004) at allocation, g_1 and first- and second-order beliefs, $g_{\tilde{2}}$ and $g_{\tilde{\tilde{1}}}$, is[21]

$$U(g_1, g_{\tilde{2}}, g_{\tilde{\tilde{1}}}) = u(\pi_1(g_1, g_{\tilde{2}})) + Y\kappa(g_1, g_{\tilde{2}})\lambda(g_{\tilde{2}}, g_{\tilde{\tilde{1}}})$$

where $\pi_1 = W - g_1 + \gamma(g_1 + g_{\tilde{2}})$, the utility of own material payoff, $u(\cdot)$ is linear, $Y > 0$ is the individual's sensitivity parameter, (un)kindness of player 1 towards player 2 is $\kappa(g_1, g_{\tilde{2}}) = \pi_2(g_{\tilde{2}}, g_1) - \pi_2^e(g_{\tilde{2}})$ and player 1's belief about player 2's (un)kindness towards her is $\lambda(g_{\tilde{2}}, g_{\tilde{\tilde{1}}}) = \pi_1(g_{\tilde{\tilde{1}}}, g_{\tilde{2}}) - \pi_1^e(g_{\tilde{\tilde{1}}})$ where $\pi_i^e(\cdot)$ is player *i*'s equitable payoff. It is straightforward to verify the following statements (see Online Appendix O.3).

Observations For our linear public good games:

1. The equitable payoff, $\pi^e(\cdot)$ corresponds to allocation, $g^c = (W + c)/2$
2. Second-order beliefs are irrelevant for kindness functions as well as for the utility
3. For linear $u(\cdot)$, optimal allocations are either the minimum permissible allocation or, depending on the sensitivity parameter, switch to the maximum permissible level at some threshold level of first-order belief larger than $(W+c)/2$. Contraction has a positive effect on the threshold, hence a negative effect on allocations.
4. For nonlinear $u\cdot$ of material payoff, if $g_{\tilde{2}} > (W + c)/2$ then optimal (interior) allocation increases in (first-order belief) other's allocation and decreases in minimum permissible contribution, *c*.

The intuition for the first observation follows from the largest allocation, *W* leading to the maximum payoff, and the smallest allocation, the least permissible level, *c*, resulting in the minimum payoff, for any beliefs. Together with linearity of monetary payoffs in allocations, they

[21] We have dropped subscripts on Y, κ and λ to simplify notation.

imply that equitable payoff (while differing across beliefs) is always reached at allocation (W+c)/2. So, an allocation larger than (W+c)/2 is as kind in the provision game as it is in the appropriation game. Thus, for any given first-order belief, the best-response allocation is invariant across game forms.

For non-binding contractions, a low bound on permissible contributions increases the threshold, (W+c)/2 for contributions to be considered "kind", which thereby has a predicted negative effect of contractions on contributions to the public good. For example, in the full game (in our experiment) the average maximum and minimum payoffs correspond to contributing 5. In a contraction game, with 4 as a low bound on allocations, the average maximum and minimum payoffs correspond to contributing 7. Player 2 contributing 6 is kind in the full game but it is unkind in the contraction game. So, a player 1 who is motivated by "kindness" of player 2, allocates more than 4 (as contraction is not binding) in the full game but she goes for 4, the minimum permissible allocation, in the contraction game.

3.2.2 Reference Dependence with Loss Aversion Choice

Following the literature (Tversky and Kahneman 1991; Koszegi and Rabin 2006) we assume additive separability across dimensions and a linear gain-loss utility specification. The implications are derived (see Online Appendix O.4 for details) for two potential reference points of set $S(g_{-i})$: (1) "g_{-i} conditional status quo" − the vector of payoffs conditional on other players' allocations when player i contemplates her choice; and (2) "unconditional status quo" − the vector of initial payoffs at the beginning of the game (before any player makes a choice).

Specification 1: g_{-1} conditional reference point. In the provision game the reference point corresponds to initial allocation 0, which is $r^p = (W + \gamma g_2, W - g_2 + \gamma g_2)$. In the appropriation game, the reference point corresponds to initial allocation W, which is $r^a = (\gamma W + \gamma g_2, W - g_2 + \gamma W + \gamma g_2)$. In Figure 1, the reference point of $S(5)$ in the provision game is the most southeast point, (13.75, 8.75) whereas in the appropriation game is the most northwest point, (11.25, 16.25). If (13,11) (i.e., allocate 3 to the public account) maximizes utility of consumption, then the choice in the appropriation game will be northwest of (13,11) (i.e., allocate more than 3) because r^a is northwest whereas in the provision game it will be southeast of (11,13) (i.e., allocate less than 3) because r^p is southeast of (13,11). This is also true generally (see

Online Appendix O.4). An implication of reference dependent choice with loss aversion is smaller (best-response) allocations to the public account in provision than appropriation game.

In case of non-binding floors, at any given g_2 player 1's reference point in the appropriation game corresponds to allocation *W*, is not affected by non-binding contractions; so there is no contraction effect in appropriation game. In the provision game, depending on internalization of the floor, the reference point either remains r^p, (and so no effect on choice) or it moves northwest, to $r^p + (\gamma - 1, \gamma)c$. For a visualization, in Figure 1 the reference points in the full and contraction provision game are the most southeast points in *S*(5) and *T*(5). For non-binding contractions, the chosen point in the full game is in the loss-gain domain (i.e., first player loss, second player gain) with respect to either reference point. This together with the gain-loss utility being additively separable, imply that the chosen point in the contraction game is the same as in the full game. The prediction of reference dependent choice with loss aversion is that non-binding low bounds on allocations have no effect on (best-response) allocations with the conditional reference point.

Specification 2: initial endowed payoffs reference point. Here, the reference points in provision and appropriation games are initial endowed payoffs, (W, W) and $(2\gamma W, 2\gamma W)$. In Figure 1, $r^p = (10,10)$ and $r^a = (15,15)$. The non-binding contractions have no effect on either reference point, so a null effect on best-response allocations is predicted. The game-form effect, however, is ambiguous (see Online Appendix O.4).

Summarizing, we have the following implications for reference dependence with loss aversion models (see Online Appendix 4):

a. Non-binding contractions have no effect on choices.
b. Depending on the choice of reference point, either the appropriation game elicits larger contributions than the provision game or the effect is ambiguous.

3.3 Implications of Moral Monotonicity

We first identify moral reference points and subsequently use M-Consistency and M-Monotonicity to derive implications of moral monotonicity.

3.3.1 Moral Reference Points in g^e-games

It seems promising for the moral reference point to incorporate two intuitions into theory of choice: my ethical constraints on interacting with others may depend on (a) endowed (or initial) payoffs in the game and (b) conditional on others' choices, the payoffs one can receive when the others' payoffs are maximized (a.k.a. "minimal expectation payoffs). Intuition (a) reflects the idea that larger endowed payoffs entitle one to larger payoffs from playing the game. This initial position (or "property right") effect captures an important consideration in everyday life when one is faced by decisions in a strategic interaction with others: what are our payoffs before we and they make decisions that change them? Intuition (b) reflects the idea that (conditional) larger minimum payoffs, corresponding to most generous outcomes for others, entitle one to larger payoffs. This captures a second important feature of strategic decisions: within the environment of our interaction, what is the least each of us can logically expect from playing the game? This captures one's intuition that ideas of socially desired outcomes are dependent on the environment of a strategic interaction, not absolutes independent of the environment.

Without any loss of generality, we focus on player 1's moral reference point.[22] Any given allocation, g_2 to the public account by player 2 determines player 1's feasible set (in payoff space). In a g^e-game, the initial endowed payoff of each player is

(1) $\omega^e = W - g^e + \gamma(g^e + g^e)$

The minimal expectation payoff, 2_* of player 2 is when player 1 allocates the minimum required amount, c to the public account:

(2) $2_* = W - g_2 + \gamma(g_2 + c)$

So, from the perspective of player 1, the moral reference point with respect to player 2 is the ordered pair from (1) and (2):

(3) $r_2^1 = (\omega^e, 2_*) = (W - g^e + 2\gamma g^e, W - g_2 + \gamma g_2 + \gamma c)$

The minimal expectation payoff, 1_* of player 1 is when player 1 allocates all her W units of resource to the public account:

(4) $1_* = \gamma(W + g_2)$

[22] Separate detailed explanations of moral reference points in provision, appropriation, and mixed games with contraction ($c > 0$) or without contraction ($c = 0$) can be found in Text Appendix 2 and Online Appendix O.5.A.

So, from the perspective of player 1, the moral reference point with respect to oneself is

(5) $r_1^1 = (\omega^e, 1_*) = (W - g^e + 2\gamma g^e, \gamma W + \gamma g_2)$

Table 1 shows observable moral reference points *from the perspectives of both players* in the special case of a two-player g^e-game.

Table 1. Moral Reference Points in a Two-Player g^e - Game

	Player 1 Perspective at $T(g_2)$	Player 2 Perspective at $T(g_1)$
Player 1 Dimensions	$(\omega^e, \gamma W + \gamma g_2)$	$(\omega^e, W - g_1 + \gamma g_1 + \gamma c)$
Player 2 Dimensions	$(\omega^e, W - g_2 + \gamma g_2 + \gamma c)$	$(\omega^e, \gamma W + \gamma g_1)$

Notes: W is total amount of resource, γ is the mpcr, g_i is player i's allocation to the public account, $c = 0$ when there is no contraction, $\omega^e = W - g^e + 2\gamma g^e$ is the endowed payoff in the two-player g^e-game.

Using a specific example, Figures 1 and 2 show the locations of minimal expectations payoffs, labeled s_*, t_*, and initial endowed payoffs for provision and appropriation games labeled, respectively, as ω^p and ω^a. Table 1a reports the moral reference points *from the perspective of player 1* as ordered pairs. The first coordinates are initial endowed payoffs whereas the second coordinates correspond to minimal expectation payoffs. In the left column (provision game), the initial endowed payoff of each player is 10 whereas the minimal expectation payoffs are: 11.25 for player 1 (when she adopts the most generous action of contributing 10), and 8.75 for player 2 (when player 1 adopts the most greedy action of contributing 0).[23] In the appropriation game (middle column), the initial endowed payoff of each player is 15,[24] whereas the minimal expectation payoffs (second coordinates) remain the same as

Table 1a. Illustration of Moral Reference Points (from the perspective of player 1)

Game	Provision (Fig.1) $S(g_2 = 5 \mid g^e = 0, c = 0)$	Appropriation (Fig.1) $S(g_2 = 5 \mid g^e = 10, c = 0)$	Provision with Contr. (Fig.2) $T(g_2 = 5 \mid g^e = 10, c = 2)$
Player 1 Dim.	(10, 11.25)	(15, 11.25)	(10, 11.25)
Player 2 Dim.	(10, 8.75)	(15, 8.75)	(10, 10.25)

[23] 11.25 = (10 -10)+ .75(5+10) and 8.75 = (10-5)+ .75(5+0).

[24] 15=0+ .75(10+10)

in the provision game. The right-most column shows minimal expectation payoffs for the provision game when the smallest permissible allocation is 2 and the feasible payoff set is *T*(5), shown in Figure 2. Here, the most selfish allocation is to allocate 2 (rather than 0), so the other's minimal expectation payoff is 10.25 (up from 8.76 absent contraction) but remains 11.25 for player 1 (as the most generous allocation is still 10). Moral monotonicity (Proposition 4 below) requires that choices follow the same pattern: larger payoff for player 2 in contraction than in full provision game, which player 1 can achieve by increasing her allocation to the public account.

3.3.2 Implications of Moral Monotonicity for (Best Response) Allocations

M-Consistency and M-Monotonicity properties hold for choice sets in the *payoff* space. Here we derive implications of such properties for (best response) allocations of *tokens* to the public account.

Contraction Effect. Refer to the first column in Table 1 to verify that, from the perspective of player 1, the total change, $\delta_{i=1,2} = (\omega_i^e - \omega_i^e) + (i_*^{c_1} - i_*^{c_2})$ between the reference points in games with positive low bounds $c_1 > c_2$ on allocations is[25] $\delta_1 = 0 + 0, \quad \delta_2 = 0 + \gamma(c_1 - c_2)$. Compared to a no-contraction game ($c_2 = 0$), in games with contraction ($c_1 > 0$), player 2 is in the set, *K* of "favored" players but player 1 is not. Hence, moral monotonicity (Proposition 1) requires that player 1's choice leaves player 2 with a larger payoff in a (non-binding) contraction game, which she can do by increasing her allocation to the public account. Therefore, contrary to crowding out, moral monotonicity implies that (nonbinding) floors on allocations to the public account have a positive effect on a player's best-response allocations.

Initial Endowment Effect. Similarly, from the perspective of player 1 (first column in Table 1), for any two g^e-games with initial (per capita) allocations $g^s > g^t$ in the public account, the total change in moral reference points is $\delta_i = (2\gamma - 1)(g^s - g^t) + (i_* - i_*)$ for $i = 1, 2$. Therefore, the set, *K* of most favored players includes both players, and by M-Monotonicity, player 1 aims at a larger final payoff for herself in the game with the larger g^e, so she reduces her allocation to the public account.

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[25] The definition of total change, δ appears in the notation paragraph just above the definition of M-Consistency.

These findings are summarized in Proposition 4 (see Online Appendix O.5.B for proof).

Proposition 4. If choice sets in the payoff space satisfy M-Consistency and M-Monotonicity properties then for every g^e-game and vector of others' allocations g_{-i}:

a. $C^*(g_{-i} \mid g^e) \rhd W^*(g_{-i} \mid g^e)$ for all nonbinding[26] contractions C

b. $W^*(g_{-i} \mid g^t) \rhd W^*(g_{-i} \mid g^s)$ for all $g^s > g^t$ from $[0, W]$

An implication from part a is that a nonbinding increase in contribution to the public account financed with lump sum taxes will increase the total public good level. Part b of Proposition 4 says that, compared to mixed games, extreme (best response) allocations to the public account are larger in the provision game and smaller in appropriation game. In this way we have:

Corollary 3. Moral monotonicity implies:

a. Incomplete crowding out of voluntary contributions by (nonbinding) lump-sum-tax-imposed contributions to a public good;

b. Higher allocation to the public good in a provision game than in a payoff-equivalent appropriation game with mixed game allocation in between.

3.3.3 Extreme Nash Equilibria

Implications of Propositions 3 and 4 for effects of quotas and initial (per capita) endowment of the public account on extreme Nash equilibria when allocations are strategic complements are summarized in Proposition 5 (see Online Appendix O.6 for proof).

Proposition 5. For increasing best response, extreme (the largest and the smallest) Nash equilibrium allocations:

a. Do not vary with c and g^e for conventional rational choice theory;

b. Increase in c and decrease in g^e for morally monotonic choice theory.

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[26] Here $C = \{c, \cdots, W\}, c > 0$ is non-binding if $0 < c < \min(g_i^b, \min(g_{-i}))$ where g_i^b is the smallest best response allocation choice of player *i*.

3.4 *Summary of implications moral monotonicity, conventional rational choice, belief-based model of kindness, and reference-dependence with loss aversion.*

These theoretical models have the following predicted effects for experimental treatments.

I**. Predictions for Non-binding Contractions.** The effect of a (non-binding) floor on (best response) allocations in the public account is predicted to be:

a. Negative or Null: by belief-based model of kindness

b. Null: by conventional rational choice theory and reference-dependence with loss aversion

c. Positive: by morally monotonic choice theory

II. **Predictions for Game Form.** The effect of shifting endowment from the private to the public account on (best response) allocations to the public account is predicted to be:

a. Positive (or ambiguous): by reference-dependence with loss aversion

b. Null: by conventional rational choice theory and belief-based model of kindness

c. Negative: by morally monotonic choice theory

We observe that the predictions from morally monotonic choice theory are different from predictions of alternative theoretical models. What does the data tell us about empirical validity of these predictions?

4. Testing Alternative Theoretical Models with Existing Data

We use data from experiments reported by Andreoni (1995), Khadjavi and Lange (2015), and Reuben and Riedl (2013) to test hypotheses I.a – I.c and II.a – II.c for alternative theoretical models. We chose the Andreoni (1995) paper because it is the seminal paper for the large literature on effects of (provision vs. appropriation) game form reviewed in Text Appendix 1. We use the Khadjavi and Lange (2015) data because (to the best of our knowledge) it is the first to introduce mixed public good games and contractions (albeit exogenous). We use the Reuben and Riedl (2013) data because it has provision games with an *upper* bound on contributions.[27]

The three experiments all include 10 rounds of play, pay subjects their total earnings from all rounds and, after each round, provide subjects with information on their own payoff and the total allocation to the public account. Andreoni (1995) uses a strangers design, with groups of 5

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[27] We thank the editor for suggesting the Reuben and Riedl (2013) paper.

players, whereas partners designs are used in Khadjavi and Lange (2015), with groups of 4 players, and Reuben and Riedl (2013), with groups of 3 players. Andreoni (1995) uses evocative subject instructions that highlight positive externalities in the provision game and negative externalities in the appropriation game. Khadjavi and Lange (2015) uses neutral wording in subject instructions. Andreoni (1995) includes payoff-equivalent provision and appropriation games, Khadjavi and Lange (2015) adds a payoff-equivalent mixed game in which subjects can make transfers in both directions between the public account and their private accounts. Khadjavi and Lange (2015) also includes a treatment with exogenous contraction in a mixed game that places a lower bound on individual allocations to the public account. Reuben and Riedl's (2013) treatment URE includes an exogenous contraction in the provision game that restricts contributions of the high-endowment player *from above*.[28]

Table 2 reports (random-effects) GLS regression for the last five rounds of data on individual allocations in each of these three experiments. Explanatory variables include: $(G_{-i})_{t-1}$, the total allocation by others to the public account in the previous period; and g^e, the per capita *endowment* (of tokens) in the public account; and dummies for contractions.

A central theoretical prediction about game form can be tested with data from the Andreoni and Khadjavi and Lange experiments. The value of g^e determines whether the game form is provision (g^e =0) or appropriation (g^e =60), in Andreoni's experiment, and whether the game form is provision (g^e =0) or mixed (g^e =8) or appropriation (g^e=20) in Khadjavi and Lange's experiment. The significantly negative estimates of the coefficient for g^e are consistent with prediction II.c for morally monotonic choice theory.[29] These negative estimates are inconsistent with predictions II.a and II.b for models of reference dependence with loss aversion, conventional rational choice theory (including consequentialist models of social preferences), and belief-based model of kindness.

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[28] In both URE and UUE treatments, the game is a provision game with mpcr of 0.5, and in each group of three players, one player is endowed with 40 tokens whereas the other two are endowed with 20 tokens. The high-endowment player can contribute all 40 tokens in UUE but only up to 20 in URE. The low-endowment players can contribute all 20 tokens in both UUE and URE treatments.

[29] These estimated effects are for "token" endowments. The implied dollar amounts are economically significant. For example, the -0.11 token coefficient for Andreoni's data corresponds to -6.6 tokens when endowment of the public account is changed from 0 to 60 tokens. So, with n = 5 and mpcr = 0.5, the payoff from the public account decreases by $16.50.

Table 2. Individual Allocations to Public Account in Previous Experiments (per. 6 to 10)

Dep. Var: g_i Allocation	**Andreoni Data** {0...60}	**Khadjavi and Lange Data** {0…20} & C={8…20}		**Reuben and Riedl Data** Low: {0...20} High: {0…40} & C={0…20}		
Group size	5	4		3		
Range of G_{-i}	{0...240}	{0...60}	{24...60}	High {0...40}	Low {0...60}	{0...40}
	(1)	(2)	(3)	(4)	(5)	(6)
$(G_{-i})_{t-1}$	0.05***	0.13***	0.09***	0.37***	0.22***	00.28***
	(0.019)	(0.022)	(0.034)	(0.080)	(0.029)	(0.029)
g^e	-0.11**	-0.09*	-0.24**			
	(0.047)	(0.054)	(0.100)			
(D) Contraction: Contrib. Floor		4.67***	3.71***			
		(0.830)	(0.951)			
(D) Contraction: Contrib. Ceiling				-7.77***	1.32	0.04
				(2.070)	(1.031)	(1.182)
Constant	11.53***	3.39***	6.77***	4.38**	1.19	1.17
	(2.598)	(0.984)	(2.159)	(2.057)	(1.121)	(1.035)
Punishment Opp.	no	no	no	yes	yes	yes
R-Squared (overall)	0.065	0.368	0.151	0.651	0.635	0.647
Subjects	80	160	95	35	70	57
No. of clusters	80	40	27	35	35	29
Observations	400	800	345	175	350	269

Notes: Random-effects GLS regression. Robust standard errors in parentheses; clustered at group level for data in K&L and R&R. Feasible set of contributions in braces. *** p<0.01, ** p<0.05, * p<0.1

A second central question is how subjects' choices respond to non-binding contractions of feasible sets. Andreoni's experimental design does not include contractions. The Khadjavi and Lange experiment and the Reuben and Riedl experiment do include contractions. The significantly positive estimates of coefficients for a floor on contributions (in the Khadjavi and Lange experiment) are consistent with prediction I.c for morally monotonic choice theory but inconsistent with predictions I.a and I.b for other theoretical models. The URE treatment in the Reuben and Riedl experiment puts a ceiling on contributions of the high endowment subjects. The significantly negative coefficient in column (4) for high players is consistent with the prediction from morally monotonic choice theory, as are the insignificant coefficients in columns (5) and (6) for low players.[30]

There are several limitations in using data from these studies. First, the findings for effects of these studies' *exogenous* contractions of feasible sets could result, mechanically, from floors (or ceilings) being binding rather than validated or contradicted predictions from alternative theoretical models. Secondly, the subjects' decisions could be motivated by reciprocity, in particular in Khadjavi and Lange and Reuben and Riedl experiments, that use a partners design. Thirdly, using previous period total contributions as proxy for individual's beliefs, while reasonable, can be arguable. These limitations motivated our new experiment. In the new experiment, subjects' first-order beliefs are elicited. The elicited beliefs, and subjects' choices in a previous round, are used in imposition of *endogenous*, non-binding contractions. The new experiment also limits the number of decision periods to three and uses a strangers design without feedback between periods.

5. New Experimental Design with Endogenous Contractions

We design a two-player experiment with provision, appropriation and mixed games.[31] We observe individuals' chosen allocations in the full game (baseline) and elicit subjects' guesses about others' allocations, and use them to inform nonbinding contractions of feasible sets that exclude only alternatives that have not previously been chosen nor believed in being chosen by subjects matched in a subsequent play of a contracted game. This design provides sharp discrimination between implications of alternative theoretical models. We cross feasible set contractions with provision or appropriation game forms. In addition, we have treatments for mixed games that allow both provision and appropriation. In all treatments, the game is between two players and the public account marginal per capita return is 0.75. Table 3 shows parameter configurations, in terms of initial allocations between the two accounts used in each treatment.

[30] For the high-endowment player, the upper bound on contribution in URE makes own minimal expected payoff higher than in UUE. Hence, for any given contribution of the low-endowment player, moral monotonicity predicts the high type's best response is lower in URE than in UUE. For the low-endowment player, the upper bound on high's contribution has no effect on low's moral reference point, so moral monotonicity predicts that for any given contribution of the high-endowment player, low's best response is the same in the two treatments.

[31] The experiment was approved by the Institutional Review Board at Georgia State University.

Table 3. Experimental Design and Treatments

	Contracted Provision	Provision	Mixed Games			Approp.	Contracted Approp.
Initial Endowed Payoff	\$10	\$10	\$11	\$12.5	\$14	\$15	\$15
Initial Tokens in Private Account	10	10	8	5	2	0	0
Action Set[a]	[c, 10][b]	[0, 10]	[-2, 8]	[-5, 5]	[-8, 2]	[-10, 0]	[-t, 0][c]
Feasible Allocations in Public Account[a]	[c, 10]	[0, 10]	[0, 10]	[0, 10]	[0, 10]	[0, 10]	[10-t, 10]
Design	Within Subjects			Within Subjects		Within Subjects	
Subjects: Order	40: BCB 40: CBC			72: random order of 8,5,2		40: BCB 40: CBC	
Decisions per Subject	3			3		3	
Nr. of Subjects	80			72		80	
Observations	240			216		240	

Note: [a] Possible choices in the experiment include discrete amounts in the intervals. [b] $c = \min_i\{g_i^* - 1, guess(g_{-i})\}$.
[c] $t = \max_i\{t_i^* + 1, guess(t_{-i})\}$. B = $\{0,\cdots,10\}$. C is $\{c,\cdots,10\}$ in provision and $\{-t,\cdots,0\}$ in appropriation.

The decision task consists of allocating W=10 tokens between the private and public accounts. Different subjects participated in the provision game, mixed game and appropriation game treatments. Subjects who participated in the mixed games faced tasks in g^e = 2, 5, and 8 games in random order. Each subject made three decisions without feedback on others' choices and was randomly and anonymously paired with a different other subject in each of the three decision tasks. After making each decision, each subject was also asked to report own expectation ("guess") about the other's decision; correct guesses were paid \$2 but incorrect guesses were not paid. One of the three decisions was randomly selected for payment at the end of each experiment session, which yielded average subject salient payoff of \$15.71. After all choices and guesses had been entered, subjects were asked to complete a questionnaire (included in Online Appendix O.8). In addition to demographic questions, it contained questions about a subject's altruistic activities and about their opinions of the altruism vs. selfishness of others. Sessions lasted about one and one-half hours including time for reading instructions, making decisions, answering the questionnaire, and receiving payment. There were 36 or 40 subjects in each session.

Provision or appropriation games are implemented (within-subjects) with and without contractions. In a baseline (B) game, the set for tokens that can be allocated to the public account includes integers in [0,10]. In a contraction (C) game, the set of tokens that can be allocated to the public account includes integers in [c,10] for some $c \geq 0$, chosen to be "nonbinding," as explained below. To control for order effects, half of the subjects participated in the BCB treatment order and the other half in the CBC order. For each pair of subjects who faced the contraction set [c,10] in treatment C after the larger set [0,10] in treatment B, the contraction set contained the observed choices and guesses of both players in the previous baseline treatment.[32] To control for "corner set" effects and/or one-sided errors, the minimum allocation, c was 1 less than the smallest allocation within a pair of subjects.[33] For example, if the allocations of a pair of subjects in the provision game were 3 and 5 and the reported guesses were 4 and 3 then the set of allocations for the pair in the provision game with contraction was $\{2,\ldots,10\}$.

The construction of contractions in the appropriation game treatment was guided by the same logic. As an illustration, for a pair of subjects with appropriations 2 and 6 in the appropriation game and the reported guesses 4 and 3, the contracted set for transfers from the

the public account to the private account would be $\{0,1,\cdots,7\}$.[34]

6. Empirical Play in the New Experiment

As reported in Table 3, seventy-two subjects participated in the mixed-game treatment with each subject making three decisions.[35] In addition, we have data from eighty other subjects who made three decisions in provision games, with and without contraction, and another eighty subjects who made three decisions in appropriation games with and without contraction.[36] Table 4 reports

[32] In a CBC session, the contraction sets used in the first C task are the same as in a preceding BCB session.

[33] Exceptions to the "$1 less" criterion are when choices in the preceding task are at a corner amount of 0 or close to 10. In a BCB session, if either subject guessed 0 or allocated 0 to the public account in the first B task then the set in treatment C would be integers from [0,10]. If application of the "$1 less" criterion would have resulted in a set with fewer than three options (i.e., lower bound 8 or 9) the set of allocations for task C was $\{5,6,\ldots,10\}$.

[34] Note that this set, described in terms of the number of tokens allowed to be allocated to the public account is $\{3,4,\cdots,10\}$.

[35] That is, one decision in each of the 2-game, 5-game, and 8-game; the order of the three decision tasks was randomized across subjects.

[36] The experiment was not pre-registered. All of the data from the experiment we conducted are used in the regression reported in Table 4; we collected no other unreported data.

results from regression analysis of data from our experiment using a model specification similar to the one used to analyze data from previous experiments (reported in Table 2).

The estimated coefficients for initial endowed tokens in the public account (g^e) and non-binding restrictions on minimum allocations to the public account (the low bound c) provide tests of the predictions for alternative theoretical models summarized statements I.a – I.c and II.a – II.c in section 3.4. The negative estimates of the coefficient for g^e are consistent with prediction II.c for morally monotonic choice theory but inconsistent with predictions II.b and II.a for conventional rational choice theory (including consequentialist models of social preferences), belief-based model of kindness, and models of reference dependence with loss aversion. Similarly, the positive estimates of the coefficient for c are consistent with prediction I.c for morally monotonic choice theory but inconsistent with predictions I.a and I.b for the other theoretical models.

Table 4. Individual Allocations to Public Account in Our Experiment

Dep. Variable: g_i Allocation	**(1)**	**(2)**
Guessed Other's allocation	0.62*** (0.047)	0.61*** (0.045)
g^e	-0.05* (0.030)	-0.07** (0.031)
c	0.36*** (0.054)	0.37*** (0.051)
Constant	1.37*** (0.245)	1.56*** (0.366)
Demographics	no	yes
R-Squared (overall)	0.435	0.458
Subjects	232	232
Observations	696	696

Notes: Linear estimators with standard errors clustered at subject level. Demographics include dummies for Female, Black, Self Image (give to a stranger, give to charity, help others with homework, share secrets) and Other's Image (disabled car assistance, selfish, dislike helping others). Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

7. Conclusion

Our topic of study is robust patterns of data from public good experiments that have been anomalous to existing theory for more than 25 years. The anomalous patterns are: (a) games with provision elicit larger amounts of the public good than do *payoff-equivalent* games with appropriation; and (b) games with *non-binding* floors elicit larger amounts of the public good than do games without contractions of the feasible set. Robust pattern (a) is exhibited by experiments in papers included in the selective literature survey in Text Appendix 1. Robust pattern (b) is exhibited in papers included in footnote 3.

Since the robust data patterns are anomalies, a research priority is development of a new theoretical model. A second priority is testing predictions of the new model, and existing alternative models, with data from a selection of experiments in the literature. A third research priority is challenging the new theoretical model with experimental tests of its idiosyncratic predictions. This paper pursues all three research priorities.

We extend the Consistency property that characterizes rational choice theory (Arrow 1959) to incorporate reference points and postulate choice monotonicity to reference-points with the M-Consistency and M-Monotonicity properties. These two properties could be applied with various specifications of reference points. Indeed, in section 2 we use definitions of reference points from a belief-based model of kindness (Dufwenberg and Kirchsteiger 2004) and reference dependence with loss aversion (Tversky and Kahneman 1991; Kőszegi and Rabin 2006), along with M-Consistency and M-Monotonicity, to make clear that the different predictions from the models cannot solely be attributed to different specifications of reference points.

Our application to public good games in section 3 uses a specification of "moral reference point" based on two *observable* features of the choice environment: endowments and minimal expectations payoffs. We derive moral monotonicity implications for effects of game form (provision, appropriation, or mixed) and nonbinding contractions on best response allocations in public good games, and for efficiency of (Nash) equilibrium play when contributions are strategic complements. Also in section 3, we derive predicted effects for game form and nonbinding contractions of alternative theoretical models including a prominent belief-based model of kindness (Dufwenberg and Kirchsteiger 2004), prominent models of reference points with loss aversion (Tversky and Kahneman 1991; Kőszegi and Rabin 2006), and conventional rational choice theory (including consequentialist social preferences models).

A summary statement of the testable implications of alternative theoretical models for experiments on game form and contractions is reported in statements I.a – I.c and II.a – II.c in section 3.4. Estimated coefficients reported in Tables 2 and 4 with data from experiments reported in three previous papers and data from our experiment are consistent with the implications of morally monotonic choice theory but mostly inconsistent with alternative theoretical models. Other tests reported in Text Appendices 3 and 4 support similar conclusions.

Text Appendices

Text Appendix 1: Related Literature on Payoff-Equivalent Public Good Games

To our best knowledge, Andreoni (1995) is the first study to look at behavior in positively-framed and negatively-framed voluntary contributions public good games. His between-subjects experiment co-varied game form (provision or appropriation) with wording of subject instructions that made highly salient the positive externality from contributions in a provision game or the negative externality from extractions in an appropriation game. Subsequent literature explored both empirical effects of variations in evocative wording of subject instructions and effects of changing game form (from provision to appropriation) with neutral wording in the subject instructions. We here summarize findings on effects of game form and various framings on contributions, extractions, and beliefs.

Subjects' Characteristics

Some studies look at interaction between subjects' attributes (social-value orientation, gender, attitudes towards gains and losses) and game framing (positive or negative). The main findings include: (1) play of individualistic subjects but not social-value oriented subjects is sensitive to the framing of the game (Park 2000); (2) more cooperative choices by women than men in the negatively-framed game but not in the positively-framed game; (3) for both genders, positive framing elicits higher cooperation than negative framing (Fujimoto and Park 2010); and (4) lower cooperation in taking than in giving scenarios with gain framing but the effect appears to be driven entirely by behavior of male subjects (Cox 2015). With loss framing, no clear effect is detected (Cox 2015).[37] Cox and Stoddard (2015) explore effects of interaction of partners vs. strangers pairing with individual vs. aggregate feedback in payoff equivalent provision (give) and appropriation (take) games and find that the take frame together with individual feedback induces bimodal behavior by increasing both complete free riding and full cooperation.

Beliefs and Emotions

While give vs. take frames are found to affect contributions, this effect appears to be less strong than the effect on beliefs (Dufwenberg, Gächter, and Hennig-Schmidt 2011; Fosgaard, Hansen,

[37] In the Loss-Giving setting, subjects *contribute* to prevent loss whereas in the Loss-Taking setting, subjects *take* to generate a loss (Cox 2015).

and Wengström 2014). A close look at triggered emotions in positively-framed and negatively-framed public good games is offered by Cubitt, Drouvelis, and Gächter (2011) who find no significant effects of punishments or reported emotions.[38] This is one of few studies that find no game form effect on contributions.

Environment

Studies in this category focus on effects of features of the environment (such as status quo, communication, power asymmetry) on play across take or give public good games. Messer, et al. (2007) report an experimental design that interacts status quo (giving or not giving) in a public good game with presence or absence of cheap talk or voting. They find that changing the status quo from "not giving" to "giving" increases average contributions in the last 10 rounds from 18% (no cheap talk, no voting) up to an astonishing 94% (with cheap talk and voting). Cox, et al. (2013) report an experiment involving three pairs of payoff-equivalent provision and appropriation games. Some game pairs are symmetric while others involve asymmetric power relationships. They find that play of symmetric provision and appropriation, simultaneous-move games produces comparable efficiency whereas power asymmetry leads to significantly lower efficiency in sequential appropriation games than in sequential provision games. Cox, et al. (2013) conclude that reciprocity, but not unconditional other-regarding preferences, can explain their data. A framing effect on behavior is observed in public good games with provision points (Bougherara, Denant-Boemont, and Masclet 2011, Sonnemans, Schram and Offerman, 1998). In their experiment, van Soest, Stoop and Vyrastekova (2016) compare outcomes in a provision (public good) game with outcomes in a claim game in which subjects can appropriate the contributions of others before the public good is produced. They report non-positive production of the public good in the claim game even in early rounds of the experiment.

The experiment in the literature that is most closely related to ours is reported by Khadjavi and Lange (2015). They report on play in a mixed game with a between-subjects design that includes opportunities for both provision (give) and appropriation (take) with the initial (exogenously-specified) endowments between those in give or take scenarios. They find that (1) the appropriation game induces less cooperative behavior than the provision game (replicating the

[38] Cubitt et al. (2011) use two measures of emotional response including self-reports and punishment.

central result in Andreoni 1995) and that (2) their mixed frame data does not differ significantly from data for their provision game.

One notable difference of our experimental approach from previous literature is inclusion of a within-subjects design for eliciting provision and appropriation responses in three different mixed games that span the design space between the pure provision and appropriation games. A more fundamental departure from previous experimental literature is our inclusion of *endogenous* contractions of feasible sets, in a within-subjects design, that is motivated by the Consistency axiom of rational choice theory (Arrow 1959, Sen 1971, 1986). While the Khadjavi and Lange (2015) design allows for *exogenous* contraction in the mixed game our design introduces endogenous contractions known to include previous choices in (provision or appropriation) games in addition to elicited beliefs about others' choices. Such endogenous contractions are essential to ascertaining whether behavior in provision, appropriation, and mixed games exhibits monotonicity in moral reference points.

Text Appendix 2: Play in Provision, Appropriation, and Mixed Games

A general description of provision, appropriation, and mixed games with public goods is as follows. Each player, $i \in N = \{1, \cdots, n\}$ chooses an allocation (w_i, g_i) of a scarce resource, W tokens, between two accounts: w_i to player *i*'s private account and g_i to the public account shared with *n*-1 other players. When the total of others' allocations to the public account is G_{-i}, player *i*'s money payoff is the sum of returns from the private and public accounts:

(A.2.1) $$\pi_i = w_i + \gamma(g_i + G_{-i})$$

where $w_i = W - g_i$ and $\gamma \in (1/n, 1)$ denotes the mpcr from the public account.

The initial *per capita* endowed tokens, g^e in the public account uniquely identifies the g^e-game with total endowment $ng^e \in [0, nW]$ to the public account and endowment $W - g^e$ to the private account of each of the *n* players. Special cases include: provision game $(g^e = 0)$, where a public good can be provided; appropriation game $(g^e = W)$, where a public good can be appropriated; and mixed games $(g^e \in (0, W))$, where both provision and appropriation of a public good are feasible.

Let $g_{-i} \in \{0,\cdots,W\}^{n-1}$ be a vector of allocations to the public account by players other than player *i*. Let $\pi \in \Re^n$ denote the *n*-vector of payoffs to all players including *i*. In the g^e-game the feasible set of player *i* (in the money payoff space) is

(A.2.2) $$S(g_{-i}) = \{\pi(x, g_{-i}) \mid (x, g_{-i}) \in \{0,\cdots,W\}^n\}$$

If we let $g_i^* = br(g_{-i})$ denote a best-response allocation by agent *i* when others' *n*-vector of allocations to the public account is g_{-i} then the *n*-vector of payoffs, $\pi(g_i^b, g_{-i})$ belongs to the choice set, $S^*(g_{-i})$, that is

(A.2.3) $$\pi(g_i^*, g_{-i}) \in S^*(g_{-i}) \subseteq S(g_{-i})$$

Implications of Conventional Rational Theory for Choice in Provision, Appropriation and Mixed Games

The first observation (see Online Appendix O.2) is that Consistency implies that player *i*'s choice set, $W^*(g_{-i} \mid g^e)$ remains the same if, instead of $\{0,\cdots,W\}$, player *i* is asked to choose from some (non-binding) contracted subset, $C = \{c,\cdots,W\}, c > 0$ that contains all allocations in vector g_{-i} as well as *i*'s smallest best response allocation, g_i^b for which $\pi(g_i^b, g_{-i}) \in S^*(g_{-i})$. For any given *c* such that (*) $0 < c < \min(g_i^b, \min(g_{-i}))$ the feasible set is

(A.2.4) $$T(g_{-i}) = \{\pi(x, g_{-i}) \mid (x, g_{-i}) \in C^n\} \subseteq S(g_{-i})$$

where the inclusion follows from the minimum compulsory allocation (*) and payoff function (A.2.1). By the Consistency property $S^*(g_{-i}) \cap T(g_{-i}) = T^*(g_{-i})$, and by construction, $S^*(g_{-i}) \subset T(g_{-i})$, so $S^*(g_{-i}) = T^*(g_{-i})$ Hence *i*'s choice set of allocations in the (nonbinding) contraction game remains the same, $C^*(g_{-i} \mid g^e) = W^*(g_{-i} \mid g^e)$ for all *c* that satisfy (*).

The second observation is that the Consistency property requires that player *i*'s (best response) chosen allocations are not affected by initial (the endowed per capita) allocation, g^e in the public account (see Online Appendix O.2) because the feasible set in the payoff space, $S(g_{-i})$ remains the same for all g^e.

Implications of these two observations are summarized in Proposition 3 in the text.

Moral Reference Point in g^e-games

Without any loss of generality, we focus on moral reference point from the perspective of player 1.[39] The initial endowed payoff of every player $i \in N$ is

(A.2.5) $$\omega_i^e = W - g^e + \gamma(ng^e) = W + (\gamma n - 1)g^e$$

For any given vector, g_{-1} of others' allocation in the g^e-game with feasible allocations from C, player 1's feasible set (in payoff space) is $T(g_{-1}) = \{\pi(x, g_{-1}) \mid (x, g_{-1}) \in C^n\}$. The minimal expectation payoff of a player $k \in N \setminus \{1\}$, as a consequence of player 1's choice, is when player 1 allocates the minimum required amount and leaves player k with payoff

(A.2.6) $$k_* = W - g_k + \gamma(G_{-1} + c)$$

where G_{-1} is the total of voluntary allocations, g_{-1} in the public account by other players. So, from the perspective of player 1, the moral reference point with respect to player $k \neq 1$ is the ordered pair,

(A.2.7) $$r_k^1 = (\omega_k^e, k_*) = (W - g^e + \gamma ng^e, W - g_k + \gamma(G_{-1} + c))$$

The minimal expectation payoff of player 1, as a consequence of player 1's choice, is when player 1 allocates all his W tokens in the public account. Hence, player 1's minimal expectation payoff is

(A.2.8) $$1_* = \gamma(W + G_{-1})$$

So, from the perspective of player 1, the moral reference point with respect to oneself is the ordered pair,

(A.2.9) $$r_1^1 = (\omega_1^e, 1_*) = (W - g^e + \gamma ng^e, \gamma(W + G_{-1}))$$

Replace "1" with "*i*" in statements (A.2.7-9) to get the moral reference point, $r^i \in \mathbb{R}^{2n}$ from the perspective of player *i* at feasible set $T(g_{-i})$:

[39] Separate detailed explanations of moral reference points in provision, appropriation, and mixed games with contraction ($c > 0$) or without contraction ($c = 0$) can be found in Online Appendix O.5.A.

(A.2.10)
$$r_k^i = (\omega_k^e, k_*) = (W - g^e + \gamma n g^e, W - g_k + \gamma(G_{-i} + c)), \quad k \in N \setminus \{i\}$$
$$r_i^i = (\omega_i^e, i_*) = (W - g^e + \gamma n g^e, \gamma(W + G_{-i})), \qquad k = i$$

Implications of Moral Monotonicity for Best Response Allocations across g^e-games

Contraction Effect. Let the g^e-game and vector of others' allocations, g_{-i} be given. For any two constraints $c_1 > c_2$ on minimum permissible allocations, let $r^{ic_1}, r^{ic_2} \in \mathbb{R}^{2n}$ denote the respective moral reference points for feasible set $T(g_{-i})$ as in statement (A.2.10):

$$r_k^{ix} = (\omega^e, k_*^x) = (W - g^e + n\gamma g^e, W - g_k + \gamma(G_{-i} + x)), \; k \neq i$$
$$r_i^{ix} = (\omega^e, i_*^x) = (W - g^e + n\gamma g^e, W - g_k + \gamma G_{-i}), \qquad k = i$$

where $x \in \{c_1, c_2\}$. Verify that player k's total change (defined in the Notation paragraph in the text) between the two reference points is

$$\delta_k(r^{ic_1}, r^{ic_2}) = (\omega_k^e - \omega_k^e) + (k_*^{c_1} - k_*^{c_2}) = 0 + \gamma(c_1 - c_2), \quad k \in N \setminus \{i\}$$
$$\delta_i(r^{ic_1}, r^{ic_2}) = (\omega_i^e - \omega_i^e) + (i_*^{c_1} - i_*^{c_2}) = 0 + 0, \qquad k = i$$

For games with contraction, $c_1 = c > 0$ compared to no contraction, $c_2 = 0$ the set $K = \{k \in N : \; \delta_k = \gamma c > 0\} = N \setminus \{i\}$. Moral monotonicity requires that player i's choice leaves some other player with larger extreme payoffs in the g^e-game with contraction (than in the game without contraction), which player i can do by increasing his (best response extreme) allocations to the public account

Initial Endowment Effect. By statement (A.2.10) for any two g^e-games with initial (per capita) allocations $g^s > g^t$ in the public account, $\delta_k = (\omega_k^s - \omega_k^t) + (k_* - k_*) = (\gamma n - 1)(g^s - g^t) + 0$ for all $k \in N$. Therefore, $K = \{k \in N : \delta_k = \max_{i \in N} \delta_i > 0\} = N$ and by M-Monotonicity, player i aims for larger (extreme) final payoff in the game with the larger per capita endowed tokens, g^e in the public account. These findings are summarized in Proposition 4 in the text (see Online Appendix O.5.B for formal proofs).

Text Appendix 3: Robustness Tests

Table A.3.1 Individual Allocations to Public Account in Our Experiment (Linear Reg.)

Dep. Variable: g_i Allocation	Exclude data from contractions where the rule at least "-$1" does not apply			
	Exclude data from 1st C in CBC		C=B or 1st C in CBC	
Guessed Other's allocation	0.610*** (0.049)	0.602*** (0.047)	0.635*** (0.047)	0.629*** (0.044)
g^e [-]	-0.052* (0.031)	-0.069** (0.032)	-0.049* (0.029)	-0.066** (0.030)
c [+]	0.425*** (0.064)	0.439*** (0.061)	0.402*** (0.065)	0.419*** (0.059)
Demographics	no	yes	no	yes
Observations	657	657	571	571
R-Squared	0.421	0.447	0.442	0.473

Notes: Total number of subjects (clusters) is 232. Robust standard errors (clustered at subject level) in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Table A.3.1a. Individual Allocations to Public Account in Our Experiment (Tobit Reg.)

Dep. Variable: g_i Allocation	All Data		exclude 1st C in CBC		exclude C=B or 1stC in CBC	
Guessed Other's allocation	1.099*** (0.091)	1.082*** (0.086)	1.063*** (0.093)	1.044*** (0.088)	1.073*** (0.089)	1.057*** (0.083)
g^e [-]	-0.175*** (0.059)	-0.203*** (0.060)	-0.162*** (0.059)	-0.192*** (0.060)	-0.135** (0.054)	-0.164*** (0.055)
c [+]	0.227** (0.109)	0.242** (0.103)	0.464*** (0.128)	0.480*** (0.120)	0.434*** (0.126)	0.454*** (0.115)
Demographics	no	yes	no	yes	no	yes
Observations	696	696	657	657	571	571
(left-, un-, right-) censored obs	(242, 352, 102)		(217, 340, 100)		(177, 305, 89)	

Notes: Total number of subjects (clusters) is 232. Predicted signs for moral monotonicity in square brackets. Demographics include dummies for Female, Black, Self Image (give to a stranger, give to charity, help others with homework, share secrets) and Other's Image (disabled car assistance, selfish, dislike helping others). Robust standard errors (clustered at subject level) in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Further Data Analysis We also looked at game form effect utilizing non-parametric tests for statistical inferences and used within-subject analysis focusing only on allocations of subjects whose beliefs did *not* change.

<u>*Allocations in Provision, Appropriation, and Mixed Games (Between-Subjects Analysis)*</u>

Figure A.3.1 shows histograms across games of subjects' allocations in the full games, that is, allocations are from {0,…,10}. Extensive margin effect is visible: free-riding behavior (allocating nothing in the public account) is lowest in the provision game (21%), highest in the appropriation game (48%), with the mixed games in between (39%).[40] Average token allocations to the public account reveal a decreasing pattern: 4.01 (provision), 3.64 (mixed) and 3.09 (appropriation).[41] For statistical inferences we use the Kolmogorov-Smirnov test for distributions of *g* allocations in the public account and the Pearson chi-square test for free-riding behavior, and find that public good

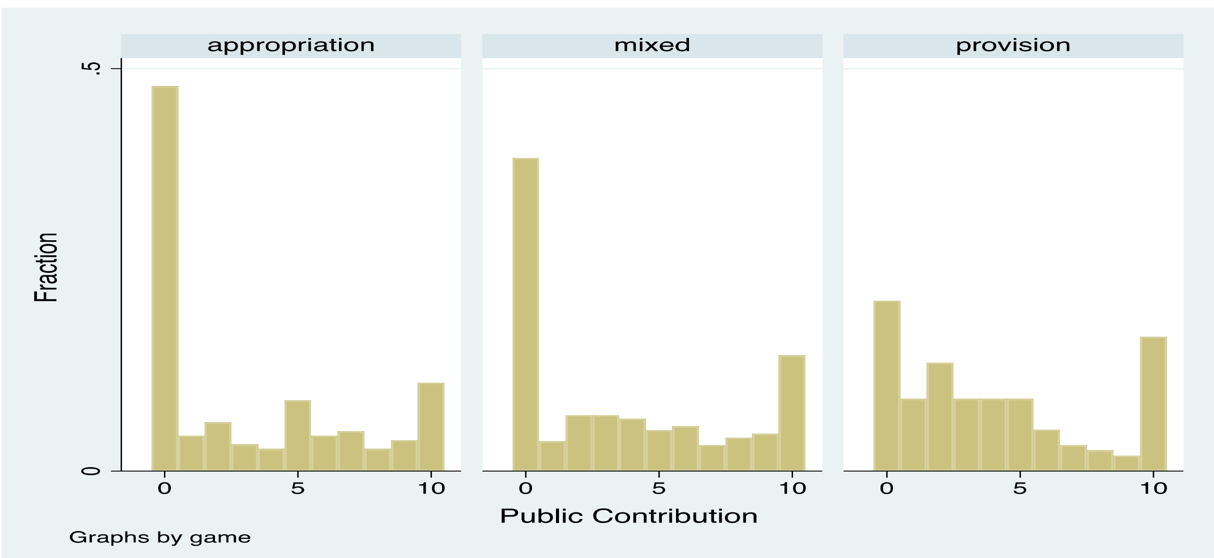

Figure A.3.1. Histograms of subject's *g* allocation from the full set, {0,…,10}

allocations of subjects in our experiment are characterized by:

(i) Larger public account allocations (p-value=0.022) and less free-riding (p-value=0.003) in provision than appropriation game data;

[40] If we allow for one token error, classifying 0 or 1 token allocations as free-riding, we get similar figures: 30.13% in provision game, 42.59% in mixed games and 52.2% in appropriation game. The odds of free-riding in provision game is less than half (0.42, *p*-value=0.01) in mixed games but in appropriation game it is 1.44 (*p*-value=0.18) times the odds in the mixed games.

[41] The 95% Confidence Intervals are: [3.46, 4.57] in provision game, [3.13, 4.15] in mixed game and [2.55, 3.63] in appropriation game.

(ii) Similar public account allocations (p-value=0.497) and less free-riding (p-value=0.247) in provision than mixed game data;

(iii) Similar public account allocations (p-values=0.384) but free-riding (p-value=0.075) in mixed and appropriation game data.

Based on these findings we conclude:

Result 1. *The provision game elicits higher average allocation to the public account than the appropriation game and the appropriation game elicits more free riding (public account allocations of 0 or 1).*

Within-Subjects Data Analysis Controlling for Beliefs

g^e *-Effect*. In mixed game treatments, excluding *selfish* subjects (who allocated 0 in all three tasks) we have 35 observations with unchanged beliefs.[42] For each subject, we constructed $\Delta g = g^i - g^j$, when the subject's guessed allocation of others in games g^i and g^j was the same, where superscripts $i<j$ denote the initial per capita endowed tokens, g^e from $\{2, 5, 8\}$. The null hypothesis from conventional rational choice theory is the mean of the distribution of Δg is not statistically different from 0 (Proposition 3, part b and Corollary 2, part b) whereas the alternative hypothesis that follows from moral monotonicity is mean (Δg) > 0 (Proposition 4, part b and Corollary 3, part b). The mean of Δg is 1.23 (95% C.I.=[-0.08, 2.53]) and the (conventional theory) null hypothesis is rejected by the *t*-test (t-statistic=1.91; p-value=0.064) in favor of moral monotonicity.[43] Our next result is:

Result 2. *Allocation to the public account in mixed games decreases as the initial endowment of the public account increases, controlling for belief about other's allocation*.

Contraction Effect. For any given allocation by the other player, conventional theory requires that (best-response) g allocations in the provision game or appropriation game be invariant to *nonbinding* contractions whereas moral monotonicity predicts that (best-response) allocations increase in c for nonbinding contractions. We constructed a new variable, Δg_i^{cb} that takes its

[42] If we include 0 allocations of *selfish* subjects with unchanged beliefs, the number of observations increases from 35 to 55.

[43] If we include 0 from *selfish* subjects, the mean of Δg decreases to 0.78 (the 95% C.I. is [-0.05, 1.61]); t-statistic=1.89; p-value=0.064).

values according to the difference between the subject's observed g allocation in the public account from the contracted set, $C=\{c,\ldots,10\}$ and the subject's allocation chosen from the full set, $B=\{0,\ldots,10\}$. The null hypothesis from conventional theory is that the mean of Δg_i^{cb} is not statistically different from 0, provided that the guess of other's contribution did not change. We have 45 observations for Δg_i^{cb} (24 and 21, resp., in the appropriation and provision treatments) observations with unchanged guesses and proper contractions (c>0). The mean of Δg_i^{cb} is significantly larger than 0 in the provision game (0.92, p-value=0.042) but not in the appropriation game (0.54, p-value=0.313). We also looked at the subset of these 45 observations with non-binding contractions; this leaves us with 28 observations for Δg_i^{cb} (17 and 11 in the provision and appropriation game) with unchanged guesses and proper contractions (i.e., c > 0). The mean of Δg_i^{cb} is 0.88 and statistically significantly larger than 0 in the provision game (p-value=0.056) but not in the appropriation game (mean=-0.36, p-value=0.476).

As a further check that the preceding tests are picking up (full vs. contracted game) treatment effects rather than decision-order effects, we also looked at Δg_i^{bb}, the within-subject difference in allocations in tasks in which subjects faced the full set, $B=\{0,\cdots,10\}$ more than once (e.g. in the BCB sessions) and their guesses did not change. There are 73 observations for Δg_i^{bb} with unchanged reported guesses. Both conventional rational choice theory and moral monotonicity require the mean of the distribution of Δg_i^{bb} to be 0. Data fail to reject this null hypothesis (mean of Δg_i^{bb} is 0.05, t-statistic=0.35, p-value=0.73). Our third result is:

Result 3. *Nonbinding lower bounds on public account allocations induce higher average allocations to the public account in the provision game, controlling for beliefs about other's allocation.*

Text Appendix 4: Maximization Approach to Testing Conventional and Moral Monotonicity Theory

As an example for tractable applications, we apply moral monotonicity theory using a parametric choice function and comparative statics analysis for interior solutions.

Special Case Morally Monotonic Best Response Allocations

Without loss of generality, consider choices by player 1. Assume a parametric form of the choice function, $U(\pi \mid r)$ discussed in the text:[44]

(A.4.1) $u(\pi) = (1 - e^{-\alpha\pi}), \alpha > 0,\ \theta(r_1) = e^{\sigma(r_{11}+r_{12})}, \sigma > 1$ and for all $k > 1$, $\theta(r_k) = e^{r_{k1}+r_{k2}}$.

Optimal (interior) solution is determined by:

(A.4.2) $$\sum_{k>1} \mathrm{e}^{(r_{k1}+r_{k2})-\sigma(r_{11}+r_{12})}\, \mathrm{e}^{-\alpha(\pi_k-\pi_1)} = (1-\gamma)/\gamma$$

Let G denote the total allocations to the public account. Verify that $\pi_k - \pi_1 = (\omega - g_k + \gamma G) - (\omega - g_1 + \gamma G) = g_1 - g_k$, substitute it in (A.4.2) and solve for g_1 to get

(A.4.3) $$g_1^*(g_{-1}, r) = br(g_{-1} \mid r) = \frac{1}{\alpha}\left(\ln(\frac{\gamma}{1-\gamma}) - \sigma(r_{11}+r_{12}) + \ln(\sum_{k>1} e^{r_{k1}+r_{k2}+\alpha g_k}) \right)$$

Details of the derivation of (A.4.3) are reported in Online Appendix O.7. It is straightforward (see that appendix for details) to show that, consistent with the general-case Proposition 4, $g_1^*(\cdot)$ increases in c and decreases in g^e.

Structural Analysis of Experimental Data. Estimating equations applied to data come from the best response function in statement (A.4.3). We estimate parameters for α and σ using data from Andreoni (1995), Khadjavi and Lange (2015), and the experiment reported herein. In our experiment, we have a two-player game and the belief about other's allocation is elicited, so the estimating equation can be written as

(A.4.4) $$g_{1t}^* = \frac{1}{\alpha}\left(\ln(\frac{\gamma}{1-\gamma}) - \sigma R_{1t} + R_{2t} + \alpha g_{2t} \right)$$

where g_{1t}^* is the individual's allocation at round t, g_{2t} is the elicited belief at round t, and $R_{kt} = (r_{k1})_t + (r_{k2})_t$, where the moral reference point is as reported in the main text.

In the Andreoni experiment and the Khadjavi and Lange experiment, at the end of each round subjects are informed of the total allocation, G_t in the public account and of course their own allocation, so they know total allocation by others in the public account, G_{-1t}. Therefore, for

[44] Superscript "1" on the reference point variables is dropped to simplify notation.

empirical estimation we assume that, at the beginning of each period t, the elicited belief is that every other player's allocation is the known average from the preceding period, $G_{-1(t-1)}/(n-1)$. Hence, statement (A.4.3) becomes

(A.4.5) $$g_1^* = br(g_{-1} \mid r) = \frac{1}{\alpha}\left(\ln(\frac{\gamma}{1-\gamma}) - \sigma R_1 + \ln\left((n\text{-}1)\, e^{R_k + \alpha g_k}\right)\right)$$

Parameter estimation with data from the Andreoni experiment and the Khadjavi and Lange experiment thus uses the estimating equation

(A.4.6) $$g_{1t}^* = \frac{1}{\alpha}\left(\ln(\frac{\gamma}{1-\gamma}) - \sigma R_{1t} + \ln(n-1) + R_{-1t} + \alpha g_{-1t}\right)$$

where g_{1t}^* is individual's allocation observed in round t, $g_{-1t} = G_{-1(t-1)}/(n-1)$ reported after round t-1, and the moral reference point specification is as in statement (10) in the text. An estimate of parameter σ (weakly) smaller than 1 would be inconsistent with moral monotonicity. Table A.4.1 reports nonlinear least square estimates of α and σ for all data, as well as separately for games

Table A.4.1. Non-linear Least Squares Estimates for Parametric Choice Function

Parameters	Andreoni (1995)[a] All Data	K&L (2015)[a] All Data	K&L (2015)[a] No Contraction	New Experiment All Data	New Experiment No Contraction
$\sigma\,[>1]$	1.11***	1.17***	1.20***	1.02***	1.03***
	(0.012)	(0.024)	(0.026)	(0.016)	(0.019)
	[1.09, 1.14]	[1.13, 1.22]	[1.15, 1.26]	[0.99, 1.05]	[0.99, 1.07]
α	1.70***	3.38***	3.04***	2.69***	2.74***
	(0.233)	(0.483)	0.453))	(0.340)	(0.380)
	[1.24, 2.17]	[2.43, 4.33]	[2.15, 3.94]	[2.02, 3.36]	[2.00, 3.49]
Observation	720	1440	1080	696	554
R-squared	0.41	0.69	0.53	0.75	0.67
Clusters	80	160	120	232	232

Notes: [a]Round 1 data are not included for Andreoni and K&L data because there is no information on others' contributions. Required value for consistency with moral monotonicity in square brackets. Robust standard errors in parentheses. 95% Confidence Intervals in square brackets.

without contraction because in Khadjavi and Lange's experiment contraction is exogenous (and therefore can be binding for some subjects). The estimated parameter for α is significantly greater than 0, revealing increasing $u(\cdot)$. The estimated parameter for σ is significantly greater than 1 with data from each of the experiments, which is consistent with moral monotonicity.[45]

[45] Using these estimates, the Nash (symmetric) equilibrium allocations (as a percentage of W) in the provision game are: 29% (Andreoni 1995), 33% (K&L 2015) and 32% (our experiment), and lower in the appropriation game: 16% (Andreoni) 1995, 24% (K&L 2015) and 31% (our experiment). These figures suggest empirical support for Proposition 5.

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