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Full agreement and the provision of threshold public goods

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Abstract

We report threshold public good experiments in which group members not only need to be individually willing to contribute enough to provide the public good but also have to agree with each other on what every group members should contribute. We find strong support to the hypothesis that full agreement increases successful provision, although it takes a few repetitions before group members can successfully coordinate. This is consistent with our theoretical results that full agreement works because it increases criticality of each individual decision. The existence of a focal point makes it possible for the group members to successfully coordinate.

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1. Introduction

A threshold public good is provided if and only if contributions reach a certain threshold. The classic example would be a capital fundraising project where, say, $10 million is needed to build a new school, cancer unit or theatre (Andreoni 1998). The potential applications of the threshold public good concept are, however, far more general than this archetypal case. For instance, the fixed costs associated with running any charity, or other group activity, require a minimum (but often quite large) amount be reached to make the activity viable (Bagnoli and McKee 1991). Political bargaining also provides a setting where success on, say, a climate change bill often requires a critical threshold of voters or countries to contribute (McEvoy 2010).

In principle, threshold public goods are not subject to the problems typically associated with public goods. In particular, there is no strategic incentive to free ride, and so no tension between individual rationality and social efficiency. Group members do, however, need to coordinate in order to provide the public good, because there are many ways to split the cost of the public good, or equivalently, multiple Nash equilibrium. Experimental evidence suggests that groups are not good at doing so; the success rate of providing threshold public goods is typically around 30-60 percent and well short of the efficient 100 percent level we might like to see (Croson and Marks 2000). This is potentially very costly to the group. It is also intriguing when one takes into account the evidence that people are remarkably good at coordinating in other contexts. In particular, we know that groups can coordinate well when there is no conflict of interest and a focal point that aids coordination (Schelling 1960; Mehta et al. 1994; Bardsley et al. 2010).

In the standard threshold public good game, considered in the literature, group members make individual contributions towards the public good. All, therefore, an individual decides, or can communicate, is his or her contribution, e.g. ‘I will contribute $15’. In applications, however, one observes the potential for more complex strategies. For instance, a group member may suggest what everyone in the group should do, e.g. ‘we should each contribute $15’, or ‘David and I should each contribute $15 and the rest of you contribute $25’. Alternatively, a group member may make their contribution conditional on others, e.g. ‘I will contribute $15 if everyone else contributes $15’, or ‘I will contribute $15 if David contributes $25’. Our objective in this paper is to question whether such strategies are a help or hindrance in groups providing the public good.

The strategies discussed above can have two effects on the way group members interact. First, they can be a means for individuals to *communicate* more with each other because an individual can say what he or she thinks others should do. Second, they may change the rules governing public good provision because *agreement* is needed if contributions are made conditional on what others will do. This latter possibility is particularly interesting because it means the group's task has become more difficult: group members not only need to be individually willing to contribute enough to provide the good but also need to agree with each other on what they should contribute. Even so, we shall argue that this can help groups coordinate.

We shall argue that the main reason agreement can help groups coordinate is that it increases the criticality of each individual's decision and makes a player more confident that other player's will not exploit his willingness to contribute. Criticality can only succeed, though, if group members know what is expected of them. This is much more likely if there is a focal point around which to coordinate. In short, criticality makes every individual feel as though their decision is *necessary* in order to achieve a successful outcome while the existence of a focal point makes it *possible* for the group members to successfully coordinate. We shall argue theoretically that the need for agreement leads to the increased prominence of an equal split focal point. This motivates our main hypothesis: that a requirement of full agreement can increase criticality and lead to increased success at providing the public good. We test this hypothesis experimentally and find support for it. Our experimental approach allows us to distinguish whether communication or the need for agreement is more important in aiding coordination, and we will come down strongly on the side of the need for agreement.

We proceed as follows: In section 2 we introduce threshold public good games. In section 3 we provide our main theoretical results. In section we describe our experimental design and in section 5 provide the experimental results. In section 6 we conclude. Additional material is provided in an appendix.

2. Threshold public good games

We shall begin by describing what we shall call the *standard game*. This is the standard game as considered in most of the prior literature when looking at simultaneous threshold public good games (e.g. Suleiman and Rapoport 1992, Cadsby et al. 2008). We shall then contrast this game with three other games that progressively differ in the feedback given to players, the strategy set, and the payoff function. The differences are summarized in table 1. In all the games we shall consider there is a set of n players $N = \{1, \dots, n\}$. Each player $i \in N$ is endowed with E_i units of a private good where E_i is some positive integer. If $E_i = E_j$ for all $i, j \in N$ then we say the game is *symmetric*. Otherwise we say that it is asymmetric. There also exist positive integers T and V that we shall refer to respectively as the *threshold* and the *value* of the public good.

In the standard game, independently and simultaneously all players must decide how much of their endowment to contribute towards a public good. The strategy set of any player $i \in N$ is, thus, the set of integers $S_i = \{0,1, \dots, E_i\}$. Let $c_i \in S_i$ denote the contribution of player $i \in N$ and let $C = \sum_{j=1}^{n} c_j$ denote total contributions. If total contributions equal or exceed the threshold T then each player receives an additional V units of the private good. We also say that the group was successful in providing the public good. If contributions are below the threshold each contribution is refunded and if contributions are above the threshold no money is rebated. The payoff of player *i* is, thus,

$$u_i(c_1, \dots, c_n) = \begin{cases} E_i - c_i + V & \text{if } C \geq T \\ E_i & \text{otherwise} \end{cases} \quad (1)$$

At the end of the game each player is told total contributions, C, but is not told the individual breakdown of contributions. A *standard game with feedback* is the same as the standard game, just described, except that players are informed at the end of the game on the list of individual contributions $c_1, \dots, c_n$. The difference between a standard game and standard game with feedback is considered by Croson and Marks (1998).

In a *game with communication* the strategy set of a player is different to that in a standard game or standard game with feedback, but all other details remain largely same. More specifically, independently and simultaneously all players must decide on a vector of contributions saying how much they think each player should contribute towards the public good. The strategy set of any player $i \in N$ is, thus, $S^C = S_1 \times \dots \times S_n$. Let $vc_i = (c_{i1}, \dots, c_{in}) \in S^C$ denote the vector of contributions chosen by player $i \in N$, where c_{ij} is the amount that player i 'suggests' player j should contribute. Let $c_i = c_{ii}$ be the amount that player *i* is willing to contribute and, as before, let $C = \sum_{j=1}^{n} c_j$ denote total contributions. The payoff function remains the same as in the standard game, equation (1). Thus, it is only the value of c_i that has any direct bearing on the game and the value of c_{ij} for $j \neq i$ is effectively cheap talk. At the end of the game players are informed on the vector of contributions suggested by each player. Even though, therefore, the value of c_{ij} for $j \neq i$ is cheap talk it is a means of communication between players.

In a *full agreement game* the strategy set is the same as that in a game with communication but the payoff function is different. The public good is provided if and only if total contributions equal or exceed the threshold *and* all players choose the same strategy. Full agreement on the vector of contributions is, thus, required. This means that every player must agree on what every other player should contribute, $c_{ij} = c_{lj}$ for any $i, l, j \in N$.[1] Formally, the payoff function of player i can be written

$$u_i(vc_1, \dots, vc_n) = \begin{cases} E_i - c_i + V & \text{if } C \geq T \text{ and } vc_1 = \cdots = vc_n \\ E_i & \text{otherwise} \end{cases} \quad (2)$$

At the end of the game players are informed on the vector of contributions suggested by each player, as in a game with communication.

Table 1: Comparison of the four games we shall consider.

Type of game	Strategy set	Feedback	Public good provided
Standard	Own contribution.	Total contributions.	Achieve threshold
Standard with feedback	Own contribution	Individual contributions	Achieve threshold
With communication	Vector of contributions	Individual vectors of contributions	Achieve threshold
Full agreement	Vector of contributions	Individual vectors of contributions	Achieve threshold and all agree on a vector of contributions

We finish this section by introduction some notation and assumptions that will prove useful in the remainder of the paper. Let $m_i = \min\{E_i, V\}$ and let $M = \sum_i m_i$. Informally, we can think of m_i as the maximum that player i can or will be willing to contribute, and M as the maximum that all players can or will contribute. We shall use $M_{-i} = M - m_i$ and $C_{-i} = C - c_i$ to denote, respectively, the amount that could be and is contributed by players other than i. Finally, We shall assume throughout the following that $M > T$ and $nE_i \geq T$ for all $i \in N$. Thus, it is socially efficient to provide the public good and players could in principle split the cost of providing the public good equally.

[1] Note that this does not in any way imply symmetry of contributions, $c_{ij} = c_{il}$.

3. Nash equilibria, criticality and focal points

All of the four games defined above have a large set of Nash equilibria that can be broadly distinguished into two categories: a set of equilibria where the sum of contributions match the threshold, and a set of where the sum of contributions are well below the threshold. In this section we shall formally define the set of equilibria for each game and discuss possible ways in which one of the equilibria may be selected or appear more focal.

We shall start with the standard game, and standard game with feedback. In these games, strategy profile $(c_1, \ldots, c_n)$ is a *Nash equilibrium* if and only if $u_i(c_i, c_{-i}) \geq u_i(c'_i, c_{-i})$ for all $c'_i \in S_i$.[2] It is a *strict Nash equilibrium* if and only if $u_i(c_i, c_{-i}) > u_i(c'_i, c_{-i})$ for all $c'_i \neq c_i, c'_i \in S_i$. One can easily derive that strategy profile $(c_1, \ldots, c_n)$ is a *strict Nash equilibrium with public good provision* if and only if

$$C = T \quad \text{and } c_i < V \text{ for all } i \in N.$$

The payoff of player i is $E_i + V - c_i$. Thus, any, ceteris paribus, change in her strategy would strictly lower her payoff, either to E_i if she decreases her contribution or to $E_i + V - c_i'$ if she increases her contribution to c_i'. The assumption that $M > T$, guarantees the existence of several such equilibria. Alternatively, strategy profile $(c_1, \ldots, c_n)$ is a *Nash equilibrium with no public good provision* if and only if

$$C < T \quad \text{and} \quad T - C + c_i > m_i \text{ for all } i \in N.$$

At least one such equilibria will exist if $m_i < T$ for all $i \in N$. In this case, player i receives payoff E_i and no, ceteris paribus, change in her strategy would change her payoff. This latter point means that every perfect Nash equilibrium is a Nash equilibrium with public good provision (Bagnoli and Lipman 1989).

Most theories of learning would suggest play should converge on a Nash equilibrium with public good provision if there is sufficient repetition. This is not, however, what we observe empirically. Typically, we observe contributions fluctuating around the threshold, even if there was a previous instance where the threshold was met exactly (Cadsby and Maynes 1999). Alberti, Cartwright and Stepanova (2011) use impulse balance theory to make sense of such empirical results. Impulse balance theory weights the impulse to contribute less with the impulse to contribute enough to provide the public good and can explain observed deviations from Nash equilibrium. In doing so, it predicts that the expected 'ex-post' impulse

[2] Where $u_i(c_i, c_{-i})$ denotes the payoff of player i if she contributes c_i and the contributions of others are denoted c_{-i}.

to change contribution will be relatively high. What we shall do here, is connect this with the idea of criticality.

3.1 Lack of criticality in the standard game

Criticality and perceived criticality has been analysed in detail in binary threshold public good games, i.e. games where a player must contribute either zero or her entire endowment (e.g. Rapoport 1987; Rapoport and Eshed-Levy 1989; Au, Chen and Komorita 1998; De Cremer and van Dijk 2002). In this setting, a player is critical if her contribution is necessary and sufficient for the provision of the public good, and perceived criticality appears to correlate with the decision to contribute. In binary games criticality is relatively simple to define. In non binary games, like we are considering here, criticality is harder to define, but probably no less relevant in trying to model behaviour. The definition of criticality we shall introduce here is one of criticality of the last unit contributed. Specifically, given strategy profile $(c_1, \ldots, c_n)$, in the standard game, we say that the *last unit contributed by player i was critical if and only if $C = T$*. This definition extends the idea of criticality from binary games in a natural way to non-binary games.

Clearly, a player can only know ex-post whether or not the last unit contributed was critical. It is, therefore, most relevant to concentrate on the probability or expectation that the last unit contributed will be critical. In order to estimate this probability we need a model of how players behave. The model suggested by Alberti, Cartwright and Stepanova (2011) is to assume that each player independently contributes each unit of the private good (up to a maximum of V) with some probability p. Contributions to the public good are thus described by a binomial distribution $B(M, p)$. This approximates relatively well observed contributions and relates nicely to the standard way of modelling behaviour in binary games.[3] For any player i, the probability distribution over the contributions of others, C_{-i}, is given by

$$\Pr(C_{-i} = x; p) = \binom{M_{-i}}{x} p^x (1-p)^{M_{-i}-x}. \quad (3)$$

If player i expects the contributions of others to be distributed as in equation (3) then we can obtain an upper bound on the probability that the last unit she contributes will be critical. If $C_{-i} \geq T$ or $C_{-i} + m_i < T$ then the last unit contributed by player i cannot be critical. An upper bound on criticality is thus given by, what we shall call, *maximum criticality*,

[3] It naturally accounts for differences in endowment as those with a larger endowment will be expected to contribute more.

$$XC_i := \max_{\substack{p\in[0,1] \\ x\in\{T-m_i,\ldots,T-1\}}} \{\Pr(C_{-i} = x; p)\}.$$

Maximum criticality provides a, potentially tight, upper bound on the probability the last unit contributed by a player will be critical. Our first result gives a reduced form expression of maximum criticality.

Proposition 1: If player i believes that contributions to the public good by others are described by binomial distribution $B(M_{-i}, p)$ then

$$XC_i = \begin{cases} 1 & \text{if } T > M_{-i} \\ \binom{M_{-i}}{T-1} \frac{T-1^{T-1}}{M_{-i}^{M_{-i}}} (M_{-i} - T + 1)^{M_{-i}-T+1} & \text{if } M_{-i} > T > \frac{\mathrm{M}+1}{2} \\ \binom{M_{-i}}{T-m_i} \frac{T-m_i^{T-m_i}}{M_{-i}^{M_{-i}}} (M-T)^{M-T} & \text{otherwise.} \end{cases}$$

Proof: If $T > M_{-i}$ then we can set $p = 1$ and obtain $XC_i = \Pr(C_{-i} = M_{-i}; 1) = 1$. Next note that if $T \leq M_{-i}$, for any $x \in \{T - m_i, \ldots, T - 1\}$ the

$$\max_{p\in[0,1]} \{\Pr(C_{-i} = x; p)\} = \binom{M_{-i}}{x} \left(\frac{x}{M_{-i}}\right)^x \left(1 - \frac{x}{M_{-i}}\right)^{M_{-i}-x}. \qquad (4)$$

Equation (4) is U shaped and so maximum criticality is obtained when either $x = T - m_i$ or $x = T - 1$. Furthermore, equation (4) is symmetric and so maximum criticality is obtained at $x = T - m_i$ if and only if $T - m_i \leq M_{-i} + m_i + 1$.■

We see from Proposition 1 that maximum criticality can be one. This will be the case if $T > M_{-i}$ and so the public good can only be provided if player i contributes something. In general, however, Proposition 1 implies that maximum criticality will be less than one, and potentially near to zero. To illustrate, Table 2 details maximum criticality in six different five player games. Note that these coincide with the games we shall consider experimentally, and what we have called the benchmark game is indeed the benchmark game in the literature (e.g. Cadsby et al. 2008).[4] Maximum criticality is high enough to justify a player contributing something, because $XC_i V > 1$. This, however, is to be expected given that there exists strict Nash equilibria with public good provision. In absolute terms maximum criticality is low. Crucially, this means that with high probability a player will know the last unit they contribute is not critical. The analysis of Alberti, Cartwright and Stepanova (2011) uses the resultant ex-post impulse to predict likely success at providing the public good. The point we

[4] In the benchmark game most observed contributions are an exact multiple of 5. The * games are, therefore, potentially more representative of how subjects perceive the game by revaluing parameters in multiples of 5.

want to pick up on here, is that a lack of criticality is the best explanation we have for why contributions do not converge on a Nash equilibrium in the standard game.

Table 2: Maximum criticality in six different five player games.

Game	Endowment		V	T	Maximum criticality	
	Players 1-3	Players 4-5			Players 1-3	Players 4-5
Benchmark*	11	11	10	25	0.129	0.129
Asymmetric*	9	14	10	25	0.133	0.136
Very asymmetric *	5	20	10	25	0.180	0.376
Benchmark	55	55	50	125	0.058	0.058
Asymmetric	45	70	50	125	0.061	0.062
Very asymmetric	25	100	50	125	0.086	0.369

If low criticality is the reason why groups fail to converge on a Nash equilibrium, and the reason why they fail to providing public goods, then increasing criticality is a potentially good way to increase efficiency (De Cremer and van Dijk 2002). So far, we have focussed on criticality in the standard game. The argument we have used, however, in particular Proposition 1, would apply equally to a game with communication. What about criticality in a game with full agreement? A-priori, one can argue that criticality in this game could be more or less than in a standard game. One could argue less, because player i can only have any influence on the outcome of a full agreement game if the other $n-1$ players agree; if this is unlikely to happen then player i's strategy, or proposed vector of contributions, is unlikely to be critical. If the public good is provided, however, then any change in player i's strategy would have meant the public good would not have been provided. This suggests that player i's strategy is highly critical. To progress further on this issue we need a model of how players may behave in a full agreement game.

3.2 Focal points in a full agreement game

The set of Nash equilibria in a full agreement game is very similar to those in a standard game. In a full agreement game, strategy profile $(vc_1, \dots, vc_n)$ is a strict Nash equilibrium if $u_i(vc_i, vc_{-i}) > u_i(vc'_i, vc_{-i})$ for all $vc'_i \neq vc_i, vc'_i \in S^C$. One can easily derive that strategy profile $(vc_1, \dots, vc_n)$ is a strict Nash equilibrium with public good provision if and only if

$$C = T \text{ and } c_i < V \text{ for all } i \in N \text{ and } vc_1 = \cdots = vc_n.$$

Note the additionally requirement here, when compared to the standard game, that all players should agree. As in the standard game, there are Nash equilibrium with no public good provision but we omit the details here. The question we need to address is whether play can reasonably converge on a Nash equilibrium with public good provision.

Clearly play can only converge on a Nash equilibrium if all players agree. This leaves players with a coordination game not unlike the matching games discussed by Schelling (1960) and Sugden (1993, 1995) such as 'write a positive number'.[5] Evidence suggests that players can solve such coordination problems, with team reasoning or collective rationality being the leading explanation of how they do so (Sugden 1993, 1995; Bacharach 2006; Mehta et al. 1994; Isoni et al 2011). The basic idea behind collective rationality is that a player will recognize a common interest in trying to coordinate on some equilibrium (Schelling 1960). Thus, players look for a decision rule that if followed by all is most likely to produce successful coordination; 'less ambiguous' and 'more obvious' rules should tend to be favoured (Sugden 1995). The pertinent question for us is whether players can solve the particular coordination problem that arises in the game with full agreement. To address this question we shall draw on the theory of focal points due to Sugden (1995).[6]

Imagine someone giving advice to a player on how much to contribute or what vector of contributions to suggest in a threshold public good game. The advice will consist of a *decision rule* and can be interpreted as a comprehensive plan to play the game; we shall have more to say on this shortly. A *recommendation* $R = (R_1, \ldots, R_n)$ details a decision rule R_i for every player $i \in N$. A recommendation R is said to be *collectively rational* if there exist payoffs $u_1^*, \ldots, u_n^*$ such that (i) if every player $i \in N$ follows her advice R_i then expected payoffs are given by $u_1^*, \ldots, u_n^*$, and (ii) if some player $i \in N$ does not follow her advice R_i then, whatever the decision rule of the other players, the expected utility of any player $j \in N$ is strictly less than u_j^*.[7] There can be at most one collectively rational recommendation (and typically there is no collectively rational recommendation). Sugden (1995) convincingly

[5] One important difference is that different Nash equilibria give a different distribution of payoffs in a threshold public good game but not a matching game. Isoni et al. (2011) also investigate non-pure coordination problems, in which there are many different Nash equilibria and in which different players earn different payoffs.

[6] Other theories of collective rationality are due to Bacharach (1993), Janssen (1993), and Casajus (2001).

[7] This definition is a reduced form of the definition given by Sugden (1995). Sugden (1995) allows that advice be conditional on a player's private description of the game and that it can consist of a set of acceptable decision rules. Note also that Sugden (1995) considers a game with two players and we consider the natural extension to more than two players.

argues that if a collectively rational recommendation exists then each player should act on that recommendation.

The multiplicity of Nash equilibria in a threshold public good game means that there will not exist a collectively rational recommendation if players have perfect information about the game. We need to consider, therefore, some ex-ante stage in which each player has some private knowledge. This can capture inherent uncertainty and ambiguity. The approach we shall take is to assume that (a) player identity is private information, and (b) player endowment is private information. So, player 1, does not know that player 2 is called player 2, and does not know that player 2 has endowment E_2. Note that each player does know the number of players in the game, does know the distribution of endowments across players, and does know own endowment. To understand these assumptions it is useful to discuss decision rules in more detail.

In the standard game one can think of a decision rule as a contribution or set of contributions. Thus, $R_i \subset S_i$, and player i is advised to randomly choose a contribution from set R_i. For example, the advice might be 'contribute 25', $R_i = \{25\}$, or 'contribute something between 25 and 35', $R_i = \{25, \dots, 35\}$. In this case, the fact that player identity and player endowment is private information is irrelevant because a player only has control over her own contribution. Analogously, in a full agreement game one can think of a decision rule as a vector of contributions or set of vector of contributions. Thus, $R_i \subset S^C$, and player i is advised to randomly choose a vector of contributions from set R_i. For example, the advice might be *'split the cost equally'*

$$R_i^E := \left\{\left(\frac{T}{n}, \dots, \frac{T}{n}\right)\right\}$$

or 'contribute zero and split the cost amongst others', which if $i = 1$ gives

$$R_1 = \left\{\left(0, \frac{T}{n-1}, \dots, \frac{T}{n-1}\right)\right\}.$$

Consider next the advice 'let someone else contribute zero and split the cost amongst others'. That this advice is given in a context where identity is private information means it must be ambiguous who the 'someone else' will be. The advice, therefore, if $i = 1$, equates to

$$R_1 = \left\{\left(\frac{T}{n-1}, 0, \dots, \frac{T}{n-1}\right), \left(\frac{T}{n-1}, \frac{T}{n-1}, 0, \dots, \frac{T}{n-1}\right), \dots, \left(\frac{T}{n-1}, \dots, \frac{T}{n-1}, 0\right)\right\}.$$

The crucial point to recognise here is that the fact player identity is private information constrains how specific advice can be. The advice 'split the cost equally' is unambiguous because there is only one way to do this, but the advice 'let someone else contribute zero and split the cost amongst others' is ambiguous because there are $n-1$ potential 'someone elses'. Recall that collective rationality will favour decision rules that are less ambiguous and more obvious. This is captured by our next result.

Proposition 2: In a standard game, standard game with feedback, and communication game, there is no collectively rational recommendation. In a full agreement game there is a collectively rational recommendation, if player identity and endowment are private information, and

$$\frac{T}{nV} < 1 - \left(\frac{1}{n-1}\right)^{n-1}.$$

The collectively rational recommendation is to split the cost equally, $R = (R_1^E, \dots, R_n^E)$.

Proof: Consider a standard game and suppose that $R = (R_1, \dots, R_n)$ is a collectively rational recommendation. Without loss of generality we can assume R_i consists of a single strategy $r_i \in S_i$. If players follow the recommendation then payoffs are either $u_i^* = E_i + V - r_i$ for all i, or $u_i^* = E_i$ for all i. Let X denote the set of strict Nash equilibria with public good provision. We know, because $M > T$, that the set X contains at least two equilibria. This means that there exists a strategy profile $(c_1, \dots, c_n) \in X$ that differs from R, in the sense that $c_i \neq r_i$ for at least one player $i \in N$. If players play this Nash equilibrium then payoffs are $u_i' = E_i + V - c_i > E_i$ for all i. If $c_i < r_i$ then clearly $u_i' > u_i^*$. If $c_i > r_i$ then either $u_i^* = E_i$ in which case $u_i' > u_i^*$ or there exists some $j \in N$ such that $c_j < r_j$ and $u_j' > u_j^*$. Either way, if players behave according to $(c_1, \dots, c_n)$ rather than R at least one player will receive a strictly higher payoff. This contradicts R being a collectively rational recommendation. A similar argument can be used in the standard game with feedback and communication game.

Now consider a full agreement game and the recommendation to split the cost equally. If players follow this recommendation then they will play a strict Nash equilibrium with public good provision. Payoffs will be given by $u_i^* = E_i + V - \frac{T}{n} > E_i$ for all i. We need to rule out the possibility that a player could expect to do better than this. To consider one alternative, suppose that player 1 chooses strategy $vc_1 = \left(0, \frac{T}{n-1}, \dots, \frac{T}{n-1}\right)$. If every player chooses the same strategy as player 1 then the payoff of any player $l \neq 1$ drops to $u_l^y = E_i + V - \frac{T}{n-1} < u_l^*$, but the payoff of player 1 increases to $u_1^y = E_1 + V > u_1^*$. The payoff gain is clearly $\frac{T}{n}$. If there exists a player j who chooses $vc_j \neq vc_i$ then the payoff of every player $l \in N$ drops to $u_l^d = E_i < u_l^*$. Now, suppose that player 1 uses the decision rule, 'contribute zero and split the cost amongst others', $R_1 = \{vc_1\}$. Suppose that every other player $l \neq 1$ uses the decision rule 'let someone else contribute zero and split the cost amongst others', for example,

$$R_2 = \left\{\left(0, \frac{T}{n-1}, \dots, \frac{T}{n-1}\right), \left(\frac{T}{n-1}, \frac{T}{n-1}, 0, \dots, \frac{T}{n-1}\right), \dots, \left(\frac{T}{n-1}, \dots, \frac{T}{n-1}, 0\right)\right\}.$$

The expected payoff of player 1 is greater than u_i^* if

$$E_1 + \left(\frac{1}{n-1}\right)^{n-1} V > E_1 + V - \frac{T}{n}.$$

This is ruled out by assumption. There are many other possible deviations from the recommendation. Reflection, however, shows that the deviation we have considered is the most likely to increase the payoff of a player. Thus, split the cost equally is a collectively rational recommendation. ■

Proposition 2 formalises the idea that in a full agreement game that 'split the cost equally' is less ambiguous and more obvious than any other possible decision rule in a full agreement game. Many have argued that split the cost equally is an obvious solution to threshold public good games and so it is no surprise that Proposition 2 picks this up. We know, however, that split the cost equally is not a good description of how players behave in the standard game (e.g. Isaac, Schmidtz and Walker 1989; Suleiman and Rapoport 1992; Croson and Marks 2001; Coats et al. 2009). Instead we observe frequent deviations from the equal split. Interestingly, Proposition 2 also picks this up by demonstrating that 'split the cost equally' is not a collectively rational recommendation in the standard game. It is only in the full agreement game, therefore, that the equal split becomes too unambiguous and too obvious to miss.

We have now done enough to state our main hypothesis. Let us briefly remind of the key points: In a standard game we expect that groups will be inefficient at providing the public good. Proposition 1 suggests that this is because of low criticality. To increase efficiency we need, therefore, something to increase criticality. In a full agreement game players should feel critical if there is a realistic possibility of reaching agreement. Proposition 2 suggests that there is a realistic possibility of reaching agreement because 'split the cost equally' is a collectively rational recommendation. This motivates our main hypothesis.

Hypothesis 1: Success at providing the public good will be higher in a game with full agreement that in a standard game.

It is important to keep in mind that the conditions for providing the public good are much more stringent in a full agreement game than in a standard game. It is far from trivial, therefore, that Hypothesis 1 will hold. It will only hold if *all* players react to the change in incentives in the way we have predicted. It is an empirical question whether or not they do.[8]

Before moving on to the experimental analysis we shall briefly revisit the role of endowment asymmetry and the assumptions that player identity and player endowment are private information. To assume that player identity is private information is very mild.[9] Moreover, if the game is symmetric then the assumption that player endowments are private information is irrelevant. Proposition 2 applies, therefore, without any qualification to the symmetric games that are most often considered in the literature. In asymmetric games, however, the assumption that endowments are private information warrants more consideration. To illustrate consider the decision rules in table 3 that are conditional on player endowments, are framed in terms of a coordination game with parameters corresponding to those in table 2. Decision rules 'split the cost proportionally' and 'split the cost so payoffs are fair' are intuitive but only possible if player endowments are common knowledge. The assumption that player endowments are private information thus rules them out.

Table 3: Decision rules.

Decision rule	Benchmark	Asymmetric	Very asymmetric
Equal split	(25,25,25,25,25)	(25,25,25,25,25)	(25,25,25,25,25)
Proportional split	(25,25,25,25,25)	(21,21,21,31,31)	(11,11,11,46,46)
Fair split	(25,25,25,25,25)	(15,15,15,40,40)	(0,0,0,62.5,62.5)

The assumption that player endowments are private information is, therefore, not innocuous. Without this assumption, however, there is no collectively rational recommendation in the full agreement game, unless it is symmetric. The intuition for this being that there is no sense in which, say, the equal split is any less ambiguous or more obvious than the proportional split, according to the definition of a collectively rational

[8] Some evidence to suggest they may is provided by van de Kragt et al. (1983). They showed that groups are very efficient at providing public goods if a minimal contributing set had been agreed in pre-play verbal communication. Evidence from the weak link game, however, gives reason to be less optimistic. The weak link game resembles the full agreement game in that coordination of all players is needed to achieve Pareto efficiency. Large inefficiency is typically observed.

[9] For instance, it seems unreasonable that were players to agree on the decision rule 'someone contribute zero and split the cost amongst others' they would all independently know who the 'someone else' should be.

recommendation. One could, thus, argue that it may be harder for players to achieve agreement in an asymmetric game. Personally, however, we feel that this need not be the case. To motivate this view, one could consider a weaker notion of collectively rationality and argue that the equal split is 'more obvious' than, say, the proportional split (Janssen 2006). This, however, seems somewhat ad-hoc and contrary to evidence in the psychology literature (van Dijk and Wilke 1993, 1995).[10] Our preferred view is to say that, even though player endowments are common knowledge, players may not focus on them or may not expect others to focus on them. One justification for this being that the equal split 'works' irrespective of endowments while things like a fair split and proportional split are conditional on endowments and so it makes sense to ignore endowments. This would be sufficient to justify the assumption that player endowments are private information, and is not unreasonable given that players are asked to specify a vector of contributions (Harris and Joyce 1980). Proposition 2 can, therefore, reasonably be applied to asymmetric games.

4. Experiment design

As already mentioned, we consider Hypothesis 1 an empirical question and so now report on experiments designed to evaluate it. In the experimental design, each of the four games presented in table 1 corresponds to a treatment. Thus, our standard treatment corresponds to the standard game used in the threshold public goods literature. The standard treatment with feedback, communication treatment, and full agreement treatment are motivated and described in more detail in Section 2. The main things to recall here are that, in the standard treatment and standard treatment with feedback subjects must simply decide how much of their endowment to contribute to the public good, while in the communication treatment and full agreement treatment subjects must decide on a vector of contributions specifying how much each group member should contribute to the public good. Moreover, in the standard treatment subjects are only informed at the end of the game of total contributions, while in the standard treatment with feedback subjects are also informed of the breakdown of contributions, and in the communication and full agreement treatments subjects are informed of the vectors of contributions chosen by others. A screen shot for the full agreement treatment is shown in the appendix.

[10] The argument would be that there is only one way to split the cost equally but lots of ways to split the cost asymmetrically. There is, however, only one way to split the cost proportionally but lots of ways to split the cost non-proportionally. The stronger notion of a collectively rational recommendation avoids such problems.

Each experimental session was divided into three parts, as summarised in Table 4. In part 1, subjects played a game with parameters corresponding to those in the benchmark game, as already detailed in Table 2, for 10 rounds. In part 2 they played a game with parameters corresponding to those in the asymmetric game for 10 rounds, and in part 3 they played a game with parameters corresponding to those in the very asymmetric game for a final 10 rounds. The type of game played, standard, standard with feedback or communication or full agreement, was the same in all three parts of a session. Note that subjects retained their role within the group throughout a part. Thus, a subject endowed with, say, 70 in an asymmetric game was endowed with 70 in all 10 rounds. Also, each subject was randomly assigned a label, such as 'player 1', at the beginning of each part. This also was kept throughout the part. (No label was linked with a specific value of endowment, unlike what is shown in table 2, where 'player 4' and 'player 5' receive a higher endowment in asymmetric games and very asymmetric games.)

The groups, of 5, were randomly assigned at the beginning of each part but remained fixed during the part. Fixed matching during each part of the session allows us to look for dynamic and learning effects as observed in previous threshold public good experiments (e.g. Cadsby et al. 2008). The use of three different sets of parameters allows us to consider symmetric and asymmetric games. The random matching between parts can potentially alleviate order effects from subjects playing, for example, a game with asymmetric endowments after experience of a game with symmetric endowments. We shall not, however, make a strong case for this. The use of the benchmark parameters in part 1 allows an unambiguous comparison of behaviour across treatments in the benchmark, symmetric case considered in the literature. Parts 2 and 3 allow us to compare behaviour across treatments as subjects are exposed to progressively more asymmetric endowments.

Table 4: Experimental Design.

Session	Treatment (Type of game)	Part 1 Rounds 1-10	Part 2 Rounds 11-20	Part 3 Rounds 21-30	No. of groups per part
5	Standard	Benchmark	Asymmetric	Very asymmetric	4
2	Standard with feedback	Benchmark	Asymmetric	Very asymmetric	4
3, 6, 7	Communication	Benchmark	Asymmetric	Very asymmetric	12
1, 4, 8	Full agreement	Benchmark	Asymmetric	Very asymmetric	12

The experiments were run at the University of Kent involving subjects recruited from the general student population. The interactions were anonymous and the experiments were computerized using z-tree (Fischbacher 2007). We took care to recruit subjects who had not taken part in similar experiments before. We ran 8 sessions in all giving a total of 160 subjects. [11] Subjects were paid in cash at the end of the session an amount equal to their payoff over the 10 rounds multiplied by 1p for one of the three parts. The relevant part was randomly selected for each subject. Each session lasted about 40 minutes and the average payment was £6.55.[12] Full details of the instructions used for each treatment are provided in the appendix. At the end of each part subjects were asked to fill in a short questionnaire regarding their general experience in the 10 rounds. Subjects were not paid for answering the questionnaires but had to answer all of the questions in order to proceed with the experiment. The analysis of the questionnaire responses is beyond the scope of the current paper.

5. Experimental results

5.1 Overview of the results

To give a first overall picture of the results, figure 1 plots the success rate at providing the public good over time in the four treatments, table 5 summarizes the success rate at providing the public good in the first five rounds and last five rounds in the four treatments, and table 6 summarizes total contributions in the four treatments. Note that the average success rates and average contributions in the standard treatment are very similar to those observed in other studies (e.g. Cadsby et al. 2008).

[11] Note that six sessions were run with 20 subjects, whereas one session involved 25 subjects and another session had 15 subjects.

[12] There was no show-up fee. Instead, student participants were guaranteed a minimum earning of £5.00 per hour experiment.

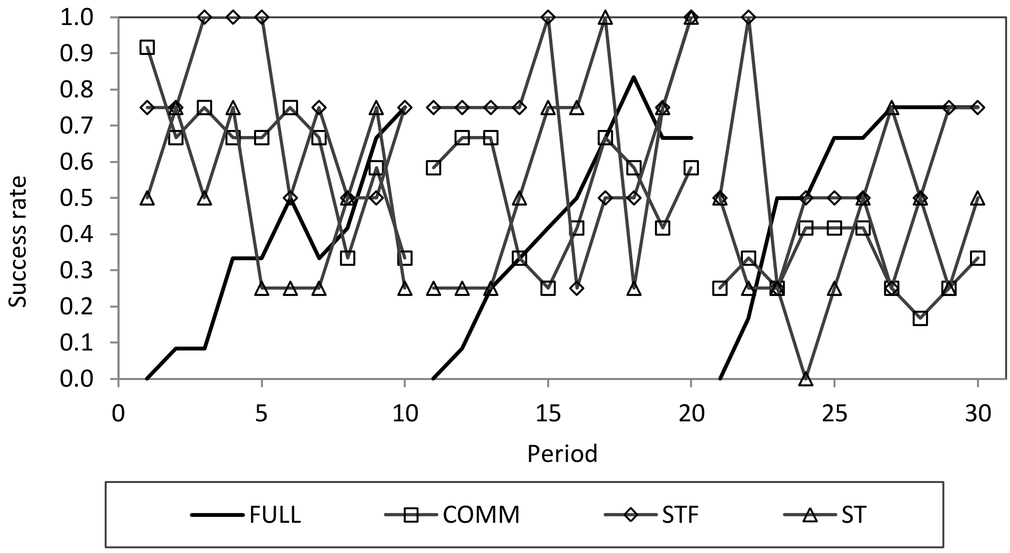


Figure 1: Success rates in the four treatments.

The most noticeable difference between treatments is in the dynamics of the success rate. Broadly speaking, the success rate appears stable or decreasing across the 10 rounds of each part in the standard treatment, standard treatment with feedback, and communication treatment, while it is increasing in the full agreement treatment. Indeed, in the first round of the full agreement treatment the success rate is consistently equal to zero. However, by the end of the ten rounds, the success rate reaches the level of 75% in part 1 and part 3 and the level of about 67% in part 2. (Notice that, across all treatments, 75% was the highest success rate in parts 1 and 3, and 67% was the second highest success in part 2.) We shall come back to these effects in more detail in Section 5.2.

Table 5: Success rates over the ten rounds.

	Success rate for provision %								
	Part 1			Part 2			Part 3		
Treatment	First five	Last five	All	First five	Last five	All	First five	Last five	All
Standard	55	40	47.5	40	75	57.5	25	50	37.5
Standard with feedback	90	60	75	80	60	70	55	55	55
Communication	73.3	53.3	63.3	50	53.3	51.7	33.3	28.3	30.8
Full agreement	16.7	53.3	35	21.7	66.7	44.2	36.7	73.3	55

It is also noteworthy that the success rate appears stable or decreasing across the three parts in the standard treatment, standard treatment with feedback, and communication treatment, while it is increasing in the full agreement treatment. This contributes to the success rate in the full agreement treatment being relatively low in part 1 and relatively high in part 3. The thing that stands out in table 6 is the relatively high contributions in the full agreement treatment. It is also noticeable that total contributions are decreasing in all four treatments and that, in part 3, total contributions in the full agreement treatment are similar to those in the other treatments.[13]

Table 6: Group contributions over the ten rounds.

	Average group contribution								
	Part 1			Part 2			Part 3		
Treatment	First five	Last five	All	First five	Last five	All	First five	Last five	All
Standard	133.5	123.8	128.6	128	134.4	131.2	109	119.3	114.2
Standard with feedback	156.3	131.8	144.1	135	126.9	130.7	126.3	122.7	124.5
Communication	139.1	122.4	130.7	125	128.9	126.9	108.7	98.25	103.5
Full agreement	165.7	159.5	162.6	154.3	151.4	152.9	124.4	121.3	122.8

Before proceeding to a more formal analysis of the data we provide figure 2 which allows an alternative comparison between the full agreement treatment and the other three treatments. It shows the success rate that would have been achieved if the rules for the provision of the public good would have been the same in the full agreement treatment as the communication and standard treatments. That is, it shows the success rate that would have been achieved if we removed the need for agreement. We see that success rates would have been very high, especially in parts 1 and 2. Thus, any lack of success in the full agreement treatment comes for a lack of agreement and not an unwillingness to contribute. This allows us to reconcile the high contributions we observe in table 6 with the not so high success rate in table 5. Note also, that in part 3 the actual success rate in figure 1 more closely resembles the hypothetical success rate in figure 2. This suggests that reaching agreement was less difficult by part 3 than in parts 1 and 2.

[13] Notice that, in all four treatments, total contributions are obtained by adding up own contributions as given even if the public good is not provided.

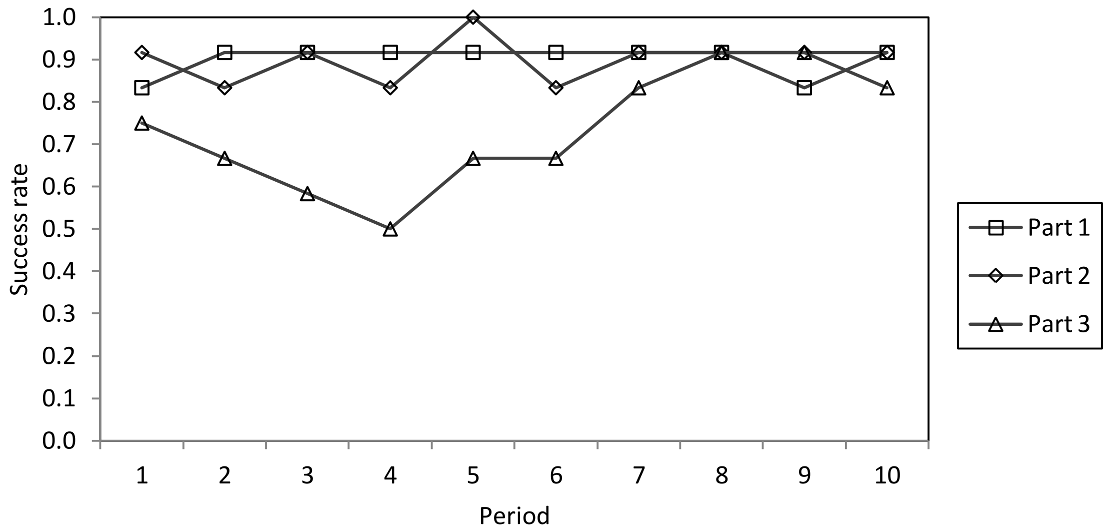


Figure 2: Success rate in the full agreement treatment if we removed the condition that all players must agree.

5.2 Success rates

In order to get a better idea whether there were significant differences between treatments in terms of the success at providing the public good over time we report results of a random-effects probit regression with the probability of success as the dependent variable. In table 7 we report estimates of two models in which the dependent variable takes value 1 if the group was successful and 0 otherwise. In the 'first model' we used four non-interactive independent variables including round number (round) and a dummy variable for each of the following treatments: standard with feedback (STF), communication (COMM), and full agreement (FA). We also used the following interactive independent variables: STF_round, COMM_round, and FA_round. Note that this implies the standard treatment is the comparator treatment. By removing seemingly insignificant variables we obtain the 'last model'.

Table 7: Results of a random-effects probit regression of the probability of success, period number (period), treatments (STF, COMM, FULL), and interaction between period number and treatments (STF*Period, COMM*Period, FULL*Period). Standard errors in brackets; * indicates significant at the 10% level, ** at the 5% level, and *** at the 1% level.

Variable	Part 1		Part 2		Part 3	
	First Model	Last Model	First Model	Last Model	First Model	Last Model
Period	-0.060 (0.071)	-0.126*** (0.036)	0.228*** (0.085)	0.321*** (0.053)	0.091 (0.087)	0.015 (-0.037)
STF	1.147 (0.832)	_	1.667* -0.949	2.566*** (0.761)	1.031 (-1.068)	_
COMM	1.05 (-0.658)	_	1.193 (0.785)	2.093*** (0.550)	0.240 (0.916)	_
FULL	-2.522*** (0.709)	-3.380*** (0.542)	-1.341 (0.852)	_	-0.708 (0.927)	-1.085* (0.607)
STF*Period	-0.058 (0.106)	_	-0.240** (0.114)	-0.333*** (0.093)	-0.071 (0.114)	_
COMM*Period	-0.098 (-0.085)	_	-0.248** (0.096)	-0.341*** (0.069)	-0.102 (-0.1)	_
FULL*Period	0.361*** (0.093)	0.432*** (0.071)	0.145 (-0.109)	_	0.246** (0.108)	0.324*** (0.075)
Const	0.266 (-0.548)	1.093*** (0.276)	-1.017 (0.684)	-1.917*** (0.396)	-0.994 (0.793)	-0.634* (0.357)
No. of obs.	320	320	320	320	320	320
No. of groups	32	32	32	32	32	32

The results in table 6 show a highly significant increasing success rate in the full agreement treatment in all parts.[14] By contrast, in part 1, the success rate is decreasing in the other three treatments; in part 2, it is increasing in the standard treatment but stable in the other two treatments; in part 3, it is stable in the other three treatments. This is clear evidence of the dynamic effect we previously noted in which there is a tendency for the success rate to increase in the full agreement treatment and not other treatments. On the other hand, the overall success rate in the full agreement treatment is lower than in the other treatments, and significantly so in part 1. The end result is a prediction of lower success rates in the full agreement treatment in earlier rounds but higher success rates by later rounds. By the end of part 3 success rates are predicted to be significantly higher in the full agreement treatment than in any other treatment.

[14] In parts 1 and 3 this is clear from the coefficient on FULL*Period. In part 2 we need to recognise that the Period coefficient is highly significant and the FULL*Period not, and so success is again modelled as increasing.

We see this as evidence consistent with hypothesis 1. Clearly, we see that subjects needed time to learn and the requirement of full agreement is not conducive to success without experience. With experience, however, success rates in the full agreement treatment were high, reaching an average over 70%, and higher than in other treatments. Also success was more lasting. We clearly see in figure 1, that success tended to be permanent in the full agreement treatment but transitory in the other three treatments. Despite, therefore, the requirement of full agreement making it more difficult in principle for groups to provide the public good, we suggest that it can help them to succeed. We shall next question whether it did so for the reasons we suggested it might in Section 3.

5.3 Individual choices

To get a better idea of how criticality and focal points could make a difference in terms of increasing success rate in the full agreement treatment, in this section we compare choices made by subjects in the full agreement and communication treatments. Before doing this we note that feedback and communication of itself appeared to make little difference. In particular, the results summarized above suggest that success rates in the full agreement treatment had a very different dynamic pattern to those in the communication treatment. Also, success rates were significantly higher in the full agreement treatment than the communication treatment after sufficient repetition. It is the requirement of full agreement, therefore, that appears to make the difference. This appears consistent with our interpretation of Proposition 2, namely that full agreement focuses attention on the equal split focal point and thereby increases perceptions of criticality.

To back this interpretation up we can consider choices made by subjects who successfully coordinated with other group members in the last round of the full agreement treatment. These choices are summarized in table 8. Summing over individual contributions, total contributions were just equal to the threshold T for five of nine groups that were successful in part 1, six of eight groups that were successful in part 2, and all nine successful groups in part 3. This suggests an increase in the efficiency of contributions from part 1 to part 3. The thing that stands out in table 7 is that most groups coordinated on the equal split, i.e. (25, 25, 25, 25, 25), even in parts 2 and 3 where player endowments were not identical.

In part 1, all successful groups coordinated on a symmetric vector of contributions and most on the equal split. In part 2, one group did coordinate on the fair split (i.e. 15, 40, 40, 15, 15), and another group coordinated on something close to the proportional split, i.e.

(19, 19, 19, 34, 34), while the other groups coordinated on a symmetric vector. In part 3, one group coordinated on again something close to the proportional split, i.e. (9, 49, 9, 49, 9), while the other eight groups coordinated on the equal split.[15] This suggests that the equal split was a strong focal point. It also suggests that in parts 2 and 3, where player endowments were asymmetric, subjects did not focus on endowments (or did not expect others to focus on the endowments). This is entirely consistent with Proposition 2.

Table 8: Coordination rules in round 10.

Part 1		Part 2		Part 3	
Group	Choice	Group	Choice	Group	Choice
1	(30, 30, 30, 30, 30)	13	—	25	(25, 25, 25, 25, 25)
2	(55, 55, 55, 55, 55)	14	(45, 45, 45, 45, 45)	26	(25, 25, 25, 25, 25)
3	(25, 25, 25, 25, 25)	15	(25, 25, 25, 25, 25)	27	(25, 25, 25, 25, 25)
4	—	16	(40, 40, 40, 40, 40)	28	(25, 25, 25, 25, 25)
5	(30, 30, 30, 30, 30)	17	—	29	(25, 25, 25, 25, 25)
6	(25, 25, 25, 25, 25)	18	(15, 40, 40, 15, 15)	30	(25, 25, 25, 25, 25)
7	(25, 25, 25, 25, 25)	19	—	31	—
8	—	20	(25, 25, 25, 25, 25)	32	—
9	(25, 25, 25, 25, 25)	21	(25, 25, 25, 25, 25)	33	(25, 25, 25, 25, 25)
10	(40, 40, 40, 40, 40)	22	(25, 25, 25, 25, 25)	34	(25, 25, 25, 25, 25)
11	(25, 25, 25, 25, 25)	23	—	35	(9, 49, 9, 49, 9)
12	—	24	(19, 19, 19, 34, 34)	36	—

To further explore the role of criticality and focal points we compare choices made by subjects in the first round and in the last round of the full agreement and communication treatments. Figure 3 shows the number of subjects suggesting an equal contribution, that is choosing a symmetric vector of contributions, in the relevant round of the full agreement and communication treatments. Notice that each treatment involved 60 subjects, so the frequencies in one treatment can be directly compared to those in the other treatment. There are two key observations we would make with regard to figure 3. First, we see that the proportion of subjects choosing an equal contribution in the full agreement treatment is significantly higher than in the communication treatment, for both rounds and all parts.

[15] Notice that, in part 3, not only the equal share of the cost but also the endowment of three of five group members was equal to 25. So perhaps (25, 25, 25, 25, 25) was even more obvious choice than it was in part 2. However, one should also notice that (25, 25, 25, 25, 25) was also chosen in part 2, where player endowments were equal to 45 and 70.

Second, the proportion of subjects choosing an equal contribution is relatively stable between rounds 1 and 10 in the full agreement (and communication treatment).

These two observations are exactly what we would expect given our interpretation of Proposition 2. The first observation is consistent with the equal split being more focal in the full agreement game that in the communication game. The second observation is important in understanding the dynamics of play in the full agreement game. In particular, it suggests that the increasing success rate we observe in the full agreement treatment is due to a small number of subjects learning how to coordinate with the majority, and not so more complex learning dynamic. A large number of subjects chose the equal split in the first round and it just takes time for other members of the group to coordinate with this. Arguably, therefore, what subjects need to learn is not the equal split but criticality.

We also looked at the distributions of unequal contribution choices including the proportional split and the fair split in the two treatments. For the communication treatment, these distributions appear to be highly dispersed (i.e. either perfectly- or nearly-uniform), equally for the first round and the last round within each part. For the full agreement treatment, there is a relatively high concentration around the fair split and the proportional split in the last round, for both parts 2 and 3.

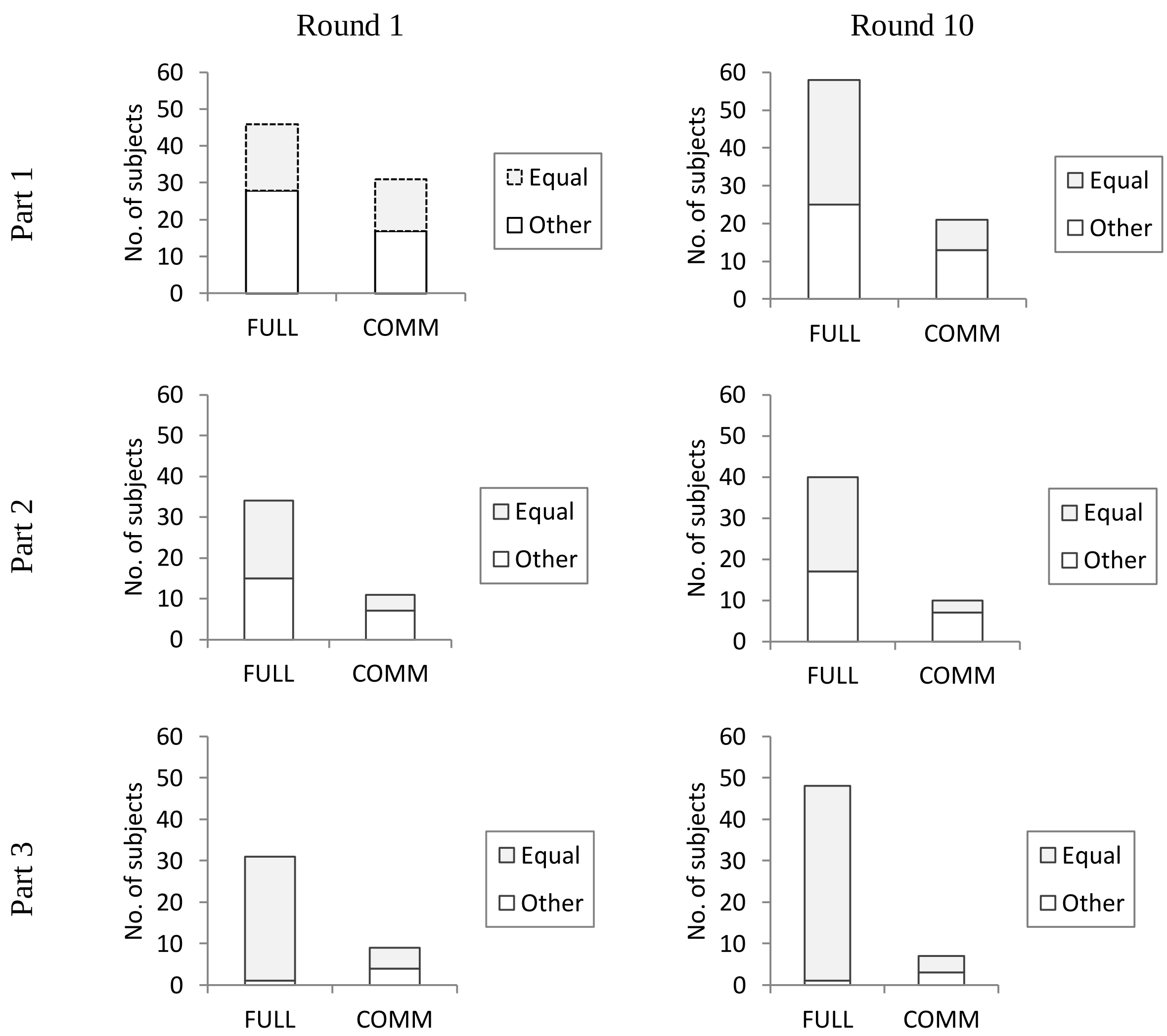


Figure 3: Choices of an equal contribution vector in the full agreement and communication treatments. Treatments on the x-axis, number of subjects on the y-axis. Light grey bar identifies the number of subjects choosing the equal split. White bar identifies the number of subjects choosing an equal contribution different to the equal split.

6. Conclusions

Many public goods can be implemented as threshold public goods so it is very important to know how threshold public goods can be provided efficiently. The evidence suggests that success at providing threshold public goods is significantly below that is expected in theory. The question is then how to increase the success rate. In this paper we investigate both theoretically and experimentally the effect of increasing criticality in threshold public goods games by requiring that players must agree on how much every group member should contribute.

We show that if no agreement is required criticality can be very low (Proposition 1). This can account for the relatively low success rate in previous experiments. We further show that if full agreement is required the equal split is a collectively rational recommendation if both player identity and the endowment are private information (Proposition 2). This suggests that players should be able to reach agreement and that criticality should be higher if full agreement is required. We thus hypothesized that success would be higher if full agreement was required. Our experimental results are consistent with our theoretical ones. We find that success at providing the public good is higher when players are required to reach an agreement, provided they have had sufficient experience. Increasing communication alone is not enough. We also find evidence that splitting the cost equally is a focal point that enables coordination.

We feel these results are important as they show that both criticality and focal points may play a very important role in public good provision. Specifically, it may be appropriate to require full agreement before a public good will be financed because this will increase perceived criticality. In real world applications, particularly as group size increases and the benefits of the public good become highly asymmetric, we may find situations in which it does not make sense to require all group members to agree. It may still, however, be appropriate to require some level of agreement in order to increase criticality. Indeed, there may be an optimal level of agreement required to trade-off the increase in perceived criticality with the difficulty of getting many to agree.

Appendix

A. Instructions for the standard treatment and standard treatment with feedback

In this experiment you will make decisions, and earn an amount of money that depends on what you and others choose. The money will be given to you at the end of the experiment. Only you will know how much money you earned.

The session will be divided into 3 parts. Each part will last for 10 periods. In each part you will be organised into groups of 5.

In each period you will receive a certain number of tokens. You will be asked to say how many tokens you want to allocate to a group account. The other four people in the group will do the same. If the sum of tokens that each person allocates is greater than or equal to 125 then you all receive an additional 50 tokens.

So, your payoff for the period is:

If the sum of tokens allocated to the group account $\geq$ 125

payoff = initial number of tokens – tokens allocated to group account + 50

If the sum of tokens allocated to the group account $<$ 125

payoff = initial number of tokens

As we said earlier, the experiment will consist of 3 parts of 10 periods each. In each part of the experiment the 5 people in your group will stay the same and the amount of tokens initially given to each person will stay the same. In each different part of the experiment there will be different people in your group and the amount of tokens initially given to each person will change. This will be indicated on your computer screen.

At the end of each part, you will be asked to fill in a short questionnaire.

Your total earnings will depend on your decisions in the 10 periods. You will be paid in cash the total amount that you earned for one of the three parts in the session. Each token will be worth 1p.

B. Instructions for the communication treatment

In this experiment you will make decisions, and earn an amount of money that depends on what you and others choose. The money will be given to you at the end of the experiment. Only you will know how much money you earned.

The session will be divided into 3 parts. Each part will last for 10 periods. In each part you will be organised into groups of 5.

In each period you will receive a certain number of tokens. You will be asked to say how many tokens you think each person should allocate to a group account. That is, you should say how many tokens you want to allocate for yourself, and how many tokens you think each of the other four people in the group should allocate. The other four people in the group will do the same. If the sum of tokens that each person allocates for him or herself is greater than or equal to 125 then you all receive an additional 50 tokens.

To illustrate, consider this example (**and it is just an example with arbitrary numbers**) where each person is allocated 70 tokens. Person 1 is saying that he or she should allocate 50 tokens to the group account, person 2 should allocate 40 tokens, and so on. In this case they will receive the additional 50 tokens because the sum of tokens each person allocates for him or herself (person 1 allocates 50, person 2 allocates 10, person 3 allocates 30, person 4 allocates 40 and person 5 allocates 20) is greater than 125.

	How much each person should allocate to the group account				
	Person 1	Person 2	Person 3	Person 4	Person 5
Person 1	50	40	60	20	10
Person 2	30	10	60	40	30
Person 3	30	30	30	30	30
Person 4	30	10	60	40	30
Person 5	40	30	10	30	20

To summarize: Your payoff for the period is:

If the sum of tokens each person allocates for him or herself to the group account $\geq$ 125

payoff = initial number of tokens – tokens allocated to group account + 50

If the sum of tokens allocated to the group account $<$ 125

payoff = initial number of tokens

As we said earlier, the experiment will consist of 3 parts of 10 periods each. In each part of the experiment the 5 people in your group will stay the same and the amount of tokens initially given to each person will stay the same. In each different part of the experiment there will be different people in your group and the amount of tokens initially given to each person will change. This will be indicated on your computer screen.

At the end of each part, you will be asked to fill in a short questionnaire.

Your total earnings will depend on your decisions in the 10 periods. You will be paid in cash the total amount that you earned for one of the three parts in the session. Each token will be worth 1p.

C. Instructions for the full agreement treatment

In this experiment you will make decisions, and earn an amount of money that depends on what you and others choose. The money will be given to you at the end of the experiment. Only you will know how much money you earned.

The session will be divided into 3 parts. Each part will last for 10 periods. In each part you will be organised into groups of 5.

In each period you will receive a certain number of tokens. You will be asked to say how many tokens you think each person should allocate to a group account. That is, you should say how many tokens you want to allocate for yourself, and how many tokens you think each of the other four people in the group should allocate. The other four people in the group will do the same. If everyone in the group says the same thing, and the sum of tokens that each person allocates is greater than or equal to 125, then you all receive an additional 50 tokens.

To illustrate, consider this example (**and it is just an example with arbitrary numbers**) where each person is allocated 70 tokens. Person 1 is saying that he or she should allocate 50 tokens to the group account, person 2 should allocate 40 tokens, and so on. In this case they will not receive the additional 50 tokens because they do not all say the same thing. Person 2 and 4 do say the same thing but it is necessary for all five to agree in order to receive the extra 50 tokens.

	How much each person should allocate to the group account				
	Person 1	Person 2	Person 3	Person 4	Person 5
Person 1	50	40	60	20	10
Person 2	30	10	60	40	30
Person 3	30	30	30	30	30
Person 4	30	10	60	40	30
Person 5	40	30	10	30	20

To summarize: Your payoff for the period is:

If everyone says the same thing, and the sum of tokens allocated to the group account ≥ 125 payoff = initial number of tokens – tokens allocated to group account + 50

If some do not say the same thing and/or the sum of tokens allocated to the group account < 125

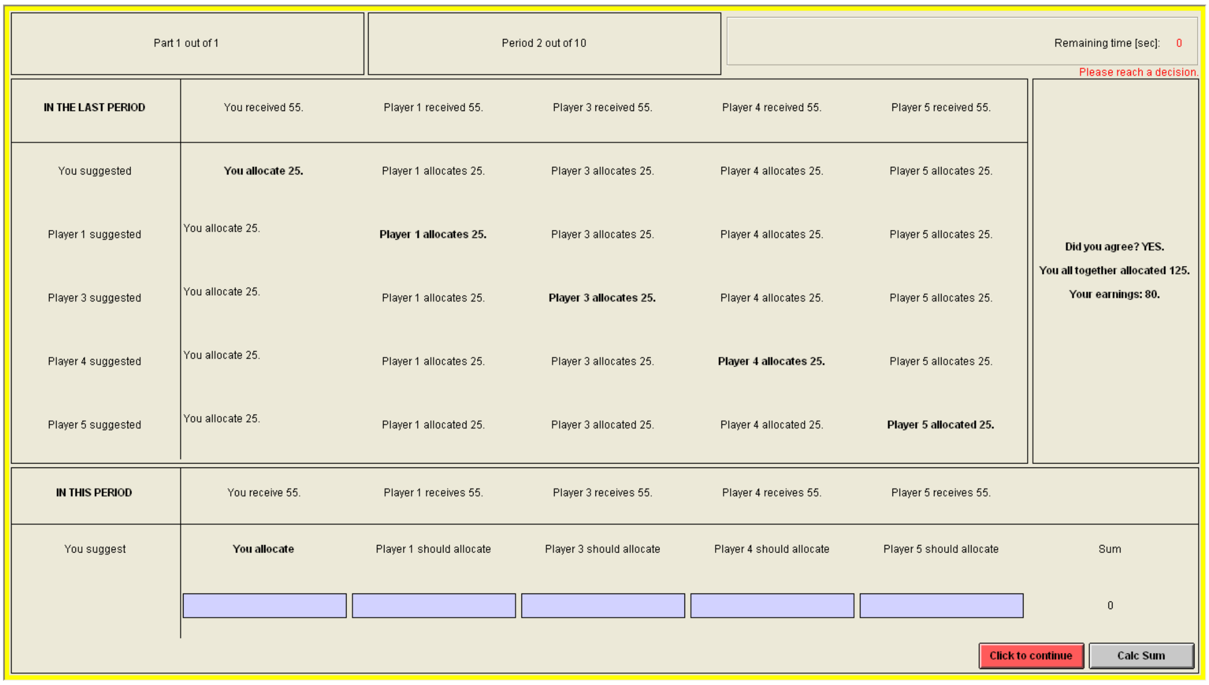
payoff = initial number of tokens

As we said earlier, the experiment will consist of 3 parts of 10 periods each. In each part of the experiment the 5 people in your group will stay the same and the amount of tokens initially given to each person will stay the same. In each different part of the experiment there will be different people in your group and the amount of tokens initially given to each person will change. This will be indicated on your computer screen.

At the end of each part, you will be asked to fill in a short questionnaire.

Your total earnings will depend on your decisions in the 10 periods. You will be paid in cash the total amount that you earned for one of the three parts in the session. Each token will be worth 1p.

D. Screen shot for the full agreement treatment



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