Social Capital and the Voluntary Provision of Public Goods[*]

by

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Abstract. Individual contributions to public good investments are subject to the classic problem of free riding. We investigate the possibility of overcoming the free-riding problem through creating social capital via communication. Drawing on social capital literature and organizational management literature, we design a novel public-goods experiment with two kinds of communication treatments. The experiment is designed to allow for robust difference-in-differences estimation of treatment effects on individual contributions to public goods. The first treatment involves structured communication via a task-oriented team-building exercise. The second involves undirected communication via a free-form interaction exercise. Two additional treatments are used to examine whether the effects of social capital on free-riding are limited at the group level or extend beyond the group. These treatments involve reallocating subjects to new groups after they participate in structured or free-form communication. We find that both forms of social capital creation increase public good contributions when individuals stay in the same group. Unstructured communication brings public good contributions closer to the efficient level than team-building when individuals remain in the same group after treatment. Further, the effect of unstructured communication is more persistent. However, when individuals are allocated to new groups, there is far less evidence of social capital creation: team-building causes a small increase in public good investments, but unstructured communication no longer has an effect.

Keywords: Social Capital, Public Goods, Free Riding, Communication

JEL Areas: C72; H41; C91; C92

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1. Introduction

Voluntary private contributions to public goods are subject to the classic problem of free riding (Buchanan, 1968; Johansen, 1977).[1] Social capital, defined as the set of values and beliefs that help cooperation (Guiso et al., 2011), by definition, is a potential cure to the problem. This paper examines whether free-riding incentives can be overcome by social capital creation via two methods of intra-group communication. One method is a directed team-building exercise, and the other is a undirected free-form interaction exercise. We selected these methods to compare the effects of (1) a goal-oriented (cooperation being the goal), structured intervention to (2) an unstructured, undirected free-form intervention that potentially create social capital through the channel of 'socialization' identified by Guiso et al. (2011). In response to the debate surrounding whether social capital constitutes of resources embedded in social relations rather than individuals, we also examine if the effects of social capital created through these interventions are limited to the group level or if the effects extend to the individual level by switching subjects across groups after treatment. Our results show that both methods reduce free riding when individuals play the public goods game with the same group after treatment. Further, contributions are significantly greater, statistically and economically, and more persistent, under the free-form communication treatment when individuals remained in the same group after treatment. In contrast, free-form communication has no effect on public goods contributions, and the positive effect of team-building is significantly diminished, when players are switched to new groups after treatment.

The relative effectiveness of these two general approaches in altering free-riding has implications for a broad set of applications: If free-form communication is at least as effective as team building, managers in business organizations should consider whether expending resources on team-building exercises is cost-effective. Policymakers attempting to avoid the tragedy of the commons may be tempted to guide communication toward cooperation and teamwork. Our results suggest that this formal structure might not work—rather, a hands-off approach might be more beneficial. This result is consistent with field work that has found spontaneous community solutions to be more successful than structured, government-managed approaches to public goods problems (Ostrom, 2010, 1990).

[1] See McMILLAN (1979) for an in-depth survey of the literature on this classic problem.

Past studies investigating the relative effectiveness of casual communication versus team-building exercises also conclude that casual communication is more effective (e.g Pentland 2012). Our findings in the treatments where we switch individuals to new groups, however, suggests that the nature of the relationship is more subtle, and nuanced. Whereas unstructured, casual communication is more effective in curbing free-riding when subjects remain in the same group after treatment, this effect vanishes if subjects are switched to new groups after treatment. The effect of the team-building exercise, although weakened, does not entirely vanish when subjects are switched. If managers in organizations foresee switching workers to different teams regularly, team-building exercises may still be more cost-effective due to workers free-riding to a lesser extent even after they are switched to new teams. If managers in organizations do not foresee frequently switching workers to new teams, then casual communication interventions may be more cost-effective, since within a group, casual communication has a stronger and more persistent effect in curbing free-riding behavior.

Social capital's weakly positive effect on curbing free-riding when individuals are reallocated to new groups after treatment also has an important lesson for the social capital literature. Whereas the effect of social capital exists, and should be conceptualized, across individual members of a group or a network rather than within an individual in isolation, the positive group externality of social capital may be transferable in certain cases. The team-building treatment does have a weakly positive impact on individual contributions even when participants play with individuals who were not a part of their team during the exercise. These contributions are, however, lower than contributions when individuals continue to play with team members. Future economic studies related to social capital must take this group-specific existence, but weak transferability of the returns into consideration, because the assumption—common in certain studies of social capital—that social capital is a trait of individuals in the economy, which can be aggregated up (see Costa and Kahn 2003, or Glaeser et al. 2002 for instance), may be misguided, and could lead to erroneous conclusions.

2. Previous Findings & Our Contribution

This paper contributes to, and is motivated by, four strands of literature. We review these in the context of our contribution in this section.

2.1. **Free riding in public good games**

Although standard game theory based on rational behavior predicts all people will free ride and contributions should be zero in public good games, previous research has shown many factors can influence individuals' willingness to cooperate. Ostrom (2000) reviews this literature in detail. These factors include the longevity of the game, the ability of participants to communicate during the game, the existence of "conditional cooperators," and the existence of "willing punishers" (Ostrom, 2000). Punishment methods include internal punishments in which the punisher contributes zero in retaliation, or external punishments in which the punisher berates non-cooperative players through communication (Fehr and Gachter, 2000). The roles of conditional cooperators and willing punishers are reinforced if such individuals are able to communicate their intentions (Ostrom, 2000). The relevant information from this strand of the literature is that, even in the absence of any treatments, we should not expect actual voluntary contributions to public goods to equal the rational contribution of zero.

2.2. **Social capital and free riding**

Another strand of literature argues that the efficiency of social exchange can be enhanced by the creation of "social capital." Although the definition and measurement of social capital varies across the literature,[2] the consensus is that the presence of social capital—group, network, or community characteristics such as norms and trust that benefit collective action—can override free-riding incentives and promote cooperation (Putnam et al., 1993; Fukuyama et al., 1995; Woolcock and Narayan, 2000; Bowles and Gintis, 2002). Guiso et al. (2011) define social capital as the set of shared beliefs and values that "help a group overcome the free rider problem in pursuit of socially valuable

[2] The lack of an unambiguous unifying definition for the concept in the literature is perhaps the main reason for a number of authors, including Solow (1995) and Dasgupta (2000), criticizing certain usages of the term. Guiso et al. (2011) interpret this criticism to indicate, for social capital to remain meaningful in any economic setting, an urgent need of dealing with the present ambiguity and adapting a precise definition that (i) clearly distinguishes social capital from human capital; and (ii) explains accumulation and depreciation mechanisms for social capital.

objectives."[3] The Saguaro Seminar at the Harvard Kennedy School[4] defines social capital as "the collective value of all 'social networks' and the inclinations that arise from these networks to do things for each other." These "inclinations" are also described as "norms of reciprocity," which are analogous to the social norms emphasized by Ostrom's work on collective action problems (Ostrom, 2000). Thöni et al. (2012) provide a summary of research which relates the concept of social capital to the levels of trust expressed by individuals, and show a positive relationship between cooperative behavior in a public goods game experiment and trust levels measured by survey responses. Using a laboratory setting, Anderson et al. (2004) use both attitudinal and behavioral measures of social capital to test the influence of social capital on the contribution levels of participants in a public goods game. The authors find that higher social capital, in terms of both attitudinal and behavioral measures, lead to increased contributions. Attitudinal measures include responses to survey questions about the trustworthiness of strangers, while behavioral measures include whether participants have loaned money to a stranger or keep the door to their home unlocked. A potential pitfall for the Anderson et al. (2004) experiment is in measuring social capital based on preexisting characteristics of the individual participants. Such characteristics can measure social capital if it exists at the level of the individual. If social capital is an attribute of social relations that exist within a group or a network, as is emphasized by much of the economic literature on social capital (e.g, Dasgupta 2000; Durlauf and Fafchamps 2005; Ostrom 2000), preexisting individual-level traits such as trust and trustworthiness are inadequate measures. Altering treatments informs the process by which social relationships (groups, networks, or communities) are formed, and thereby, affect cooperation. Field research has emphasized the relationship between social networks and social capital. Leonard et al. (2010) find that social networks tend to be positively related to charitable contributions in low-income neighborhoods. The consensus across this literature is that social capital, irrespective of individual or group-level existence, promotes cooperation—higher voluntary private contributions—in public goods settings. Based on these views, we propose that changes in public goods contributions within a group, in a controlled environment, is an ideal way to measure the effects of changes in social capital, at the individual level or at the group level. We develop a model to explicitly establish this result in section 3.

[3] (Guiso et al., 2011) coin the term 'civic' capital to distinguish the novelty of their definition from prior notions that tend to be broader and more vague and ambiguous. They also argue that this definition adequately addresses all concerns raised by authors such as Solow (1995) (See Footnote 2).

[4] See http://www.hks.harvard.edu/programs/saguaro/about-social-capital

We also extend this line of research by adding treatments in which individual subjects are reallocated to new groups to play the public goods game after our two social-capital creation treatments. The extent to which social capital exists between individuals, as emphasized by Leonard et al. (2010) and others, rather than existing as an individual trait, as emphasized by Anderson et al. (2004), is essentially empirical. We respond to this open question by reallocating individuals to new groups after treatment. If public goods contributions increase more when individuals stay in the same groups after treatment then there is a networking aspect to the returns to social capital that cannot be measured within an individual. If social-capital creation completely breaks down when individuals switch teams, there is only a networking aspect, and social capital cannot be described as an individual trait.[5]

2.3. Communication in public good games

Guiso et al. (2011) identify three channels through which social capital accumulates: inter-generational transfers, education and socialization. Accumulation through the first two channels take time, whereas accumulation through the third channel can be immediate. Because of the obvious constraint of time in a lab setting, we focus on the third channel of accumulation—socialization. Socialization among group members can lead to 'group identities' and, in turn, modified individual preferences (Durlauf and Fafchamps, 2005). We formalize this mechanism in the model developed in Section 3 and develop the hypothesis that our two methods of communication, through the channel of socialization, create social capital which translates to greater cooperation among group members.

Previous studies have allowed face-to-face communication sessions in public goods experiments (Ostrom et al., 1992; Isaac and Walker, 1988). We contribute to this literature in three important ways. First, we test whether two methods of communication, through the channel of 'socialization' identified by Guiso et al. (2011), can create social capital. We formalize the argument in a model in Section 3 and derive testable predictions, which then we test in our experiment. Second, our team-building exercise is a directed communication session which allows us to causally compare the effect of such directed communication with undirected free-form communication. Third, our free-form communication session is novel in comparison to previous studies, such as Ostrom et al. (1992) and Isaac and Walker (1988), in several important ways. First, and foremost, we do not

[5] This argument is formalized in Proposition 3.3 in Section 3

monitor the conversations during the communication sessions. We believe that the presence of the monitor itself could be a confounding factor—the nature of conversations or communication among subjects could, due to the intrusion, be unnatural and confound the results. We allow the free-form communication session to evolve organically in the absence of such intrusion. Second, the subjects in past studies know from the outset that they will play another round of public goods games after the communication session; our subjects do not. This knowledge could lead to strategy building during the communication session, which may not fall under the definition of social capital formation. Since our goal is to isolate the role of communication in social-capital creation, we avoid informing subjects about the content of subsequent sessions. Subjects are only aware of what will happen during the current session. Third, past studies tell subjects that communication may be beneficial to cooperation in the game, which we avoid. Providing such information may provide a clue to the subjects that they will be playing again in subsequent stages of the experiment. We do not allow such anticipation regarding future stages of the experiment to influence the nature of communication during the communication session. Fourth, the subjects, in past studies, are explicitly told to not engage in physical threats of violence, which we avoid. We anticipate such explicit instructions could affect both the communication session and contributions after the sessions.[6] Finally, past studies prohibit conversations about side payments, which we do not. Such prohibition may also help subjects anticipate that the game will be repeated after the treatment.

We examine the effect of our communication-based treatments on cooperation in a public goods game, while controlling for individual characteristics which influence contributions (as in Anderson et al. (2004)) through random assignment, and by controlling for individual-specific effects in our estimation. In the first communication session—the team-building exercise—we prompt the participants to discuss and agree on "what makes a good team." Participants jointly agree on a team-building statement and each participant then signs the joint statement in a fashion similar to an oath.[7] This may help elicit the true social preferences of group members (Jacquemet et al., 2013). In the second communication session—the free-form communication session—participants are free to discuss whatever they like. The goal of the experiment is to (a) measure the effect of the two types of communication sessions on the formation of social capital, as measured by changes

[6] Threats of physical violence are illegal in Wyoming where the experiment was conducted. See https://legisweb.state.wy.us/statutes/compress/title06.doc. We do not anticipate subjects engaging in physical violence. Further, our experimental design and estimation strategy control for such individual-level effects. See sections 4 and 6 for details.

[7] For details, see the exact forms used for this session attached in Appendix A.

in public contributions after treatments; (b) to measure whether there are significant differences across the two treatments; and (c) to test whether social capital signifies resources at the level of an individual (whether individual traits such as trust or trustworthiness can measure social capital) or resources at the level of a group as a whole. Our emphasis is on how the treatments during the experiment, rather than preexisting group or individual characteristics, influence public good contributions, which in turn measure the influence of these treatments on social capital formation. Accordingly, we control for individual-level characteristics in our estimation strategy.

2.4. **Team-building exercises and team performance**

Directed team-building exercises are widely used in business organizations to reduce employee free riding and improve group performance. Evidence exists in the management literature that such team-building exercises can improve some measures of group performance (Klein et al., 2009). However, a widely cited survey of around 2000 British employees conducted in 2012 by Vodafone UK and YouGov found that most employees believed structured team-building exercises were a waste of time. The employees instead preferred greater ability to communicate freely (Telegraph, 2012). In another 2012 study, Pentland (2012) found that unstructured communication time during breaks improved team performance at the call center of a major bank.

While these studies suggest that free-form communication may be preferable to team-building exercises, they do not permit causal inference regarding the relative effectiveness of structured team-building exercises compared to unstructured, free-form communication. Confounding complexities of the real world provide context, but at the expense of control: The Vodafone-YouGov survey of British employees reflects how group members in the real world *perceive* the effectiveness of structured team-building exercises and how they *perceive* free-form communication. Whether these perceptions translate into actions—whether structured team-building *causally* changes employee performance, and whether communicating freely *causally* changes employee performance—is difficult to measure in real-world settings where employees self-select into organizations which may prefer one method over another. The absence of random assignment impedes causal inference. The study by Pentland (2012) shows that a positive correlation exists between unstructured communication and team performance—greater unstructured communication and better team performance go hand-in-hand. Due to the lack of control on selection, the design of the study can not identify whether greater casual communication *causes* better team performance or whether better team performance *causes* greater casual communication—does the team do better because the members hang out together during breaks, or do the members hang out together because they do well as a team? A laboratory setting, on the other hand, allows for random assignment to treatment groups and control over confounding factors. Our experimental design identifies causal relationships between free-riding, which translates to lower contributions to public goods, and each of our treatments—directed team-building and undirected free-form communication—but at the cost of real world context.

3. A basic model

This section develops a basic model with altruistic preferences to show (i) that social capital created through intra-group socialization can curb free-riding between group members in a public goods game; and (ii) that these positive externalities of increased cooperation may be 'transferable'. The incentives for cooperation may increase between individuals across different groups.

3.1. The basic environment

We consider an environment where individual player i is assigned to a group g of size N, and each group participates in a standard linear-technology public goods game for T rounds. In each round t, player i allocates her endowment W to the production of a public good, $x_{it} \in [0, W]$, and her consumption of a private good, $W - x_{it}$.

The monetary payoff for individual i from group g in round t, is

$$\pi_{i,t} = W - x_{it} + aX_t. \tag{1}$$

Here, $X_t = \sum_{k \in g} x_{kt}$, and $0 < a < 1 < Na$. This restriction on the technology parameter a ensures individual i's payoff is maximized by contributing zero to the public good whereas the group's payoff is maximized when each group member contributes the entire endowment to the production of the public good.

3.2. Pro-social preferences

We introduce pro-social preferences into this setting by assuming that the extent to which individual i is concerned about any other individuals' payoff is measured by the altruism parameter $\theta_i \in [\underline{\theta}, \bar{\theta}]$. Individual i's contemporaneous utility is assumed to be quasi-linear in her own payoff, $\pi_{i,t}$, and the sum of the other group members' payoffs, $\sum_{j \neq i, j \in g} \pi_{j,t}$:

$$U(\pi_{i,t}, \sum_{j \neq i, j \in g} \pi_{j,t}) = \pi_{i,t} + \theta_i v_i (\sum_{j \neq i, j \in g} \pi_{j,t}), \tag{2}$$

where the preferences over other members' payoffs are captured in the continuous, twice-differentiable function v_i which we assume is well-behaved: $v_i' > 0$, $v_i'' \leq 0$, and $v_i'(0) \to \infty$. This specification is a modified version of the utility function in Durlauf and Fafchamps (2005),[8] and represents purely altruistic preferences as in Andreoni (1988): individual i receives utility from higher payoffs of other players in g in addition to utility from her own payoff.

3.3. Optimal contributions

Let $X_{-it} \equiv X_t - x_{it}$ denote the sum of the contributions to the public good by all members of group g barring i, in round t. Notice, then, using (1), the payoff for player j, another member of group g (i.e., $j \neq i; j \in g$) can be rewritten as

$$\begin{aligned} \pi_{j,t} &= W - x_{jt} + aX_t \\ &= W - x_{jt} + a(x_{it} + X_{-it}) \\ &= W + ax_{it} - x_{jt} + aX_{-it}. \end{aligned} \tag{3}$$

The sum of the payoffs of the other $(N-1)$ members of group, $\sum_{j \neq i, j \in g} \pi_{j,t}$, is then

$$\begin{aligned} \sum_{j \neq i, j \in g} \pi_{j,t} &= \sum_{j \neq i, j \in g} [W + ax_{it} - x_{jt} + aX_{-it}] \\ &= (N-1)(W + ax_{i,t}) + [(N-1)a - 1]X_{-it}. \end{aligned} \tag{4}$$

[8] Durlauf and Fafchamps (2005) model a two-player prisoners' dilemma with pro-social preferences. They specify individual i's payoff as $U = (1-\alpha)\pi_i + \alpha\pi_j$; the weight α on player j's payoff represents player i's extent of pro-social concern. Notice that if we set $\theta = \frac{\alpha}{1-\alpha}$, and assume $v'' = 0$, in (2), we get identical preferences to Durlauf and Fafchamps (2005)

We follow the standard assumption of player i taking all other players' contribution to the public good as given. From (2) it then follows that a higher contribution to the public good by player i gives her an additional utility of

$$\begin{aligned}\frac{\partial U}{\partial x_{it}} &= \frac{\partial U}{\partial \pi_{i,t}}\frac{\partial \pi_{i,t}}{\partial x_{it}} + \frac{\partial U}{\partial \sum_{j\neq i, j\in g}\pi_{j,t}}\frac{\partial \sum_{j\neq i, j\in g}\pi_{j,t}}{\partial x_{it}} \\ &= -\underbrace{(1-a)}_{MC_x} + \underbrace{(N-1)a\theta_i v_i'(\sum_{j\neq i, j\in g}\pi_{j,t})}_{MB_x},\end{aligned} \tag{5}$$

where the second line follows from substituting in from (1), (2), and (4) into the first.

This result immediately leads to the following Proposition.

Proposition 3.1. *Player i's optimal contribution in any given round t is characterized by the following:*

(i) If player i is purely self-interested, her optimal voluntary contribution to the production of the public good equals zero, i.e., $x^*_{it} = 0$.

(ii) If player i is pro-social, her optimal contribution to the production of the public good is a non-zero amount, i.e., $x^*_{it} \in (0, W]$.

Proof. Part (i)

If player i is purely self-interested, a rational egoist who cares only about her own payoffs, $\theta_i = 0$. Setting $\theta_i = 0$ in (5) gives

$$\begin{aligned}&\frac{\partial U}{\partial x_{it}} = -(1-a) < 0 \quad \text{(by assumption)},\\ &\Leftrightarrow x^*_{it} = 0.\end{aligned}$$

Intuitively, if $\theta_i = 0$, $MC_x > 0$, but $MB_x = 0$. A positive contribution hurts player i but has no gains for her. Any positive contribution in this case, is therefore, suboptimal.

Proof. Part (ii)

If player i has pro-social preferences, $\theta_i \in (0, 1]$. By (5),

$$x^*_{it} \in (0, W] \Leftrightarrow -(1-a) + (N-1)a\theta_i v'_i(\sum_{j \neq i, j \in g} \pi_{j,t}) \geq 0$$

$$\Leftrightarrow v'_i(\sum_{j \neq i, j \in g} \pi_{j,t}) \geq \frac{(1-a)}{(N-1)a\theta_i}. \tag{6}$$

Since by assumption $v'_i > 0$, and $v'_i(0) \to \infty$, $\exists \quad x_{it} > 0$ such that (6) is satisfied. □

Intuitively, if $\theta_i > 0$, the marginal benefit of contributing to the public good, given by the second term in (5), is positive, and increasing in $(N-1)$, and θ_i. With $v'_i(0) \to \infty$, the marginal benefit of contributing a positive amount will be at least as large as the marginal cost. Note that if the group size, conditional on θ_i (or θ_i, conditional on the group size) is large enough to make the marginal benefit of contributing necessarily larger than the constant marginal cost, (6) will hold as a strict inequality, and, player i will contribute her full endowment to the production of the public good.

The proposition above shows that unless player i is explicitly concerned with the payoff of other members in her group, she will always choose to spend her entire endowment on the private good. Her contribution to the production of the public good will be zero in equilibrium. If, however, she is concerned with the payoff of other members in her group, her equilibrium contribution to the public good will be a non-zero amount.

3.4. **Socialization, social distance and contributions**

We now examine the role of social capital in influencing voluntary contributions to public goods by extending the model above. Building on the premise of social value (or 'norms of good behavior') -based cooperation presented in Tabellini (2008), we assume that individual players are uniformly located along a circle which has a circumference of $2C$. The perceived 'social' distance between individuals, along the periphery of the circle, is a measure of the familiarity between individuals. We assume that the extent to which individual i is concerned about any other individual j's payoff, θ_{ij}, depends upon player i's perceived distance between i and j, D_{ij}: $\theta_{ij} = \theta(D_{ij})$.[9] We assume

[9] The fundamental difference between the model in Tabellini (2008) and our simplified version arises from the difference in focus of the respective research questions. Tabellini's concern is with the endogenous evolution of 'norms

that the extent of concern for another player's payoff is assumed to be higher for players located closer: θ is assumed to be non-increasing in D_{ij}: $\theta(D_{ij}) \geq \theta(D'_{ij}) \quad \forall D_{ij} \leq D'_{ij}$. The assumption reflects the idea that reduced social distance between two players implies that for either player, the "other" is lesser an unknown individual from some arbitrary crowd and more an identifiable victim (Bohnet and Frey, 1999), and that "the more we know, the more we care" (Schelling, 1968).

To fix ideas, consider the example in Figure 1. Based on i's perceived distance from j along the perimeter of the circle (in discrete arc-length units d with $d \equiv \frac{C}{4}$), i can consider j to belong to any of the following four (arbitrarily classified) networks.

Individual i considers individual j

(i) to be a part of her 'Family' network if $D_{ij} \in (0, d]$;

(ii) to be a part of her 'Friends' network if $D_{ij} \in (d, 2d]$;

(iii) to be a part of her 'Acquaintance' network if $D_{ij} \in (2d, 3d]$;

(iv) to be a part of her 'Stranger' network if $D_{ij} \in (3d, 4d]$.

The extent of concern individual i has for individual j's payoff depends on the network j belongs to, which, in turn, is reflected in the social distance between i and j. If i perceives j to belong to her 'Family' network, she cares maximally for j's payoff; if i perceives j to belong to her 'Strangers' network she cares minimally for j's payoff. Individual i's perception regarding j's location then yields the following ranking of weights θ to the payoff of j:

$$\theta(D_{\text{Family}}) > \theta(D_{\text{Friends}}) > \theta(D_{\text{Acquaintance}}) > \theta(D_{\text{Stranger}}).$$

We assume for simplicity that individual i's perceived social distance between herself and all other members of her group is the same: $D_{ij} = D_{ij'} \quad \forall j, j' \in g$.[10] Individual i's contemporaneous utility

of good behavior', and in turn, the intent to cooperate, between individuals given their relative locations on the circle. Our concern is with the implications when the relative locations can be influenced, given the extent to which i cares about j's payoff, which is based on i's distance from j. We ask whether, through structured or unstructured communication, the perceived distances between individuals can be altered. The dependence of concern, of an individual i for the payoffs of another individual j, on i's perceived distance from j, in our model, is taken to be exogenous. We focus on the implications of influencing the perceived distances between i and j.

10 Allowing for different perceived social distances between i and the members of her group is straightforward. Effectively the second term on the right-hand side in (7) would become $\sum_{j \neq i, j \in g} \theta_i(D_{ij}) v_i(\pi_{j,t})$. However, allowing for such differences neither yields any additional insight, nor affects the results in any significant way.

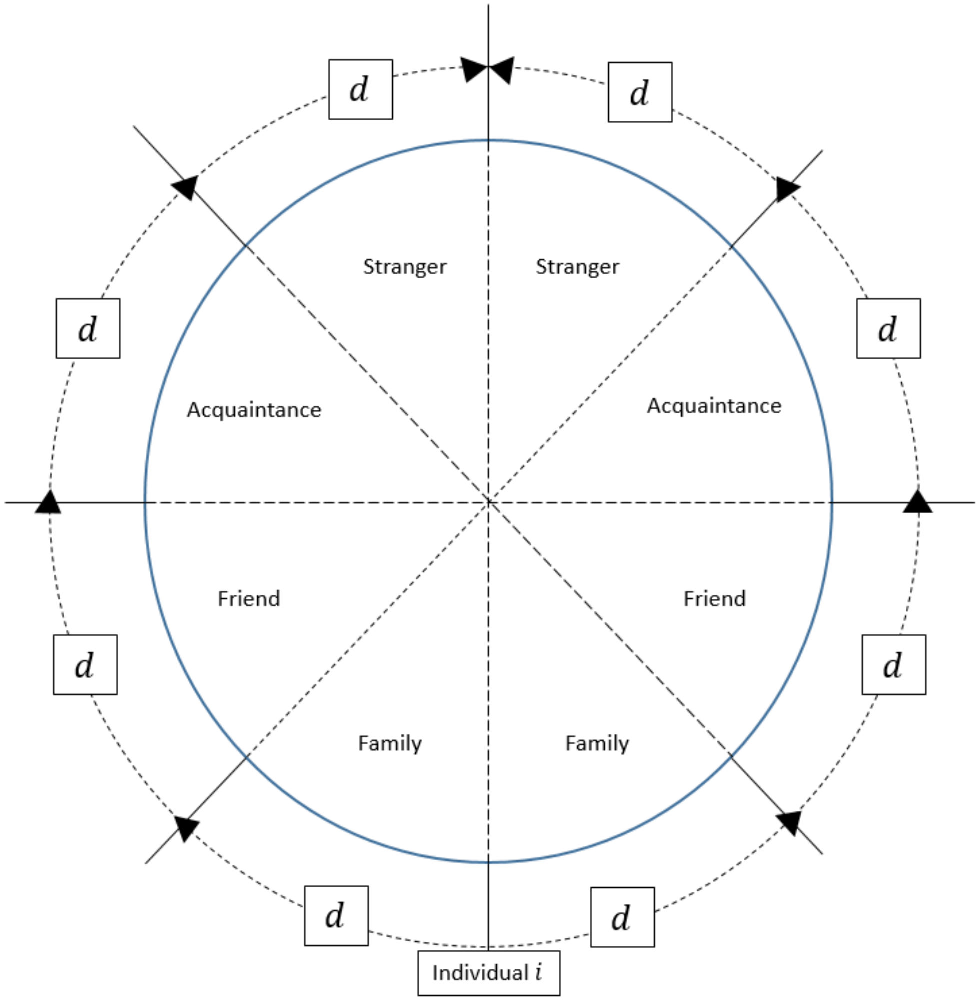


Figure 1. Location and *Perceived* Social Distance

now becomes

$$U(\pi_{i,t}, \sum_{j \neq i, j \in g} \pi_{j,t}) = \pi_{i,t} + \theta(D_{ij}) v_i(\sum_{j \neq i, j \in g} \pi_{j,t}), \tag{7}$$

so that player i's marginal utility of contributing to the public good now depends on the social distance between her and other members of her group:

$$\frac{\partial U}{\partial x_{it}} = -\underbrace{(1-a)}_{MC_x} + \underbrace{(N-1)a\theta(D_{ij})v_i'(\sum_{j \neq i, j \in g} \pi_{j,t})}_{MB_x}. \tag{8}$$

Note since θ is decreasing in the social distance between individuals, the marginal benefit of contributing to the public good is higher for i when other members of her group are located closer. She cares more about payoffs of members of her 'Friends' network than about payoffs of members of her 'Acquaintance' network, which translates to an incentive to contribute more to the public good when other members of her group are ‘Friends’ rather than ‘Acquaintances’. The social distance between individuals translates to a metric for social capital—the closer individuals are located, the higher the incentive for cooperation between them.

The next proposition specifies the nature of the relationship between a player’s contributions to the public good and social distances between herself and other players in her group.

Proposition 3.2. *Player i’s contribution is never lower when other members of her group are located closer.*

Proof. Corner solutions of either zero or full contribution occur when either individual i is purely self-interested ($\theta(D_{ij}) = 0$) or when her preferences over payoffs of other players is linear ($v'' = 0$). Individual i’s contribution is not affected by changes in the social distance between her and other members of her group in either of these cases:

$$\frac{\partial x^*_{it}}{\partial D_{ij}} = 0 \quad \text{if} \begin{cases} \text{either } \theta = 0 \quad \& \quad x^*_{it} = 0, \\ \text{or } v'' = 0 \quad \& \quad x^*_{it} = W. \end{cases} \tag{9}$$

An interior solution, $x^*_{it} \in (0, W)$, is given by

$$v'_i(\sum_{j \neq i, j \in g} \pi_{j,t}) = \frac{(1-a)}{(N-1)a\theta(D_{ij})}. \tag{10}$$

Equation (10) implicitly defines $x^*_{it}(D_{ij})$. By the implicit function theorem,

$$\frac{\partial x^*_{it}}{\partial D_{ij}} = -\frac{(N-1)a\dfrac{\partial \theta}{\partial D_{ij}} v'_i(\sum_{j \neq i, j \in g} \pi_{j,t})}{\underbrace{[(N-1)a]^2 \theta(D_{ij}) v''_i(\sum_{j \neq i, j \in g} \pi_{j,t})}_{(-\text{by SOC})}}, \tag{11}$$

which is negative, since $\partial \theta / \partial D_{ij} < 0$, by assumption. Hence we have that $\partial x^*_{it} / \partial D_{ij} \leq 0$, with strict inequality at interior solutions, and the statement follows. □

Intuitively, since player i’s marginal benefit of contributing to the public good is increasing in θ, and θ is non-increasing in D_{ij}, lower D_{ij} creates a stronger incentive for player i to contribute.

In the context of our discrete example in Figure 1, Proposition 3.2 states that when other members in individual i’s group belong to a network that is located closer, she contributes more to the public good. Her optimal contribution is greater when other players belong to her 'Family' network compared to when other players belong to her 'Friends' network and so on:

$$x^*_{it}(D_{\text{Family}}) > x^*_{it}(D_{\text{Friends}}) > x^*_{it}(D_{\text{Acquaintance}}) > x^*_{it}(D_{\text{Stranger}}). \tag{12}$$

Two key points are worthy of note. First, in this formulation, social capital is network-specific. The incentives to cooperate depend on social distances between individuals. If we consider an individual in isolation, social capital has no meaning. Second, incentives for cooperation among members of a group is an external benefit that arises due to social capital. These externalities are also network-specific. The additional contribution made by player i because the members of her group are located in a closer network are enjoyed by these members only.

However, the externalities may be transferable in the following sense. Suppose some form of socialization (through, for example, communication) between members of a group reduces the social distance between members of the group. If this reduction in distance also influences player i's perception of the social distance between her, and all others along the circle, her extent of concern for those other individuals will also change. Communication between 'Friends' may translate to 'Strangers' feeling like 'Aquaintances'. This is particularly relevant for our 'Team-building' treatment. If the exercise influences the intent to become a better 'team-player' positively, that intent may be transferable. Player i may have an incentive to contribute more to the public good because of her intent of becoming a better team player in general rather than becoming a better team player only when assigned to her specific team. The free-form communication treatment also, in theory, could lead to such transferable externalities. If communicating freely with members of her group leads to player i feeling closer to all other players j, where j may or may not belong to her assigned group g, her intent to contribute to the public good will increase irrespective of whether she plays the post-treatment rounds with the individuals she communicated with or others.

To formalize the notion of transferability of the externalities from social capital suppose player i communicates with members of her group g in some period τ, which reduces the distance between her and these members, and then is reallocated to some other group g'. If the externalities from communication are transferable, her perceived distance from players $j' \in g'$ is lower after period τ: $D_{ij',\tau-1} > D_{ij',\tau+1} \quad \forall j' \in g'$. Since θ is decreasing in social distance, $\theta_{ij',\tau-1} < \theta_{ij',\tau+1}$. By Proposition 3.2, we then have that player i's round-t contribution to the public good, where she plays with new group members, for any $t > \tau$, will be higher compared to if she had not communicated with other members of group g. Let $x^C_{ig,t}$ denote player i's round-t contribution to the public good when she continues to play with members of group g after communicating with them; let $x^C_{ig',t}$ denote player i's round-t contribution to the public good when she is reallocated to a new group g' after communicating with members of group g; let $x^{NC}_{ig,t}$ denote player i's round-t contribution to the public good when she continues to play with members of group g without any communication; let $x^{NC}_{ig',t}$ denote player i's round-t contribution to the public good when she is reallocated to a new group g' without any communication. The following Proposition formalizes the notion of transferable externalities from social capital arising from communication:

Proposition 3.3. $\forall \quad t > \tau$,

(i) If social capital leads to non-transferable positive externalities,

$$x^C_{ig,t} > x^{NC}_{ig,t} \quad \& \quad x^C_{ig',t} = x^{NC}_{ig',t};$$

(ii) If social capital leads to transferable positive externalities,

$$x^C_{ig,t} > x^{NC}_{ig,t} \quad \& \quad x^C_{ig',t} > x^{NC}_{ig',t}.$$

Proof. Follows directly from definitions of $x^C_{ig,t}, x^{NC}_{ig,t}, x^C_{ig',t}, x^{NC}_{ig',t}$, and $D_{ij',\tau-1} > D_{ij',\tau+1} \quad \forall j' \in g'$ implying that $\theta_{ij',\tau-1} < \theta_{ij',\tau+1}$, by Proposition 3.2. □

The logic for Proposition 3.3 is straightforward: if the influence of socialization, between the members of a network, on beliefs and values is restricted within members of the network, cooperation increases from the resulting social capital only within the network. Only the social distance between communicating members of a group changes. The social distance between members across groups remains the same. Cooperation will not increase if members are reallocated to other groups after communication. If the influence of communication, between members of a network, on the beliefs and values extends beyond members of the network—if the social distance between individual i and individual j, where $i \in g$ and $j \in g'$, with $g \neq g'$, is also influenced by communication between i and other members of her group—cooperation may increase if members are reallocated to other groups after communication.

To summarize, our model delivers three key results. First, unless individuals behave in some pro-social manner, where they attach a positive weight to other individuals' payoffs, non-zero contributions are suboptimal. The *rational egoist*, concerned only with his own material payoff, maximizes utility by contributing nothing to the public good. Altruistic individuals—those who care about payoffs of others as well—in contrast, always find it optimal to contribute a non-zero amount to the public good. Second, the greater the pro-social concerns of an individual, the higher the weight on payoffs of others, the higher she contributes to the public good. Third, socialization can reduce free riding in a public goods game by reducing social distances between individuals. If the positive externality of social capital is non-transferable—limited only to socializing individuals—cooperation may increase between individuals who have socialized, but not between individuals who have not. If, on the other hand, the positive externality of social capital is transferable, socialization between members of a group may lead to increased cooperation between individuals across groups.

3.5. Hypothesis and empirical design

Proposition 3.3 forms the basis of empirically testable predictions: First, if we can reduce the social distance between players through communication, contributions to the public good should increase. Averaging over all rounds, conditional on individual-specific factors $\mathbf{Z_i}$, the prediction is that if communication creates social capital, then

$$\mathbb{E}(x_{ig}^{C}|\mathbf{Z_i}) - \mathbb{E}(x_{ig}^{NC}|\mathbf{Z_i}) > 0, \tag{13}$$

where $\mathbb{E}$ is the conditional expectation operator, x_{ig} is the contribution of individual i when she plays with members of group g and, as before, the C and NC superscripts denote whether individual i participates in an intra-group communication treatment or not. Since Social Capital is the set of *beliefs and values that increase cooperation*, and reduced social distances increase cooperation, we take a reduction in social distances through communication as 'creation' of social capital through the channel of socialization identified by Guiso et al. (2011). Second, if either type of intra-group communication leads to transferable social-capital externalities, cooperation will increase between members of a group as well as between members across different groups. The prediction is that if communication creates transferable social capital externalities, then

$$\mathbb{E}(x_{ig',t}^{C}|\mathbf{Z_i}) - \mathbb{E}(x_{ig',t}^{NC}|\mathbf{Z_i}) > 0. \tag{14}$$

Our experiment is designed to generate the data required to test these two predictions.

4. Experimental Design

This section describes the design of the experiment. First, we discuss the general design. We then provide a more detailed discussion of each stage.

4.1. General design

Figure 2 shows the general design of the experiment. The experiment consisted of three stages: pre-treatment public goods game, treatment, and post-treatment public goods game. Some subjects remained with the same group before, during, and after treatment, while other subjects were assigned to new groups after treatment. This design allows for robust difference-in-differences estimation of the effect of social-capital treatments on public goods contributions. There were a total of six possible treatments: the control group, the team-building treatment, the free-communication treatment, the control group with group reallocation after treatment, the team-building treatment with group reallocation after treatment, and the free-communication treatment with group reallocation after treatment.

We recruited participants from the student body of the University of Wyoming via email. Interested students could sign up for a single session of the experiment. Treatments were randomly assigned to sessions. Although participants in the same session were assigned the same treatment, participants were not provided any information which indicated differences across sessions. These steps ensured random assignment of treatment across participants.

In Stage 1, participants played ten rounds of a public goods game. In Stage 2, participants of the control group were given a two-minute break in which no communication occurred, while participants in the two treatment groups participated in one of the two communication treatments. In the third stage, participants of all three categories played the same public goods game, again for ten rounds. Three sessions involved group reallocation after treatment. For the control group this involved reallocating all individuals to new groups after the two minute break, while subjects in treatment sessions were reallocated to new groups after treatment. There were 16 subjects in each session — four groups of four subjects. When reallocation occured, we ensured that no two subjects remained on the same team after treatment (after the break in case of the control group). The change in contributions between Stage 1 and Stage 3 will be compared between the treatment groups and between the treatment and control groups. If the difference in changes in contributions between groups is significant, then the treatment will have had an effect on social capital formation.

The participants in each category received instructions for each stage of the experiment at the beginning of that stage. They were informed that there would be three stages of the experiment prior to beginning the first stage, but were not given any specific information about the second and third stages until immediately before those stages started. The exact instructions for each stage are attached in Appendix A. Reallocation to new groups was not included in the instructions. For group-reallocation sessions, the moderator had subjects return to there original seats, then had subjects switch seats two at a time in a manner that ensured no two subjects remained on the same team as before treatment.

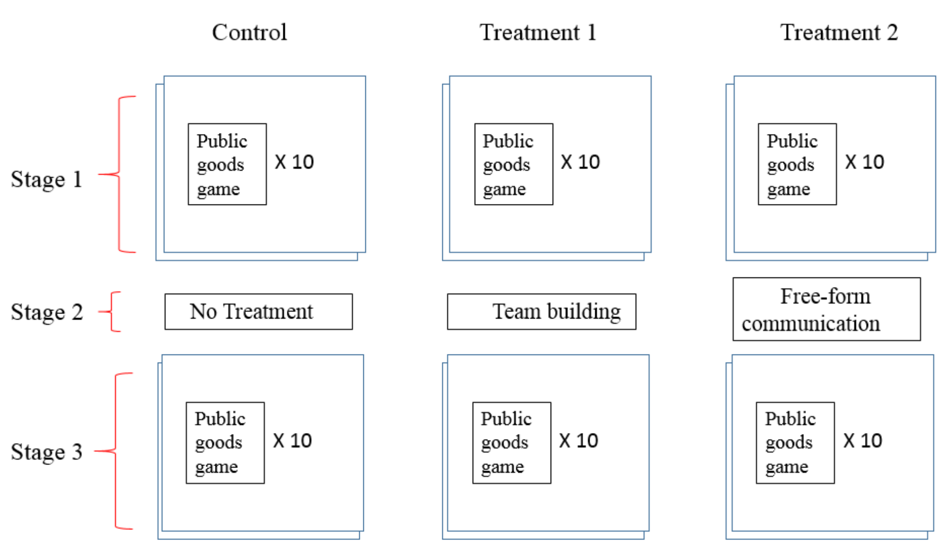


FIGURE 2. The design of the experiment—all groups play ten rounds of the public goods game in Stage 1 and Stage 3. In Stage 2, the control group gets a 2-minute break, Treatment 1 receives the team-statement treatment and Treatment 2 receives the free-communication treatment.

4.2. **Stage 1: Pre-treatment public goods game**

The first and third stages involved playing ten rounds of a basic public goods game on a computer. The participants were randomly assigned to four-member groups with all members of a group sitting along the same row. This assignment remained unchanged through the three stages of the experiment for the non-reallocation sessions, while the assignment changed after treatment for the reallocation sessions. The participants were informed that they had been assigned to a four-member group, and that the other members of their groups were those sitting in the same row. Any form of communication was strictly prohibited at this stage. In each round of the public goods game, each player from the four-member group received an endowment of 50 tokens and had to decide how much of their endowments to invest in the production of a public good. Each round lasted for 60 seconds. If the clock ran out on a participant who had not recorded an amount yet, a default contribution of '0' would be recorded for them for that round. After each member of a team had submitted their contributions for that round, each member would earn a return on the cumulative investment made by the four members of the group. The game was set up so that each member earned three-fourths of the total group contribution. At the end of the round, the computer screen showed the participant the total amount contributed by the group, the resulting return for the participant from that round, and the total number of tokens accumulated so far. Any number of tokens not invested accumulated across rounds. The instructions also informed the participants that for every 100 tokens accumulated, they would be paid a dollar at the end of the experiment. The instructions for this stage contained three examples of how exactly cumulative contributions translated into individual earnings per period, and then a quiz to test whether the participants understood the rules and the payoff structure of the game. After the instructions were read aloud, the participants played a practice round to get used to the game. Stage 1 ended when ten rounds of the public goods game were completed.

4.3. **Stage 2: Treatments**

Control

In stage 2, the participants assigned to the control category got a two-minute break. They were told to wait while the next stage was being prepared. No communication was allowed and participants remained in their seats at their individual computer terminals.

Treatment 1—Team building exercise

In Stage 2, the participants assigned to the T1 treatment did a two-step team building exercise. The steps involved filling out two forms, (1) individually and (2) as a team.[11] In the first step, each participant was handed a copy of "Document A."[12] This document required the participant to write down at least two characteristics that (s)he believed "are essential for successful teamwork," and then write down at least two characteristics that (s)he thought "describe a good team player." The participants had five minutes to complete this form. After the five minutes were over, the second step of the team-building exercise was initiated. In this second step, each group was assigned a separate room, and the members of each group were instructed to meet in their designated rooms. The purpose of the meeting was to collaboratively fill out another form. The form was titled "Document B: Team statement" and required each group to come up with at least four characteristics that are "essential to successful teamwork," and at least four characteristics that "describe a good team player." Each member of the group was required to sign and date the form after they were done filling it out. The groups had ten minutes to complete this task. This step concluded the second stage of the experiment for the T1 category.

Treatment 2—Free-form communication

In Stage 2, the participants assigned to the T2 treatment were allowed to communicate freely with the other members of their assigned groups. To prevent communication across groups, the free-form communication treatment was conducted in the following manner: each group was assigned a separate room, and the members of each group were instructed to meet in their designated rooms. No communication was allowed between participants until they were in their assigned rooms with the door closed. The members of each group were told they had ten minutes to communicate in private. After ten minutes, the members of each group came back from their designated rooms to their designated seats.

11 This team building exercise was chosen for several reasons. First, this activity is based on four key models–goal setting, interpersonal relations, problem solving, and role clarification–of an effective team-building exercise identified in the organizational-management literature on team building (see Salas et al. (1999)). Second, the exercise (i) is based on subjects' personal opinion—no specific knowledge uncommon to the group is required; (ii) requires that subjects collaborate; (iii) was manageable in a university laboratory environment; and (iv) did not require abnormal physical activity. See Bond (2012).

12 "Document A" and "Document B" are included at the end of the instructions in Appendix A.

4.4. **Stage 3: Post-treatment public goods game**

Stage 3 was an exact repeat of Stage 1 for subjects that were not reallocated to new groups. Subjects who were reallocated initially returned to there new seats. The moderator then had two subjects move at a time in a manner that ensured no two players remained on the same team. The participants were told, at the beginning of this stage, that they would play ten rounds of the same public goods game that they played in Stage 1. The only difference was that there was no practice round in this stage, and subjects in the reallocation groups were playing the public goods game with a new group of four. The stage ended when the participants finished playing ten rounds of the public goods game.

5. Efficiency versus Individual Rationality

Recall that each individual subject receives 3/4 of the total group contribution to the public good. The Pareto efficient allocation of public goods contributions occurs when each subject contributes all 50 of their tokens to the public good in each and every round. For any other allocation, potential Pareto improvements will be available with side payments, so these allocations are not efficient. This results from the fact that the collective marginal cost of an additional public good contribution is one token, and the collective marginal benefit is three tokens (all four players will receive 3/4 token from the contribution). Fully rational individuals acting solely in their own self-interest would not be expected to reach this efficient allocation (Ostrom, 2010).

The Nash equilibrium outcome based on rational, self-interested behavior on the part of individual subjects implies contributions of zero tokens in each and every round of the public goods game. The marginal cost of an additional unit of public good to the individual player is one token, while the marginal benefit is 3/4 token, so an individual player would contribute zero if acting rationally and assuming that other players would act rationally. We hypothesize that both the team-building treatment and the free-communication treatment will increase the efficiency of public good contributions relative to the control group, but we do not expect the control group to converge to the fully rational Nash equilibrium for the reasons discussed in Ostrom (2000). We are *a priori* unsure about the relative effectiveness of our treatments. Our strategy for testing the hypothesis, and examining the relative effectiveness of the treatments, is the topic of the next section.

6. Estimation Strategy and Data

We designed the experiment (a) to provide data for difference-in-differences estimation of the treatment effects associated with each of our treatments (to test if either of (13) and (14) hold for each of our treatments), and (b) to provide data for a within-treatment analysis to compare how long the effects of each treatment last.

(a) Difference-in-Differences estimation

The difference-in-differences, DD, of the effect of treatment i on the dependent variable of interest y is

$$DD = [(\bar{y}_2|D_i = 1) - (\bar{y}_1|D_i = 1)] - [(\bar{y}_2|D_i = 0) - (\bar{y}_1|D_i = 0)], \quad (15)$$

where $D_i = 1$ if the treatment is given and $D_i = 0$ if the treatment is not given, and $\bar{y}_t$ is the mean of the dependent variable in period t (Greene, 2012). The first bracketed term gives the change in mean of the dependent variable for the treatment group from the pre-treatment period to post-treatment period. The second bracketed term gives the analogous measure for the control group. The difference in the bracketed terms indicates the effect of the treatment relative to the control. The difference-in-differences estimators for our treatments can be estimated using the following regression

$$\begin{aligned} C_{it} = \alpha_i + T_i\beta_T + F_i\beta_F + R_i\beta_R + TR_i\beta_{TR} + FR_i\beta_{FR} \\ + S2_t\beta_{S2} + T_iS2_t\beta_{T2} + F_iS2_t\beta_{F2} + R_iS2_i\beta R2 + \\ TR_iS2_t\beta_{TR2} + FR_iS2_t\beta_{FR2} + \epsilon_{it}, \quad (16) \end{aligned}$$

where T_i is an indicator variable equal to one if individual i is in the team-building treatment group and plays public goods games with the same four people for the entirety, and zero otherwise, F_i is an analogous variable for the free-communication treatment, R_i is an indicator variable equal to one if individual i was reallocated to a new team after treatment, TR_i is an indicator variable equal to one if individual i is in the team-building treatment group and is reallocated to a new team after treatment, FR_i is an analogous variable for the free-communication treatment, and $S2_t$ is an indicator of the post-treatment stage of the experiment, so is equal to one if the contribution occurred in Stage 3 of the experiment. The coefficients to be estimated are β_T, β_F, β_R, β_{TR}, β_{FR}, β_{S2}, β_{T2},

β_{F2}, β_{R2}, β_{TR2}, and β_{FR2}. The difference-in-differences estimators for the team-building and free-communication treatments are β_{T2} and β_{F2}, while the difference-in-difference estimator for group reallocation is β_{R2}, and the difference-in-difference estimators for the combination of treatments and team reallocation are β_{TR2} for team-building and β_{FR2} for free communication.

(b) Within-treatment analysis

The difference-in-differences estimation informs us as to how the treatments causally influence contributions. To compare how long the effects of each treatment last we conduct a within-treatment analysis. We examine, for each treatment, the number of rounds over which post-treatment contributions are, economically and statistically, different compared to the pre-treatment baseline. By comparing the round-specific behavior of contributions *across* treatments, we also examine the relative effectiveness of each treatment as the number of rounds increase and approach round ten. We estimate the following equation:[13]

$$c_{it} = \alpha + \psi_t + \omega_i + \epsilon_{it}. \tag{17}$$

The dependent variable, c_{it}, denotes individual i's contribution in round t, α is the constant, ψ_t captures round-specific effects on contributions, ω_i captures individual-specific effects on contributions, and ϵ_{it} is the error term. Equation (17) is estimated, separately for each treatment, as a random effects regression. Round ten is dropped and thus serves as the baseline in each case.[14] The parameters of interest are the round-specific coefficients, ψ_t, which show how contributions, within a specific treatment, vary relative to contributions in the baseline round. A declining trend, in the estimated round-specific coefficients, over rounds, will imply stronger treatment effects at the initial post-treatment rounds compared to latter post-treatment rounds—the effects are initially strong, causing the estimated round-dummies to be significantly higher than the baseline, but then they taper off causing the estimated round dummies to become smaller and approach the baseline. The fewer the number of rounds required for this tapering off – the less persistent was the treatment effect. By the same logic, if the trend of the estimated coefficients does not exhibit a decline, this will reflect a persistence of the treatment effect.

13 Evaluating treatment persistence by conducting a within-treatment analysis in this fashion is a standard practice in the literature. See (Kroll et al., 2007) for instance.

14 The estimated constant for each treatment will equal the mean round-10 contribution for that treatment.

6.1. **Data**

Our data are from one control session (20 subjects × 20 rounds), one team-building communication session (16 subjects × 20 rounds), two free-form communication sessions (32 subjects × 20 rounds), one control session with group reallocation (16 subjects × 20 rounds), one team-building session with team reallocation (16 subjects × 20 rounds), and one free-communication session with team reallocation (16 subjects × 20 rounds).[15]

7. Results

Figures 3 and 4 show average contributions by treatment group. Figure 3 shows average contributions by round from the sessions in which subjects played public goods games in the same group of four people in Stage 1 and in Stage 3. Figure 4 shows average contributions by round from sessions in which subjects were reallocated to new groups in Stage 3. The average contributions in the pre-treatment stage (rounds 1 - 10) across all treatments exhibit similar trends. The average contributions for these pre-treatment rounds are also similar across all treatments except for the control group from the group reallocation sessions. Subjects in this session contributed significantly less on average than subjects in any of the other sessions. Our differences-in-differences estimation controls for such differences in average contributions.[16]

Figure 3 shows large increases in average contributions after treatment (rounds 11 through 20) for the non-reallocation sessions. The effect of free communication on contributions is clearly larger and more persistent than for team-building in these sessions. The effect of treatments in sessions with group reallocation appear to be much smaller, and the effect of team-building is larger than the effect of free communication for these sessions.

[15] Data from our initial team-building with group reallocation session needed was discarded because of a breach in the "no-communication" rule before Stage 1 began. Also, we did two free-communication sessions without group reallocation due to the appearance of some strange behavior in the first free-communication session: one group of four in the first free-communication session had contributions of 50 tokens in all 20 public good game rounds of the experiment. This unusual behavior could have resulted from communication that occurred outside of the experimental design or nonrandom sampling, e.g., the four group members were friends, or all four group members may have been "willing cooperators" (Ostrom, 2000). The first two explanations imply the data should be thrown out, while the third implies it should be kept. We have chosen to present results with the complete sample. These unusually high contributions will lead to a smaller difference-in-differences estimator, so it will not lead to spurious significance related to nonrandom sampling, and will strengthen any significantly positive results associated with the free-communication treatment.

[16] We find no evidence to reject the parallel trends assumption across all treatment and control groups. The estimates for testing the parallel trends assumption are available on request.

FIGURE 3. Average contributions per round by treatment without group reallocation.

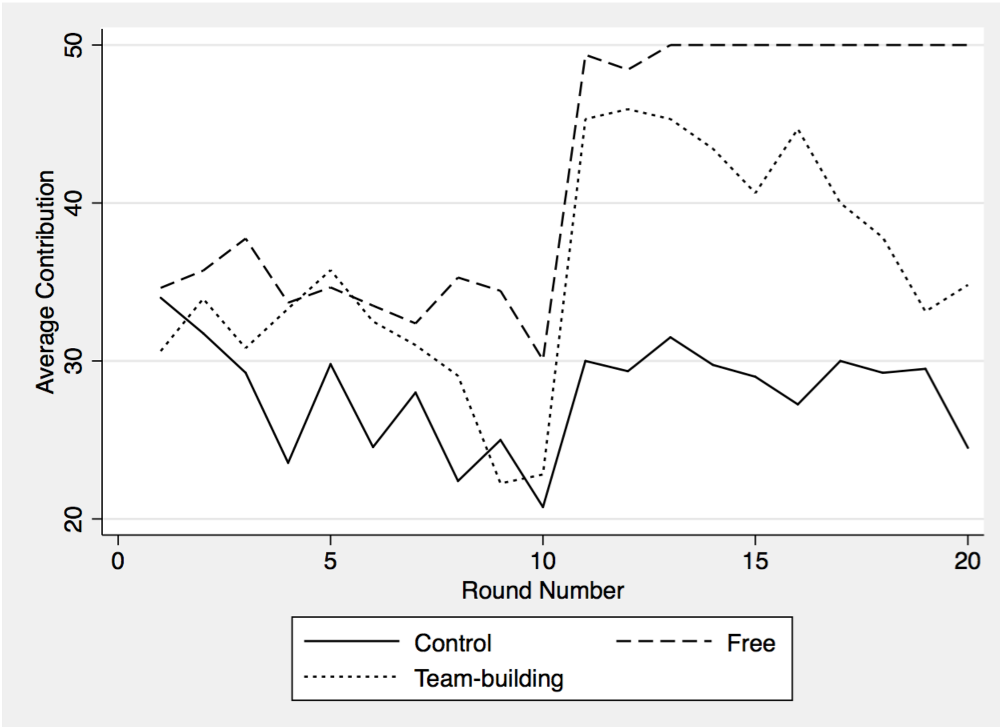


Table 1 presents results from the difference-in-differences estimation of the treatments on public goods contributions. The first column reports estimates of full-sample, random-effects, panel-estimation of the effects of the treatments on public goods contributions. The second column reports estimates of the analogous estimation with robust standard errors. The third and fourth columns report estimates using the natural log of contributions on the left-hand side of (16). In columns (1) and (2) absolute changes in contributions resulting from treatments are estimated, while in coumns (3) and (4) relative changes in contributions are estimated. The estimated statistics in Figures 3 and 4, and Table 1 lead us to several results.

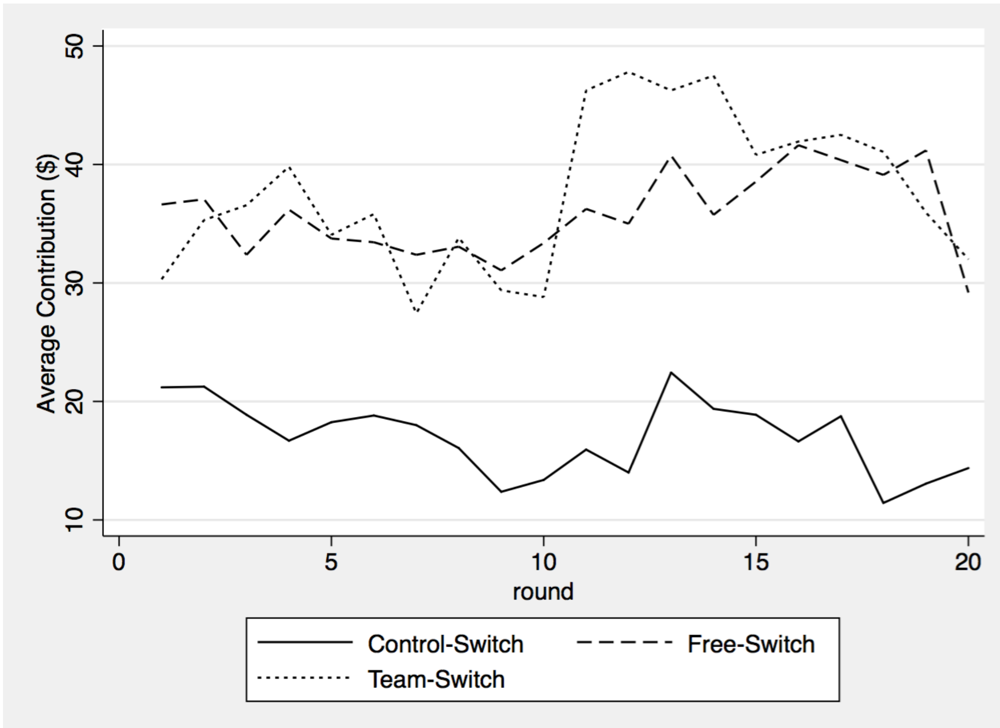
Result 1

The team-building treatment generates more efficient public goods contributions relative to the control when subjects stay in the same group after the team-building exercise.

Support

The seventh row of Table 1 (labeled "team2") shows the difference-in-differences estimate of the effect of the team-building treatment on public good contributions. The estimate is positive and

Figure 4. Average contributions per round by treatment with group reallocation.



statistically significant in two out of the four specifications. The estimate is not statistically significant with robust standard errors. This indicates the result may be driven by large outliers. If our sampling was random as designed, the results without the robust standard errors continue to be meaningful. These estimates provide strong evidence for a positive treatment effect associated with the team-building exercise.

The effect is economically significant. The point-estimate of 8.8 tokens means that, on average, subjects in team-building groups increased their public goods contributions by almost nine tokens more in Stage 3 relative to Stage 1 than subjects in the control group increased their contributions. This means that a total of almost 360 more tokens were contributed to the public goods investment by the end of Stage 3, which represent approximately $2.00 extra per player in a team of four (the players would each have earned a dollar by keeping these tokens). As indicated by columns (3) and (4), this represents a more tan 40% increase in average contributions relative to the control group.[17]

Result 2

[17] Subjects in the control group increased contributions by an average of 2.1 tokens per round from Stage 1 to Stage 3, so the total increase for the team-building subjects was approximately 11 tokens per round.

TABLE 1. Difference-in-differences estimation of effects of team-building treatment and free-communication treatment on public good contributions. Columns (2) and (4) use robust standard errors.

	(1) contribution	(2) contribution	(3) ln_contribution	(4) ln_contribution
period2	2.105	2.105	0.127	0.127
	(1.69)	(1.22)	(1.34)	(1.00)
team	3.301	3.301	0.0736	0.0736
	(0.92)	(0.68)	(0.30)	(0.21)
free	7.304*	7.304	0.363	0.363
	(2.40)	(1.83)	(1.75)	(1.33)
control_switch	-9.417**	-9.417*	-0.569*	-0.569
	(-2.63)	(-2.28)	(-2.33)	(-1.87)
team_switch	6.226	6.226	0.380	0.380
	(1.74)	(1.44)	(1.56)	(1.44)
free_switch	7.026*	7.026	0.410	0.410
	(1.96)	(1.71)	(1.68)	(1.45)
team2	8.795***	8.795	0.431**	0.431
	(4.71)	(1.75)	(3.02)	(1.28)
free2	13.47***	13.47***	0.605***	0.605**
	(8.48)	(4.49)	(4.99)	(3.08)
control_switch2	-3.105	-3.105	-0.268	-0.268
	(-1.66)	(-1.05)	(-1.88)	(-1.09)
team_switch2	6.970***	6.970*	0.212	0.212
	(3.73)	(2.38)	(1.48)	(1.26)
free_switch2	1.745	1.745	-0.0760	-0.0760
	(0.93)	(0.52)	(-0.53)	(-0.39)
_cons	26.90***	26.90***	2.803***	2.803***
	(11.26)	(8.72)	(17.25)	(12.58)
N	2320	2320	2320	2320

t statistics in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

The free-communication treatment generates more efficient public goods contributions relative to the control when subjects stay in the same group after the free-communication session.

Support

The eighth row of Table 1 (labeled "free2") shows the difference-in-differences estimate of the effect of the free-communication treatment on public good contributions. The estimated free-communication effect is positive and statistically significant in all four regression specifications.

The effect is economically significant. The point-estimates of the treatment effect are 13.5 tokens per round, which translates to increased earnings of approximately $2.50 per subject relative to the control group. This represents a more than 60% increase in average contributions from free-communication subjects, as indicated by columns (3) and (4).

Result 3

The free-communication treatment produced higher public goods contributions relative to the control group than the team-building treatment when subject played public goods games with the same four people for the entirety of the experiment.

Support

The estimated magnitude of the free-communication treatment (free2) is larger than the estimated magnitude of the team-building treatment (team2) across all four specifications, and the increase associated with free communication is statistically significant at the 0.1% level in all four specifications. We tested the null hypothesis that the two treatment effects are statistically identical. An F-test indicates that the absolute increase in contributions associated with free-communication is greater than the absolute increase in contributions associated with team-building when normal standard errors are used, i.e., under the column (1) specification in Table 1. F-tests did not indicate statistical differences for the other three specifications.

Result 4

The free-communication treatment has a longer-lasting effect on public goods contributions than the team-building treatment when subject played public goods games with the same four people for the entirety of the experiment.

Support

Figures 3 demonstrates this result. Our within-treatment analysis provides formal statistical support. Comparing the post-treatment average contributions between the two treatment groups in the figures, we see that while the average contributions from the "team-building" treatment gradually decline, the average contributions from the "free" treatment do not show any such tendency. On the contrary, these contributions reach the maximum immediately after the treatment, and then stay at the maximum through all ten rounds of the post-treatment stage. Table 2 shows the

TABLE 2. Within-treatment Analysis

	Control	Statement	Free	FreeR
Round 11	9.250**	22.50***	19.31***	28.87***
	(2.60)	(4.29)	(7.12)	(7.04)
Round 12	8.600*	23.13***	18.38***	27.00***
	(2.41)	(4.41)	(6.78)	(6.58)
Round 13	10.75**	22.50***	19.94***	30.12***
	(3.02)	(4.29)	(7.35)	(7.34)
Round 14	9.000*	20.63***	19.94***	30.12***
	(2.53)	(3.93)	(7.35)	(7.34)
Round 15	8.250*	17.81***	19.94***	30.12***
	(2.32)	(3.39)	(7.35)	(7.34)
Round 16	6.500	21.88***	19.94***	30.12***
	(1.82)	(4.17)	(7.35)	(7.34)
Round 17	9.250**	17.19**	19.94***	30.12***
	(2.60)	(3.28)	(7.35)	(7.34)
Round 18	8.500*	15.00**	19.94***	30.12***
	(2.39)	(2.86)	(7.35)	(7.34)
Round 19	8.750*	10.31*	19.94***	30.12***
	(2.46)	(1.97)	(7.35)	(7.34)
Round 20	3.750	12.00*	19.94***	30.12***
	(1.05)	(2.29)	(7.35)	(7.34)
Constant	20.75***	22.81***	30.06***	19.88***
	(5.32)	(5.16)	(13.12)	(5.78)
Observations	400	320	640	320

z statistics in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

results of the within-treatment estimation. We only present estimates from the post-treatment rounds here. The full table with all rounds is in Appendix B. [18] Notice from the table that both the magnitude and the statistical significance of the round-specific effects in the control (column

[18] Recall that in the estimation, the round-specific dummy for the 10th round—the last round before treatment—was omitted and thus serves as the baseline: The estimated constant (bottom row) presents the average contributions in the 10th round ($\bar{c}_{j,10}$, for jth treatment in round 10). Every other row, representing a particular post-treatment round t, presents the estimated coefficient on the round-specific dummy, $\hat{\psi}_{j,t}$, for each treatment j. These effects are the estimated distance between the average contributions in that round ($\bar{c}_{j,t}$, for jth treatment in round t) and the constant, i.e., the average contributions in the 10th round for that treatment ($\bar{c}_{j,10}$). The average contribution in round t in treatment j, $\bar{c}_{j,t}$, equals the sum of the estimated constant, $\bar{c}_{j,10}$, and the number reported in the corresponding row in the table, $\hat{\psi}_{j,t}$.

1) and the statement treatment (column 2) exhibit, overall, a declining trend. The trend though, is much more pronounced for the statement treatment compared to the control. The estimated magnitude as well as statistical significance in the initial rounds immediately following treatment are significantly larger than those in the penultimate rounds.[19] Although there is some oscillation, the general trend is that the estimates get smaller, both in magnitude and significance, as we approach the latter rounds. The estimated coefficients for the first four rounds in the post-treatment stage, for the statement treatment, remain consistently above 20 (significant at the 0.1% level). From round 16 onward, the estimated coefficients exhibit a steadily declining trend, reaching 12 (significant at the 5% level) in the last round.

In contrast, the magnitudes and statistical significance of the estimates for the "free" treatment, both in the full sample (the "Free" column) and the reduced sample (the "FreeR" column), exhibit no such declining trend. The estimates reach the maximum value by the third post-treatment round (round 13), and stay there. There is no decline in either magnitude or in statistical significance. These coefficients correspond to rounds where every member of each group under the "free" treatment made full contributions of 50 tokens (the sum of the estimated constant and the round-specific dummy equal 50). Comparing these estimated trends across the treatments, we conclude that the "free" treatment leads to a longer-lasting effect—a persistent increase in contributions—whereas the "statement" treatment leads to an increase in contributions that is transitory relative to the "free" treatment.

Result 5

Team-building increases absolute contributions even when subjects are reallocated to new teams after treatment

Support

The tenth row of Table 1 (labeled team_switch2) shows the difference-in-difference estimates for subjects who were treated with the team-building exercise, and were reallocated to new groups of four after treatment. Columns (1) and (2) indicate that team-building led to statistically significant absolute increases in contributions even when subjects were reallocated to new groups after treatment. The estimated increase relative to the control group was approximately 7 tokens per

[19] The estimated round-specific coefficients for the statement treatment in the post-treatment stage are larger than those for the control, which also provides additional support for Result 1.

round. As indicated by columns (3) and (4) this represents a more than 20% increase in absolute contributions. The relative changes, however, are not statistically significant.

Result 6

Free communication does not increase contributions when subjects are reallocated to new teams after treatment.

Support

The eleventh row of Table 1 (labeled free_switch2) shows the difference-in-difference estimates for subjects who were treated with free-communication, and were reallocated to new groups of four after treatment. The estimates indicate no statistically significant difference between Stage 1 and Stage 3 contributions relative to the control group. In fact, the point estimate for relative changes, shown in columns (3) and (4), indicates the control group contributions increased more than the free-communication group when subjects were reallocated.

In summary, we find both treatments increase voluntary contributions to public goods relative to the control when subjects play the public goods game with the same group before and after treatment, but the free-communication treatment leads to a larger increase in voluntary contributions which persists until the last round of the game. The increase in the voluntary contributions from the statement treatment, in contrast, are smaller and less persistent.

On the other hand, when subjects are reallocated to new groups to play the public goods game after treatment, the team-building treatment continues to lead to increased contributions relative to the control, while the free-communication treatment does not lead to statistically significant changes in contributions.

8. Discussion

Several of our results are surprising and useful. Our results indicate that socialization through unstructured free-form communication leads to greater increases in public good contributions, or greater social capital formation,than does a structured, guided team-building communication session when individuals continue to interact with the same people after communication occurs.

Furthermore, increases in contributions associated with free-form communication persist, while increases associated with team-building decline.

The implications of these results are broad. First, our results imply that exogenously guided communication in communities trying to solve public goods problems may be unwarranted. To the extent that guided communication serves to replace or crowd out more unstructured and spontaneous communication among stakeholders, such guided communication may end up *decreasing* cooperation and social capital formation in the community. This provides support for previous field research that has found non-coercive government programs designed to decrease free riding in public goods have sometimes been unsuccessful. Such exogenous efforts may *poison the well* of social capital that spontaneous and free communication creates.

Second, we have provided evidence that imply managers should indeed be cautious of team-building relative to more casual opportunities for communication amongst employees to decrease the possibility of free-riding in the work force when the employees continue to work with the same group after team-building. Our results provide causal support to the claims of both the British employee survey results as well as the team-performance study by Pentland (2012). However, if the manager is attempting to build social capital in employees who will not necessarily be working together after team-building, then our results indicate that team-building may be more successful than casual communication.

Third, we have shown that social capital does not necessarily follow individuals, but may be purely a characteristic existing within a group of individuals. The complete breakdown in social capital creation from the free-communication sessions with group reallocation, along with the decrease in social capital creation from the team-building sessions with group reallocation provide evidence that social capital cannot be measured on the individual level. Additionally, the vehicle through which social capital is created may play a role in determining whether the returns to social capital are transferable or not. If policymakers are attempting to affect public good contributions on an individual level rather than across a group of people, goal-oriented, guided communication may be a preferable strategy.

9. Conclusion

Motivated by the notion that communication creates social capital via the channel of socialization, and that social capital creation increases voluntary contributions to public goods by individuals, we designed communication treatments in a public goods experiment to create social capital. Our experimental design and estimation strategy allowed us to decipher causal relationships between these treatments and public goods contributions, and to further test whether the returns to social capital are limited to the level of the socializing group, or are transferable across socializing groups.

We found that both team-building and free-form communication sessions serve to increase social capital as measured by increased public goods contributions when subjects play public goods games with the same group of people throughout the experiment. We also found that free-form communication increases public goods contribution more than team-building communication, and increases associated with free-form communication are more persistent, which has broad implications for policymakers trying to help communities escape the tragedy of the commons. Such policymakers could inadvertently restrict social capital creation, and thereby cooperation, among community members by offering guided, goal-oriented communication. Imposing such guided, goal-oriented communication may serve to suppress spontaneous free communication among stakeholders. This relative effectiveness of unstructured casual communication over structured team-building exercises that we find is in line with the general conclusion of studies such as Pentland (2012).

We further found that the positive externality of increased cooperation arising from team-building is weakly transferable whereas that from free-form communication is not. Even if players are switched to new groups after the team-building exercise, cooperation in absolute terms increases. When players are switched to new groups after the free-communication intervention, there is no change in cooperation. In both cases where players are switched to new groups, contributions were lower compared to the cases where players remain in the same groups after treatment, providing evidence that the external benefits of cooperation from social capital are not fully transferable across groups. The fact that contributions did not fall all the way to control-group levels with team-building after reallocation, however, implies that the positive externality of social capital is not entirely non-transferable across groups either. On the other hand, the fact that contributions did fall to control-group levels with free-communication when players are reallocated indicated that the degree to which the external benefits of social capital are transferable may be contingent on the process through which the social capital was created.

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Appendix A: Experiment Instructions

WELCOME!

Please make sure you have signed the consent form and ID document at this time. This is an experiment in the economics of decision making. Based on the choices you make in this experiment, you may earn a CONSIDERABLE AMOUNT OF MONEY which will be PAID TO YOU IN CASH at the end of the experiment. This experiment will have three stages. In this experiment you are assigned to a group four people. Your group consists of the others in your row. The instructions for each stage of the experiment will be distributed and read immediately prior to the beginning of that stage. Any kind of communication with other experiment participants is prohibited during stages 1 and 3 of the experiment. Communication will be allowed in part of stage 2, but must occur according to the procedures outlined in the stage 2 instructions.

Stage 1 Instructions

The amount of money you earn in this stage of the experiment depends on your contributions, as well as the contributions of others in your group. This stage of the experiment will have **10 rounds** of play in which you will be choosing how many tokens to contribute to a group investment. At the end of the experiment, you will be able to redeem your earned tokens for cash. The exchange rate is 100 tokens for $1. For example, if you have accumulated 1000 tokens at the end of the experiment, you will receive $10 in cash.

The Investment Decision

At the beginning of each round, you will have 50 tokens. You will choose how many of the 50 tokens to contribute to a group investment. At the end of each round, your total earnings consist of two parts. The first part is the number of tokens remaining after you contribute to the group investment. The second part is the number of tokens you earn from the group investment. What you earn from the group investment will depend on the *total number of tokens* that you and the other three members of your group contribute to the group investment. The more the group as a whole contributes to the group investment, the more tokens each member of the group earns. Specifically, *Each* member of the group earns 3 tokens for every 4 tokens contributed to the group investment. I will now explain three examples.

Example: Suppose that you decided to contribute 40 tokens to the group investment, and the three other members of your group contributed a total of 80 tokens, so the total group contribution is 80 + 40 = 120. Your earnings from the group investment would be 3/4 of 120, or 90 tokens. Everyone else in your group would also earn 90 tokens from the group investment. Your total number of tokens earned in this round would be (50 - 40) + 90 = 100 tokens.

Example: Suppose that you decided to contribute 0 tokens to the group investment, and the three other members of your group contributed a total of 100 tokens. Your earnings from the group investment would be 3/4 of 100, or 75 tokens. Everyone else in your group would also earn 75 tokens from the group investment. You also have your original 50 tokens. Your total number of tokens earned in this round would be (50 - 0) + 75 = 125 tokens.

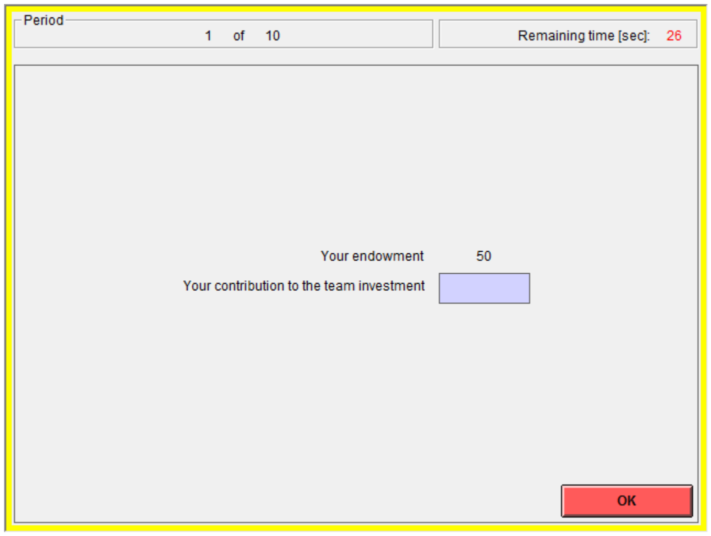
Example: Suppose that you decided to contribute 25 tokens to the group investment, and the three other members of your group each contribute 25 tokens. The total group investment is 100 tokens. Your earnings from the group investment would be 75 tokens. Everyone else in your group would also earn 75 tokens from the group investment. Your total number of tokens earned in this round would be (50 - 25) + 75 = 100 tokens.

Please raise your hand now if you have any questions about these examples.

Stage 1 Steps

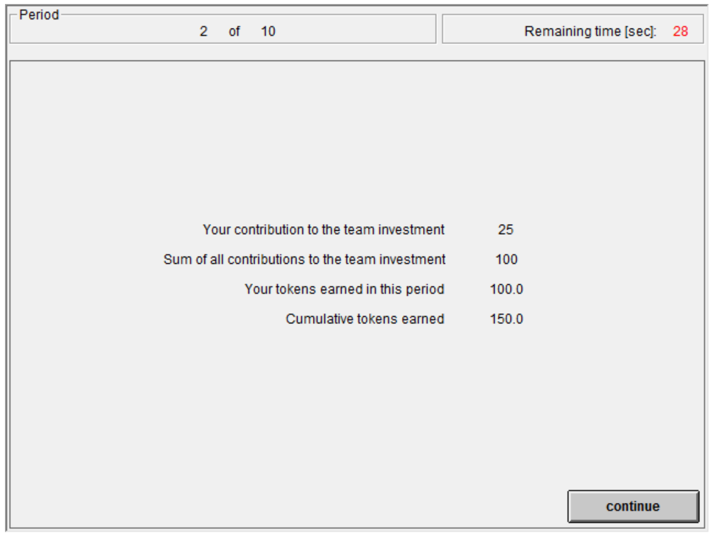
Stage 1 will be conducted using computer software. After the experiment moderator initiates the software program, the steps of each round of experiment will be as follows:

Step 1: You will see a screen which shows your endowment of 50 tokens and asks for your contribution of tokens to the group investment. In the box, enter your contribution to the group investment for this round. *You may enter any whole number value between 0 and 50.* You must enter a whole number; fractions are not valid. For example, you may choose to enter “10” but not “10.5”. An example of this screen is shown below:



Step 2: After you have entered your contribution quantity into the box, press “OK” to continue to the next screen. You have **1 minute** to enter a contribution and press “OK”. If your box is blank when time expires, your contribution will be set to zero. The time remaining is shown in the top right corner of the screen. After you press “OK”, you may see a waiting screen as other players finish their contribution decisions.

Step 3: Next, you will see a screen which lists four pieces of information: The number of tokens that you individually contributed to the group investment, the total number of tokens your group contributed to the group investment, the number of tokens that you individually earned in this round, and the total number of tokens you have earned throughout all rounds that have been played so far. When you are ready to continue to the next round of the experiment, press “Continue”. An example of this screen is shown below:



These steps will be repeated in each of the 10 rounds of this stage of the experiment. A single practice round will be played at the beginning of this stage. The outcome of the practice round will not affect the amount of money earned in the experiment. The practice round will be followed by 10 rounds which will affect your payoff.

Stage 1 Instructions Quiz

You will now be given 2 minutes to take a short quiz to confirm your understanding of the payouts in Stage 1. Fill in the blanks with your answers. Your answers to these questions will not be viewed by anyone else and do not affect your compensation in any way. I will review the answers after the two minutes is up.

(1) In a single round of Stage 1 of the experiment, you decide to contribute 20 of your tokens to the group investment. Another one of your group members decides to contribute 20 tokens. The other two group members do not contribute any tokens to the group investment. You will earn _____ tokens in this round.

(2) In a single round of Stage 1 of the experiment, you decide to contribute 10 of your tokens to the group investment. Two members of your group decide to contribute 0 tokens. The other member contributes 30 tokens. You will earn _____ tokens in this round.

Raise your hand now if you have any questions about Stage 1.

Stage 2 Instructions

In this stage of the experiment, you will fill out two documents called **Document A** and **Document B**. **Document A** is located with these instructions. During this stage, you will be meeting with your group in one of the small conference rooms which is connected with this room. Communication between participants is prohibited *unless* you are in one of the conference rooms *with the door closed*. Before meeting in the conference rooms, you will be given 5 minutes to fill out **Document A**. After these 5 minutes have passed, I will instruct you to get up out of your seat and meet with the other members of your group [20] Recall that your group number is written at the top-right corner of the first page of these instructions. Each group will meet in a separate conference room where a copy of **Document B** is located. The conference room assignments for each group are as follows (I will point to these locations as they are read):

(1) Group 1 will meet in room #1

(2) Group 2 will meet in room #2

(3) Group 3 will meet in room #3

(4) Group 4 will will meet in room #4

You will be given one minute to move to your group meeting location. If you need assistance, you may raise your hand and the moderator will assist you – remember that no communication is allowed while relocating into rooms. Next, you will be given 10 minutes to fill out **Document B** as a group. Once the group has agreed on a final version of **Document B**, each member of the group will sign the document. All group members must sign the document by the end of 10 minutes, even if all members have not agreed on a final version. At the end of ten minutes, the moderator will come to each of the conference rooms and notify you to return to your same, original seats.

---

[20] Please let the experiment moderator know if you have any physical limitations which might prevent you from moving about the room, and the moderator will gladly modify the experiment to accommodate you.

Stage 3 Instructions

Stage 3 of this experiment will be identical to Stage 1, but without a practice round. You will make the same investment decision, with the same payoffs, for 10 rounds.

Post-Experiment

Survey

Please fill out a paper **Survey** sheet located on your desk. You will be given 10 minutes to complete this.

Payment

After the surveys are filled out, I will call you up in order of your *Participant Number*, which is written on the top-right corner of both your **Payment Sheet** and the first page of these instructions. When I call your number, walk to the front of the room with your **Payment Sheet** and completed **Survey**. An assistant will write your total payoff on the payment sheet. You will then sign this document to receive payment. You have then completed your role in the experiment and may leave the room.

THANK YOU!

Document A

I believe the following characteristics are essential to successful teamwork (Please name at least two characteristics):

1.

2.

3.

4.

I think the following characteristics describe a good team player (Please name at least two characteristics):

1.

2.

3.

4.

Document B

TEAM STATEMENT

We believe the following characteristics are essential to successful teamwork (Please list at least four characteristics):

1...

2...

3...

4...

5...

We think the following characteristics describe a good team player (Please name at least two characteristics):

1...

2...

3...

4...

Each group member sign and date below:

X
....

X
....

X
....

X
....

THE UNIVERSITY OF WYOMING EQUALITY 1886

APPENDIX B: Full table for Result 4

Table 3. Within-treatment Analysis

	Control	Statement	Free	FreeR
Round 1	13.25***	7.813	4.563	10.31*
	(3.72)	(1.49)	(1.68)	(2.51)
Round 2	11.00**	11.13*	5.656*	10.75**
	(3.09)	(2.12)	(2.09)	(2.62)
Round 3	8.500*	8.000	7.688**	13.81***
	(2.39)	(1.52)	(2.84)	(3.37)
Round 4	2.800	10.50*	3.625	4.000
	(0.79)	(2.00)	(1.34)	(0.97)
Round 5	9.050*	12.94*	4.594	5.250
	(2.54)	(2.47)	(1.69)	(1.28)
Round 6	3.800	9.688	3.438	3.875
	(1.07)	(1.85)	(1.27)	(0.94)
Round 7	7.250*	8.188	2.313	5.250
	(2.04)	(1.56)	(0.85)	(1.28)
Round 8	1.650	6.250	5.219	8.000
	(0.46)	(1.19)	(1.93)	(1.95)
Round 9	4.250	-0.562	4.375	5.562
	(1.19)	(-0.11)	(1.61)	(1.36)
Round 11	9.250**	22.50***	19.31***	28.87***
	(2.60)	(4.29)	(7.12)	(7.04)
Round 12	8.600*	23.13***	18.38***	27.00***
	(2.41)	(4.41)	(6.78)	(6.58)
Round 13	10.75**	22.50***	19.94***	30.12***
	(3.02)	(4.29)	(7.35)	(7.34)
Round 14	9.000*	20.63***	19.94***	30.12***
	(2.53)	(3.93)	(7.35)	(7.34)
Round 15	8.250*	17.81***	19.94***	30.12***
	(2.32)	(3.39)	(7.35)	(7.34)
Round 16	6.500	21.88***	19.94***	30.12***
	(1.82)	(4.17)	(7.35)	(7.34)
Round 17	9.250**	17.19**	19.94***	30.12***
	(2.60)	(3.28)	(7.35)	(7.34)
Round 18	8.500*	15.00**	19.94***	30.12***
	(2.39)	(2.86)	(7.35)	(7.34)
Round 19	8.750*	10.31*	19.94***	30.12***
	(2.46)	(1.97)	(7.35)	(7.34)
Round 20	3.750	12.00*	19.94***	30.12***
	(1.05)	(2.29)	(7.35)	(7.34)
Constant	20.75***	22.81***	30.06***	19.88***
	(5.32)	(5.16)	(13.12)	(5.78)
Observations	400	320	640	320

z statistics in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

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