**SUPPLEMENTARY INFORMATION**

**SUPPLEMENTARY METHODS**

**Simulating the learning environment**

As we mention in the main text, we re-ran the whole set of simulations 10 times to estimate the consistency of the results (Supplementary Table 6).

**Learning the game in a black box**

A verbatim copy of the paper handout we used for instructions follows on the next three pages. These instructions were primarily read on-screen, but the paper handout included a conceptual figure to help explain the experiment (the on-screen instructions directed participants to look at the figure), and the paper handout was available for reference during the entire experiment.

After the experiment we checked the participants had not perceived the experiment as a social one by asking them, "In a few words, please tell us what, if anything, you think the experiment was about?" All responses are available in the Supplementary Spreadsheet on Questionnaire Responses and in the raw data files.

**Welcome to the experiment!**
A copy of these instructions is also available on-screen.
We are going to give you some virtual coins. Each *'coin'* is worth real money.

You are going to make a decision regarding the investment of these 'coins'.
This decision may increase or decrease the number of coins you have.
The more coins you have at the end of the experiment, the more money you will receive at the end.

At the end of the experiment the total amount of 'coins' you have earned will be converted to pennies at the following rate: 100 coins = 75 pennies, or = £0.75.

In total, you will be given 960 coins £7.20 with which to make decisions and your final total, which may be more or less than 960 coins, will depend on these decisions.

**The Decision**
You will face the same decision many times. Each time we will give you 20 virtual 'coins'. Then you must decide on how many of your 20 coins to input into a virtual ***'black box'***.

This *'black box'* performs a mathematical function that converts the number of 'coins' **inputted** into a number of 'coins' to be **outputted**.

The mathematical function contains **two components, one constant, deterministic, component which acts upon your input, and one *'chance'* component.**

You will play with this 'black box' for many rounds (more on this later), and the mathematical function will not change, but the chance component means that if you put the same amount of coins into the 'black box' over successive rounds, you will not necessarily get the same output each time.

The number outputted may be **more or less than you put in**, but it will never be a negative number, so the lowest outcome possible is to get 0 (zero) back.

If you chose to input 0 (zero) coins, you may still get some back from the black box.

All coins not inputted into the black box will be automatically *'banked'* into your private account.
All coins outputted from the black box will also be 'banked' and go into your private account.
You will be paid all the coins from your private account at the end of the experiment.

So, in summary, your income from each decision will be the initial 20 coins, minus any you put into the *'black box'*, plus all the coins you get back from the *'black box'*.

**Playing the same box many times**
You will play this game (make this decision) 16 times. Each time we will give you a **new set** of 20 coins to use.

**Each decision is separate but the *'black box'* remains the same.**
This means you cannot play with money gained from previous decisions, and the maximum you can ever put into the *'black box'* will be 20 coins.
And you will never run out of money to play with as we will give you a new set of coins for each decision.

Please see the attached figure overleaf for a summary of the experiment.

**Playing with different boxes**
After you have finished your 16 decisions, you will play again with a new *'black box'*.
In total, you will play with 3 black boxes in the whole experiment.

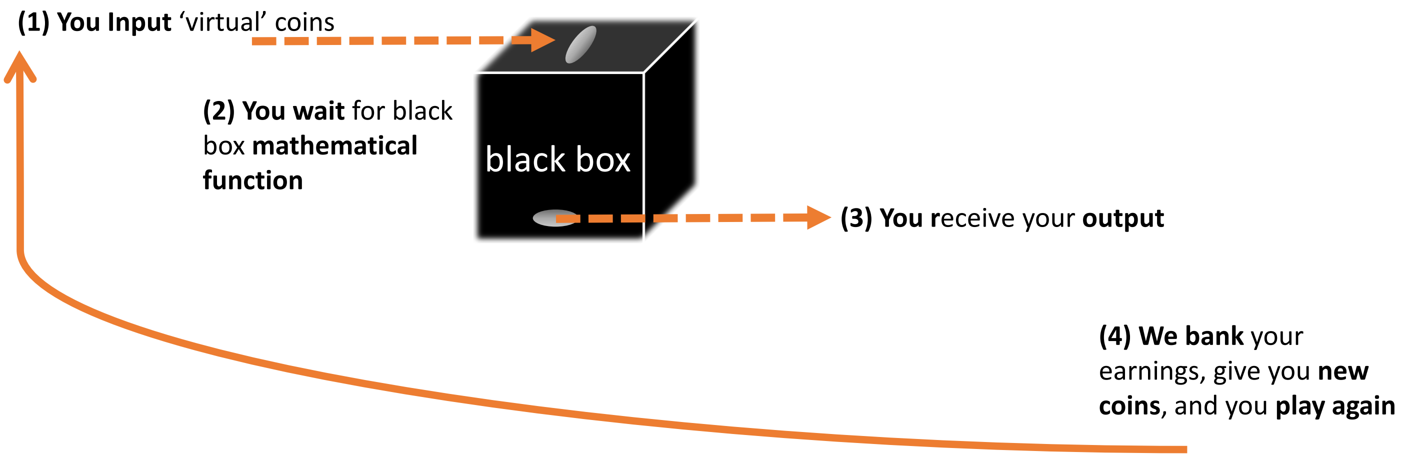
All black boxes are the same in that they perform a mathematical function that converts the number of coins inputted into a number of coins to be outputted.
**However each black box will have a different mathematical function.**

But the functions will always contain two components, one constant, deterministic, component, and one *'chance'* component. You will play with this black box for many rounds, and the mathematical function will never change, but the chance component means that if you put the same amount of coins into the black box over successive rounds, you will not necessarily get the same output each time.

**You will be told when the decisions are finished and it is time to play with a new black box.**

If you are unsure of the rules please hold up your hand and a demonstrator will help you.

## The Experiment



**Learning can explain variation across public-goods games.**

**Literature search.** Overall we found 130 suitable articles (Supplementary Figure 6, [1-130]). We used the "Web Of Knowledge" database to perform an extensive literature search in May 2014. We made two searches, one using the phrase "public good* game*", and one use "voluntary contribution mechanism". Search results were refined to "articles" only and those that were written in "English". These combined searches returned over 600 articles for consideration, 69 of which were eligible for inclusion [3, 7, 16, 21, 24, 27, 31-34, 36, 37, 39, 41-47, 49-52, 54-59, 61, 63, 64, 67-69, 72-75, 77-86, 88-104, 109, 112].

We then searched the references within three articles that review social dilemmas [131-133] and found an additional 14 [2, 8-15, 17-19, 22, 23], 1 [5], and 3 [29, 70, 116] eligible articles respectively.

Finally, we conducted another literature search in October 2017 for new articles in English occurring since our first search (2014-2017 inclusive). This second search used the phrase "public good* game*", refined by TOPIC: "experiment" AND "voluntary contribution mechanism", and returned 40 articles, 12 of which were eligible for inclusion [105, 107, 110, 114, 115, 118-120, 123-125, 127]. Another search using "repeated public good* game*" refined by TOPIC: "experiment" returned 37 articles, 8 of which were eligible for inclusion [108, 111, 113, 121, 122, 126, 129, 130].

During our research we also came across articles that were potentially eligible but had not been found in the literature search. Ultimately, we found 22 such articles that were eligible [1, 4, 6, 20, 25, 26, 28, 30, 35, 38, 48, 53, 60, 62, 65, 66, 71, 76, 87, 106, 117, 128]. This gave us a total of 130 studies referenced here in chronological order of publication date. For one study we emailed the authors to request a copy of the necessary data [53].

**SUPPLEMENTARY RESULTS**

**Learning the game in a black box**
We found that most of the players in the high influence treatment experienced a significantly negative correlation between their own contributions and their own payoffs (51 of 72 players). In contrast, only a minority of players experienced a significant negative correlation when either group size was large (13 of 72 players), or the MPCR was high (6 of 72 players), these players have been graphically coded with filled circles in Supplementary Figure 4.

**Learning can explain variation across public-goods games**
**Robustness Checks.** In order to test the robustness of our general results we repeated the analyses reported in the main text in several different ways. Specifically, we (1) restricted the data to just the first 10 rounds in games; (2) omitted 20 studies that were arguably of low suitability with regards to testing this study's hypotheses; (3) removed the weighting of the residuals by the number of participants; (4) weighted the residuals by the number of independent groups rather than individuals; (5) removed the covariates; and (6) removed the cases where we had to impute the covariates. In each case we found qualitatively similar results, with the best model always being the one based on our estimated correlations from the simulations (Supplementary Table 5).

**Learning from others.** We examined the effect of providing more information to participants in experiments. Typically, studies tended to only show players the total/average contribution of their groupmates ('SumC', N = 149 of 237), but some also showed the individual contributions of groupmates ('Ci', N = 59) whereas even fewer also showed the individual payoffs/earnings (Ei, N = 27) (the levels of information are hierarchical so the 27 samples showing individual payoffs also contained information on individual contributions and the average contribution; at the other extreme two samples only provided information on a focal player's own payoffs, Supplementary Table 9).

If players are using payoff-based learning, then showing them both the individual contributions (Ci) and payoffs (Ei) of their groupmates should facilitate payoff-based learning and hasten the decline in contributions/cooperation. This is because they will always observe a perfectly negative correlation between contributions and payoffs among all members of the group (when MPCR < 1). In contrast, if players are motived by conditional cooperation to match the contributions of their groupmates (Ci), then additionally showing them the payoffs of their groupmates (Ei) should make little difference to the rate of decline in contributions. Likewise, if one assumes that players are motivated by inequity aversion to match the payoffs of their groupmates, then one must assume that players calculate the payoffs from the contributions, and thus the information on payoffs is redundant.

To test between these two predictions, we can compare the coefficients for Information*Round (Supplementary Table 3). The coefficients suggest that the effect of providing information on individual payoffs (Ei) is to quicken the decline in contributions, whereas showing individual contributions (Ci) per se has no effect (Ci*Round: unstandardized coefficient B, relative to showing payoffs = +0.8 ±0.26) compared to merely showing the average contribution of groupmates (SumC*Round: B relative to showing payoffs = +0.9 ±0.24, Supplementary Table 3, model 1). Substituting in a binary variable that encodes if the information showed the payoffs of groupmates or not finds that this distinction is significant ($F_{1,173.2} = 12.9$, $P < 0.0001$) and that the decline in contributions is 0.8 ±0.23 percentage points faster when information on payoffs is provided (Supplementary Table 3, model 2).

If players can use information on their groupmates to learn then this also means that such information will negate the importance of influence over own payoffs (*i*) for learning. We tested this idea by testing for a three-way interaction between our binary covariate on the level of information in each game (either with or without information on the payoffs of groupmates), and our influence over payoffs (*i*) variable and round of the game. We found that this three-way interaction was significant ($F_{1,336.6} = 17.5$, $P < 0.001$, Supplementary Table 3, model 3) and the coefficient for influence*round was significantly less negative when payoffs were shown.

Interpreting three-way interactions can be difficult. Therefore, we further illustrated the idea that information on payoffs diminishes the importance of individual influence over own payoffs by splitting the data. We made two sets, one where the information showed the payoffs of groupmates and one where the information did not. We then tested them separately for an effect of influence (*i*) on the rate of decline (an interaction with Round). When participants could not see information on the payoffs of groupmates, influence (*i*) significantly affected the rate of decline (Influence*Round, $F_{1,185.9} = 66.4$, $P < 0.001$, B = -2.7 ±0.33, Supplementary Table 3, model 4). In contrast, when participants could see information on the payoffs of groupmates, influence (*i*) did not significantly affect the rate of decline (Influence*Round, $F_{1,40.2} = 3.1$, $P = 0.086$, B = 2.5 ±1.44, Supplementary Table 3, model 5). Although we caution a non-significant result is not evidence of no effect and comparing results from different models is not a direct test (unlike in Supplementary Table 3 model 3). In addition, the sample of studies showing information about the payoffs of groupmates is rather limited (N = 27). Overall, we argue that these results suggest that the importance of influence over own payoffs is diminished when individuals can observe the correlation between contributions and payoffs among the decisions of their groupmates, as predicted by the confused learners hypothesis.

**Learning to cooperate.** We tested if influence over own payoffs could affect the rate of change in contributions where the income maximizing strategy is to contribute fully (100%). In these games, the individual return from contributing is profitable (MPCR > 1), so both altruistic and self-interested players should contribute fully, making the game a 'public delight'. However, in these games contributions/cooperation still begins at intermediate levels in such games (weighted samples mean = 66.1% ±0.67% SEM ±10.7% SDV), suggesting players are 'confused'.

We used a linear mixed model containing both Round and Influence over own payoffs (*i*) and the interaction between the two, but we had to omit the covariates because our sample size was too small, exhausting our degrees of freedom. We found that the degree of influence significantly affected the rate of contributions, with contributions *increasing* when players had more influence (Linear mixed model, Influence*Round: $F_{1,14.4} = 8.7$, $P = 0.010$, $B = 8.9 \pm 3.0$). We then substituted in the mean correlation from our simulations for influence, and found that this too was significant (Correlation*Round: $F_{1,11.8} = 7.0$, $P = 0.022$, $B = 10.0 \pm 3.8$). These results suggest that, in both versions of the game (public-dilemma and public-delight), individuals began by not maximizing their income, but were quicker to approach income-maximizing behaviour when they had more influence over their own payoffs and thus payoff-based learning was less difficult. Although the small sample size of public-delight games (N=10) means we are cautious when interpreting these further results.

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**Supplementary Table 1**: Maximum likelihood linear mixed effects meta-regression models on contributions in public-goods games (MPCR < 1).

| Fixed effects[1] / Model | M1 | M2 | M3 |
|---|---|---|---|
| Intercept | 49.1 ±0.98*** | 50.1 ±0.95*** | 35.8 ±5.3*** |
| Round[2] | -2.4 ±0.11*** | -2.3 ±0.11*** | -3.3 ±0.47*** |
| Groupsize[3] | | 0.3 ±0.46 | 0.1 ±0.44 |
| Groupsize*Round | | 0.1 ±0.04* | 0.1 ±0.03** |
| MPCR[4] | | 3.0 ±0.50*** | 3.3 ±0.49*** |
| MPCR*Round | | 0.3 ±0.05*** | 0.3 ±0.04*** |
| **Covariates[5]** | | | |
| Nrounds[6] | | | -0.3 ±1.2 |
| Nrounds*Round | | | 0.7 ±0.1*** |
| End-game (No, N = 20) | | | -3.0 ±3.2 |
| End-game (Yes, N = 217) | | | / |
| End-game (No)*Round | | | 1.1 ±0.27*** |
| End-game (Yes)*Round | | | / |
| Groups (Constant, N = 186) | | | 17.7 ±4.8*** |
| Groups (Shuffled, N = 45) | | | 10.2 ±4.9* |
| Groups (Stranger, N = 6) | | | / |
| Groups (Constant)*Round | | | -0.2 ±0.43 |
| Groups (Shuffled)*Round | | | -0.1 ±0.44 |
| Groups (Stranger)*Round | | | / |
| Information (ownE, N = 2) | | | 0.1 ±8.0 |
| Information (SumC, N = 149) | | | -1.5 ±2.6 |
| Information (Ci, N = 59) | | | 1.1 ±3.0 |
| Information (Ei, N = 27) | | | / |
| Information (own E)*Round | | | 0.7 ± 0.66 |
| Information (SumC)*Round | | | 0.9 ±0.24*** |
| Information (Ci)*Round | | | 0.8 ±0.26** |
| Information (Ei)*Round | | | / |
| **Covariance parameters (Wald Z)** | | | |
| Repeated measures (AR1 diagonal) | 12.8*** | 13.7*** | 14.1*** |
| Repeated measures (AR1 rho) | 67.8*** | 69.6*** | 71.6*** |
| Random intercept (Article) | 2.9** | 3.4** | 3.0** |
| Random slope (Article) | 4.1*** | 4.6*** | 3.1** |
| Random intercept (Treatment) | 5.9*** | 5.4*** | 5.4*** |
| Random slope (Treatment) | 2.7** | 1.9* | 1.4 |
| **Model Summary** | | | |
| Number of levels | 71 | 75 | 95 |
| Number of Parameters | 8 | 12 | 26 |
| Number of Observations | 3,611 | 3,611 | 3,611 |
| **Information criteria[7]** | | | |
| AIC | 23,486 | 23,419 | 23,337 |
| AICC | 23,486 | 23,419 | 23,337 |
| CAIC | 23,543 | 23,506 | 23,524 |
| BIC | 23,535 | 23,494 | 23,498 |
| Mean IC | 23,512.5 | 23,459.4 | 23,423.9 |
| Model improvement | Reference | -53.1 | -88.6 |

[1]Parameter estimates also show the standard error. Significance < 0.001 = ***; < 0.01 = **; <0.1 = *. The necessary variables have been centered and rescaled to make the coefficients more intuitive. The reference game is a group of four players, playing with an MPCR of 0.5, who know they are playing for 10 rounds (Nrounds = 10, End-game = Yes) in a perfect-stranger design (Stranger). After each round they are told the individual contributions and earnings (Information = Ei) of all players in their group.

[2]We decreased Round by one so that the intercept represents contributions in the first round.

[3]Groupsize is centered on 4, and has been divided by 10, so the coefficient represents an additional 10 members.
[4]MPCR is centered on 0.5, and has been multiplied by 10, so the coefficient represents an increase of 0.1.
[5]To avoid 'p-hacking' we only included all or none of the covariates.
[6]The number of rounds is centered on 10, and has been divided by 10, so the coefficient represents an extra 10 rounds.
[7]Lower values indicate a superior model evaluation.

**Supplementary Table 2**: A comparison of maximum likelihood linear mixed effects models testing various hypotheses for the decline in contributions in repeated public-goods games (MPCR < 1) (see Table 1 and Figure 4).

| Parameters[1] / Model | *Learning (Qualitative)* | *Learning (Influence)* | *Learning (Simulated)* | *Inequity aversion (Absolute)* | *Inequity aversion (Proportional)[2] / PTGG-1[3]* | *PTPG-2* | *PTPG-3* | *PTGG-4* | *Unspecified[4]* |
|---|---|---|---|---|---|---|---|---|---|
| Intercept | x*** | x*** | x*** | x*** | x*** | x*** | x*** | x*** | x*** |
| Round | x*** | x*** | x*** | x*** | x*** | x*** | x*** | x*** | x*** |
| Covariates[5] | x*** | x*** | x*** | x** | x** | x** | x** | x** | x*** |
| Covariates*Round | x*** | x*** | x*** | x*** | x*** | x*** | x*** | x*** | x*** |
| Group-size | x | | | | | x | | | x |
| Group-size*Round | x** | | | | | x* | | | x** |
| MPCR | x*** | | | | | | x*** | | x*** |
| MPCR*Round | x*** | | | | | | x*** | | x*** |
| Influence | | x*** | | | | | | | |
| Influence*Round | | x*** | | | | | | | |
| SimCorrelation | | | x*** | | | | | | |
| SimCorrelation*Round | | | x*** | | | | | | |
| Multiplier | | | | | x | | | | |
| Multiplier*Round | | | | | x** | | | | |
| Benefit-to-Others[6] | | | | | | | | x | |
| Benefit-to-Others*Round | | | | | | | | x** | |
| Information criteria[7] | | | | | | | | | |
| AIC | 23,337 | 23,317 | 23,293 | 23,433 | 23,423 | 23,431 | 23,344 | 23,424 | 23,337 |
| AICC | 23,337 | 23,317 | 23,293 | 23,433 | 23,423 | 23,432 | 23,344 | 23,424 | 23,337 |
| CAIC | 23,524 | 23,489 | 23,465 | 23,591 | 23,595 | 23,604 | 23,516 | 23,596 | 23,524 |
| BIC | 23,498 | 23,465 | 23,441 | 23,569 | 23,571 | 23,580 | 23,492 | 23,572 | 23,498 |
| *Mean IC* | *23,423.9* | *23,397.2* | *23,373.0* | *23,506.4* | *23,503.2* | *23,511.7* | *23,424.0* | *23,504.2* | *23,423.9* |
| Model improvement | Reference | -26.7 | -50.9 | 82.5 | 79.3 | 87.8 | 0.1 | 80.3 | N/A |

[1]x denotes inclusion in the model; Significance < 0.001 = ***; < 0.01 = **; <0.1 = *.
[2]Both proportional inequity aversion and PTGG-1 predict that a larger multiplier will impede the decline; [3]PTPG = Preserve the greater good; [4]The model with the lowest mean information criteria score out of all 14 possible permutations of Round, Group-size and MPCR; [5]Significance relates to that of the most significant covariate; [6]The Benefit-to-others is calculated from MPCR*(N-1). N is the group-size; [7]The information criteria evaluate model performance and lower values indicate superior models.

**Supplementary Table 3**: Linear mixed model meta-regression on contributions in public-goods games (MPCR < 1) depending on the information available to players.

| **Fixed effects[1] / Model** | **M1[2] All information** | **M2 Information binary** | **M3 Information binary*Influence** | **M4 Information binary = no Ei** | **M5 Information binary = Ei** |
|---|---|---|---|---|---|
| Intercept | 35.8 ±5.3*** | 36.1 ±5.3*** | 71.3 ±8.2*** | 51.6 ±4.9*** | 65.6 ±7.2*** |
| Round | -3.3 ±0.5*** | -3.3 ±0.5*** | -4.3 ±0.8*** | -0.6 ±0.4 | -3.9 ±0.9*** |
| Groupsize | 0.1 ±0.4 | 0.1 ±0.4 | | | |
| Groupsize*Round | 0.1 ±0.0** | 0.1 ±0.0** | | | |
| MPCR | 3.3 ±0.5*** | 3.4 ±0.5*** | | | |
| MPCR*Round | 0.3 ±0.0*** | 0.3 ±0.0*** | | | |
| Nrounds | -0.3 ±1.2 | -0.0 ±1.2 | 0.8 ±1.1 | 1.4 ±1.2 | -1.3 ±2.1 |
| Nrounds*Round | 0.7 ±0.1*** | 0.7 ±0.1*** | 0.7 ±0.1*** | 0.7 ±0.1*** | 0.8 ±0.2* |
| End-game (No, N = 20) | -3.0 ±3.2 | -3.2 ±3.2 | -3.1 ±3.3 | -4.0 ±3.9 | 1.0 ±4.8 |
| End-game (Yes, N = 217) | / | / | / | / | / |
| End-game (No)*Round | 1.1 ±0.3*** | 1.1 ±0.3*** | 0.9 ±0.3**** | 0.9 ±0.3** | 1.0 ±0.6 |
| End-game (Yes)*Round | / | / | / | / | / |
| Groups (Constant, N = 186) | 17.8 ±4.8*** | 17.3 ±4.8*** | 12.1 ±4.7** | 11.6 ±4.6* | 20.7 ±4.6*** |
| Groups (Shuffled, N = 45) | 10.3 ±4.9* | 10.1 ±4.9* | 6.2 ±4.7 | 8.4 ±4.7* | / |
| Groups (Stranger, N = 6) | / | / | / | / | NA |
| Groups (Constant)*Round | -0.2 ±0.4 | -0.2 ±0.4 | -0.6 ±0.4 | -0.6 ±0.4 | -1.6 ±0.5* |
| Groups (Shuffled)*Round | -0.1 ±0.4 | -0.0 ±0.4 | -0.4 ±0.4 | -0.5 ±0.4 | / |
| Groups (Stranger)*Round | / | / | / | / | NA |
| Information (ownE, N = 2) | 0.1 ±8.0 | | | | |
| Information (SumC, N = 149) | -1.5 ±2.6 | | | | |
| Information (Ci, N = 59) | 1.1 ±3.0 | | | | |
| Information (Ei, N = 27) | / | | | | |
| Information (own E)*Round | 0.7 ± 0.7 | | | | |
| Information (SumC)*Round | 0.9 ±0.2*** | | | | |
| Information (Ci)*Round | 0.8 ±0.3** | | | | |
| Information (Ei)*Round | / | | | | |
| Info. binary (no Ei) | | -0.8 ±2.6 | -20.1 ±7.1** | | |
| Info. binary (Ei) | | / | / | | |
| Info. binary (no Ei)*Round | | 0.8 ±0.2*** | 3.6 ±0.7*** | | |
| Info. binary (Ei)*Round | | / | / | | |
| Influence (*i*)[3] | | | -55.7 ±11.0*** | -23.8 ±3.6*** | -53.9 ±10.8*** |
| Influence*Round | | | 2.3 ±1.1* | -2.7 ±0.3*** | 2.5 ±1.4* |
| Info. binary (no Ei)*Round*(*i*) | | | -4.9 ±1.2*** | | |
| Info. binary (Ei)*Round*(*i*) | | | / | | |
| **Model Summary** | | | | | |
| Number of levels | 95 | 91 | 93 | 85 | 73 |
| Number of parameters | 26 | 22 | 22 | 18 | 16 |
| Number of observations | 3,611 | 3,611 | 3,611 | 3,159 | 452 |
| **Information criteria** | | | | | |
| AIC | 23,337 | 23,330 | 23,300 | NA | NA |
| AICC | 23,337 | 23,331 | 23,300 | NA | NA |
| CAIC | 23,524 | 23,489 | 23,458 | NA | NA |
| BIC | 23,498 | 23,467 | 23,436 | NA | NA |
| Mean IC | 23,423.9 | 23,404.0 | 23,373.6 | NA | NA |
| Model improvement | Reference | -19.9 | -50.3 | NA | NA |

[1]The necessary variables have been centered and rescaled to make the coefficients more intuitive: see Table 1 in main text for details. Significance < 0.001 = ***; < 0.01 = **; <0.1 = *.
[2]M1 is the same as M3 in Table 1 in the main text.
[3]Influence ranges from near 0 to near 0.5 so we doubled it, to make the regression coefficient represent an increase from zero to maximal influence.

**Supplementary Table 4**: 'P-Hacking' a model from all possible permutations. A comparison using Maximum Likelihood of all possible permutations of group-size, MPCR, and round (MPCR < 1).

| Parameters[1]/model | M1 | M2 | M3 | M4 | M5 | M6 | M7 | M8 | M9 | M10 | M11 | M12[2] | M13 | M14 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Intercept | X*** | X*** | X*** | X*** | X*** | X*** | X*** | X*** | X*** | X*** | X*** | X*** | X*** | X*** |
| Round | X*** | X*** | X*** | X*** | X*** | X*** | X*** | X*** | X*** | X*** | X*** | X*** | X*** | X*** |
| Covariates[3] | X** | X*** | X** | X*** | X*** | X*** | X** | X*** | X*** | X*** | X*** | X*** | X*** | X*** |
| Covariates*Round | X*** | X*** | X*** | X*** | X*** | X*** | X*** | X*** | X*** | X*** | X*** | X*** | X*** | X*** |
| MPCR | | X*** | | X*** | X*** | X*** | | X*** | X*** | X*** | X*** | X*** | X*** | X*** |
| Group-size | | | X | X | X | | X | X | X | X | X | X | X | X |
| MPCR*Group-size | | | | | X* | | | | | X* | X* | | X* | X* |
| MPCR*Round | | | | | | X*** | | X*** | | X*** | | X*** | X*** | X*** |
| Group-size*Round | | | | | | | X | | X* | | X* | X** | X** | X* |
| MPCR*Group-size*Round | | | | | | | | | | | | | | X |
| Model summary | | | | | | | | | | | | | | |
| N levels | 91 | 92 | 92 | 93 | 94 | 93 | 93 | 94 | 94 | 95 | 95 | 95 | 96 | 97 |
| N parameters | 22 | 23 | 23 | 24 | 25 | 24 | 24 | 25 | 25 | 26 | 26 | 26 | 27 | 28 |
| N observations | 3,611 | 3,611 | 3,611 | 3,611 | 3,611 | 3,611 | 3,611 | 3,611 | 3,611 | 3,611 | 3,611 | 3,611 | 3,611 | 3,611 |
| Information criteria | | | | | | | | | | | | | | |
| AIC | 23'433 | 23'369 | 23'434 | 23'370 | 23'367 | 23'344 | 23'431 | 23'345 | 23'368 | 23'342 | 23'365 | 23'337 | 23'334 | 23'336 |
| AICC | 23'433 | 23'370 | 23'434 | 23'371 | 23'368 | 23'344 | 23'432 | 23'345 | 23'368 | 23'342 | 23'365 | 23'337 | 23'335 | 23'336 |
| CAIC | 23'591 | 23'535 | 23'599 | 23'543 | 23'547 | 23'516 | 23'604 | 23'524 | 23'548 | 23'529 | 23'552 | 23'524 | 23'528 | 23'537 |
| BIC | 23'569 | 23'512 | 23'576 | 23'519 | 23'522 | 23'492 | 23'580 | 23'499 | 23'523 | 23'503 | 23'526 | 23'498 | 23'501 | 23'509 |
| *Mean IC* | 23'506.4 | 23'446.5 | 23'511.1 | 23'450.7 | 23'451.1 | 23'424.0 | 23'511.8 | 23'428.3 | 23'451.5 | 23'429.2 | 23'451.7 | 23'423.9 | 23'424.7 | 23'429.4 |
| Improvement | *Reference* | -59.9 | 4.6 | -55.7 | -55.3 | -82.4 | 5.4 | -78.1 | -55.0 | -77.3 | -54.8 | -82.5 | -81.7 | -77.0 |

[1] x denotes inclusion in the model; Significance < 0.001 = ***; < 0.01 = **; <0.1 = *.
[2]Most superior model according to mean Information Criterion score.
[3]Four covariates were added and the significance shown is of the most significant covariate.

**Supplementary Table 5.** The relative mean information criterion scores (lower is better) for each model compared to the simulated learning model, depending on various robustness checks.

| Robustness check / Model | *Learning (Qualitative)* | *Learning (Influence)* | *Learning (Simulated)* | *Inequity aversion (Absolute)* | *Inequity aversion (Proportional) / PTGG-1* | *PTPG-2* | *PTPG-3* | *PTGG-4* | *Unspecified* |
|---|---|---|---|---|---|---|---|---|---|
| 1) Restriction: first 10 rounds only | 45 | 24 | Reference | 128 | 127 | 134 | 45 | 128 | 45 |
| 2) Omit 20 low suitability studies | 49 | 18 | Reference | 109 | 106 | 114 | 48 | 106 | 48 |
| 3) Removed weighting of residuals | 47 | 17 | Reference | 140 | 140 | 148 | 47 | 141 | 47 |
| 4) Weighted residuals by number of groups | 27 | 25 | Reference | 104 | 108 | 113 | 21 | 109 | 21 |
| 5) Removed covariates | 41 | 14 | Reference | 94 | 96 | 102 | 34 | 97 | 34 |
| 6) Removed imputed values for covariates | 41 | 20 | Reference | 97 | 99 | 105 | 36 | 100 | 36 |

**Supplementary Table 6**: Testing the consistency of the simulations. We re-ran the entire set of simulations and analyses ten times and compared the summary statistics from a linear model between the mean correlations of 10,000 simulations per unique N*MPCR combination and the degree of influence in each unique combination.

| Term | Sim 1 | Sim 2 | Sim 3 | Sim 4 | Sim 5 | Sim 6 | Sim 7 | Sim 8 | Sim 9 | Sim 10 | mean | min | max | Range |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| F-stat | 125.6 | 127.4 | 126 | 124.8 | 127.1 | 126.5 | 125.4 | 125 | 125.2 | 126.5 | 125.95 | 124.80 | 127.40 | 2.60 |
| Significance | 1.30E-14 | 1.03E-14 | 1.24E-14 | 1.45E-14 | 1.06E-14 | 1.15E-14 | 1.34E-14 | 1.40E-14 | 1.37E-14 | 1.16E-14 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Intercept | -0.1155 | -0.11321 | -0.11329 | -0.11295 | -0.11421 | -0.11404 | -0.11493 | -0.11564 | -0.11513 | -0.1166 | -0.1146 | -0.1166 | -0.1130 | 0.0037 |
| Slope | -1.91757 | -1.92441 | -1.9218 | -1.9215 | -1.92168 | -1.92161 | -1.91743 | -1.91595 | -1.91654 | -1.91576 | -1.9194 | -1.9244 | -1.9158 | 0.0087 |
| Slope S.E. | 0.1711 | 0.1705 | 0.17122 | 0.172 | 0.17044 | 0.17084 | 0.17123 | 0.17135 | 0.17128 | 0.17034 | 0.1710 | 0.1703 | 0.1720 | 0.0017 |
| Rsq_adj | 0.7304 | 0.7332 | 0.731 | 0.7291 | 0.7328 | 0.7318 | 0.73 | 0.7294 | 0.7297 | 0.7318 | 0.7309 | 0.7291 | 0.7332 | 0.0041 |

**Supplementary Table 7**: Using information criteria to find the preferred Restricted Maximum Likelihood (REML) baseline model of repeated, weighted, random effects for subsequent testing of main effects.

| | | M1 | M2[2] | M3 | M4[3] | M5 | M6 | M7 | M8 | M9 | M10 | M11 | M12[4] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Main effects | Intercept | X | X | X | X | X | X | X | X | X | X | X | X |
| | Round | X | X | X | X | X | X | X | X | X | X | X | X |
| Repeated effects | Scaled identity | X | | | | | | | | | | | |
| | Autoregressive (AR1) | | X | X | X | X | X | X | X | X | X | X | X |
| Residual Weighting | Number of groups | | | X | | | | | | | | | |
| | Number of participants | | | | X | X | X | X | X | X | X | X | X |
| Random effects | Article[5] intercept | | | | | X | X | | | X | X | X | X |
| | Article slope | | | | | | X | | | | X | | X |
| | Treatment[6] intercept | | | | | | | X | X | X | X | X | X |
| | Treatment slope | | | | | | | | X | | | X | X |
| Model Summary | N Observations | 3,611 | 3,611 | 3,611 | 3,611 | 3,611 | 3,611 | 3,611 | 3,611 | 3,611 | 3,611 | 3,611 | 3,611 |
| | N levels | 67 | 67 | 67 | 67 | 68 | 69 | 68 | 69 | 69 | 70 | 70 | 71 |
| | N Parameters | 3 | 4 | 4 | 4 | 5 | 6 | 5 | 6 | 6 | 7 | 7 | 8 |
| Information criteria[7] | AIC | 30,793 | 24,657 | 24,724 | 23,919 | 23,810 | 23,570 | 23,826 | 23,541 | 23,807 | 23,499 | 23,525 | 23,485 |
| | AICC | 30,793 | 24,657 | 24,724 | 23,919 | 23,810 | 23,570 | 23,826 | 23,541 | 23,807 | 23,499 | 23,525 | 23,485 |
| | CAIC | 30,800 | 24,671 | 24,738 | 23,933 | 23,831 | 23,599 | 23,848 | 23,569 | 23,835 | 23,535 | 23,561 | 23,529 |
| | BIC | 30,799 | 24,669 | 24,736 | 23,931 | 23,828 | 23,595 | 23,845 | 23,565 | 23,831 | 23,530 | 23,556 | 23,523 |
| | Mean IC | 30,796 | 24,663 | 24,731 | 23,925 | 23,820 | 23,583 | 23,836 | 23,554 | 23,820 | 23,516 | 23,541 | 23,505 |

[1] X denotes inclusion in the model. Data were restricted to cases where MPCR < 1 (social dilemma version of the public goods game). Otherwise all cases were included.
[2] M2 was the superior repeated effects model, so we used an autoregressive covariance (AR1) structure for subsequent models.
[3] M4 was the superior weighted model, so we used weighting by individuals for subsequent models.
[4] M12 was the best random-effects model, so we used it as the platform for subsequent testing of main effects using Maximum Likelihood (ML).
[5] Article refers to the single article that may contain more than one treatment (treatments vary on at least one of the collected variables, see main text).
[6] Treatment refers to independent unit, i.e. each experimental-treatment within an article, or each geographical test of the same treatment within an article.
[7] For information criteria, lower values are preferred.

**Supplementary Table 8**: Descriptive statistics of the numerical variables used.

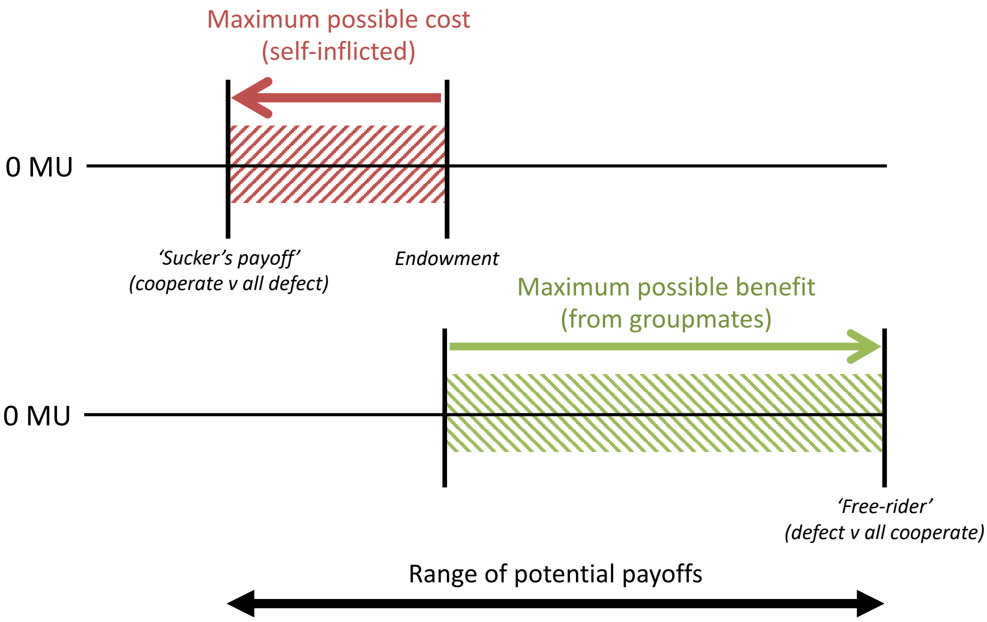
| Variable | Minimum | Mean ± St.Dev. | Maximum | Most common | 2nd most common | 3rd most common |
|---|---|---|---|---|---|---|
| Groupsize (N) | 2 | 8.3 ± 15.78 | 100 | 4 (126) | 5 (31) | 3 (18) |
| Cost of contributing (MPCR) | 0.02 | 0.46 ± 0.16 | 0.8 | 0.5 (75) | 0.4 (64) | 0.3 (32) |
| Multiplier (M) | 1.2 | 2.95 ± 5.90 | 75 | 1.6 (66) | 2.0 (46) | 1.5 (25) |
| Number of rounds | 5 | 12.4 ± 6.52 | 50 | 10 (153) | 20 (27) | 6 (10) |

Note: MPCR < 1, number of observations = 237

**Supplementary Table 9**: Descriptive statistics of the categorical variables used and number of imputed cases.

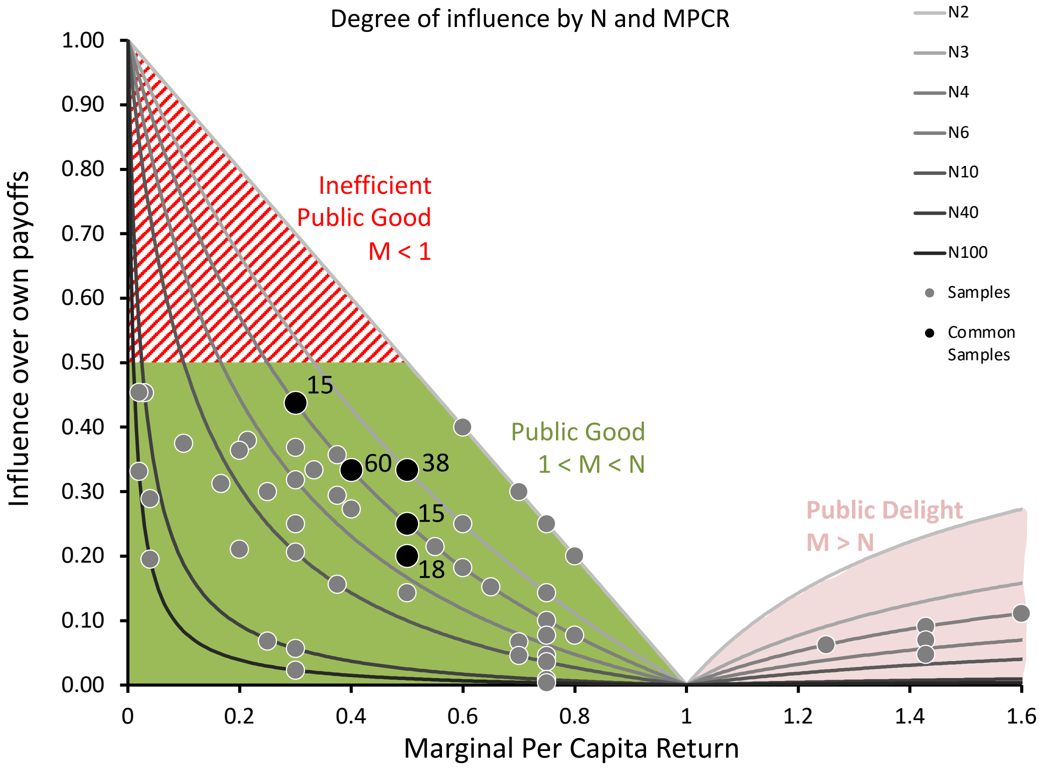
| Variable name | Description | Value | Raw frequency | Imputed Frequency |
|---|---|---|---|---|
| Matching | How groups were formed from round to round | Constant | 193 | 193 |
| | | Shuffled | 48 | 48 |
| | | Perfect Stranger | 6 | 6 |
| Final Round Known | Did players know when they were in the final round? | No | 20 | 20 |
| | | Yes | 198 | 217 |
| | | Missing value | 19 | 0 |
| Information | The information players received after each round | Own Payoff | 2 | 2 |
| | | Group average | 136 | 149 |
| | | Individual contributions | 59 | 59 |
| | | Individual earnings | 27 | 27 |
| | | Missing value | 13 | 0 |

Note: MPCR < 1, number of observations = 237

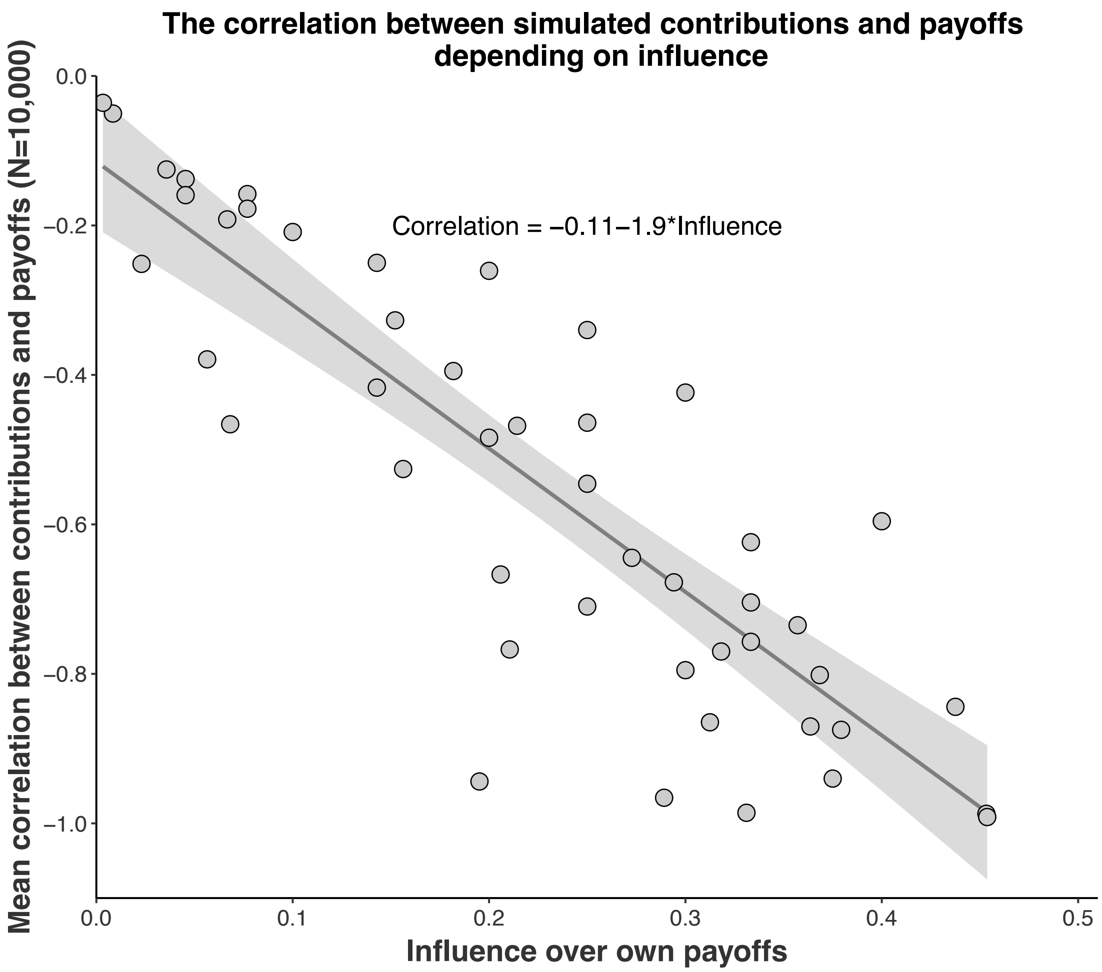



$$\textit{Influence (i)} = \frac{|\max \text{Cost}|}{|\max \text{Cost}| + \max \text{Benefit}}$$

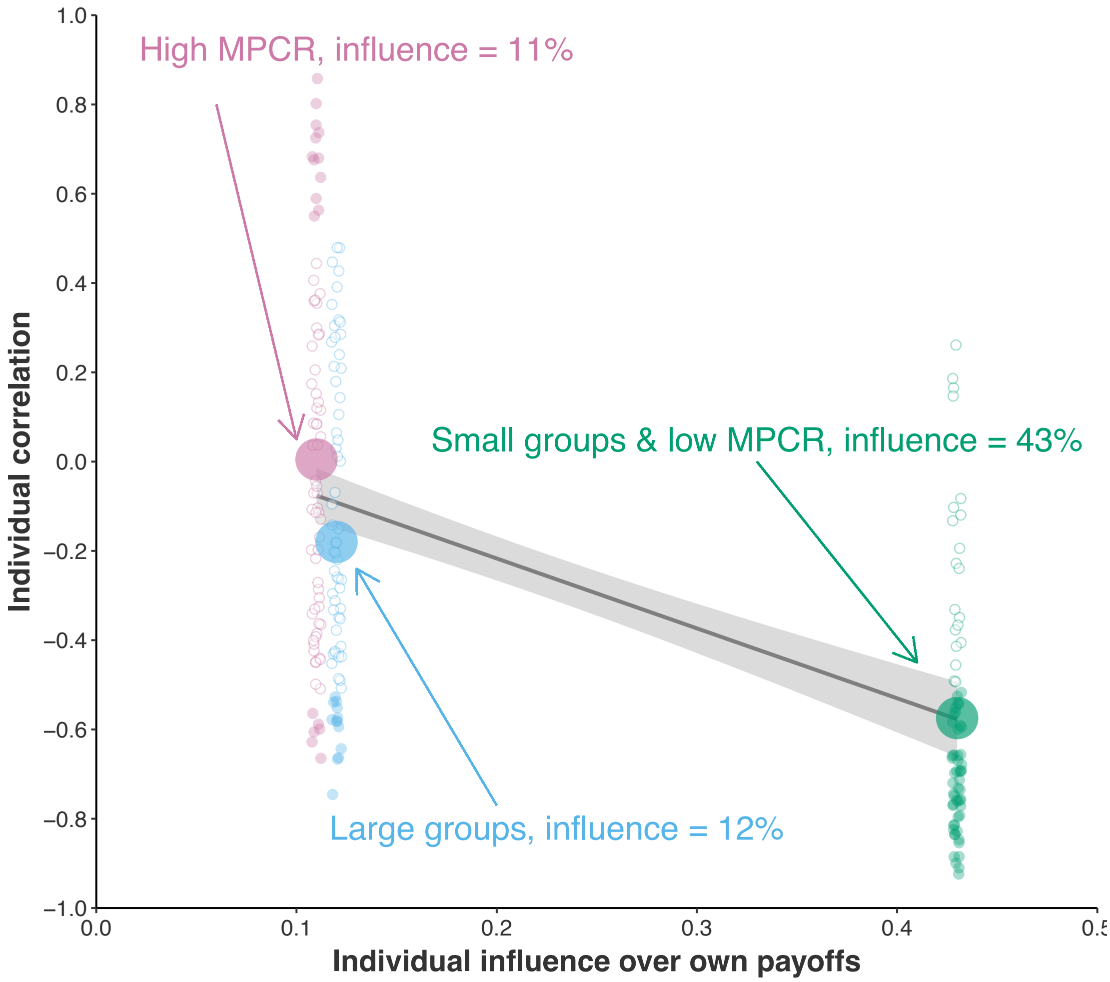
**Supplementary Figure 1.** Schematic illustrating how we calculated the degree of influence individuals had over their own potential payoffs (when MPCR < 1). Figure drawn to scale for the case where group size ($N$) is 4 and the cost of contributing ($MPCR$) is 0.4.



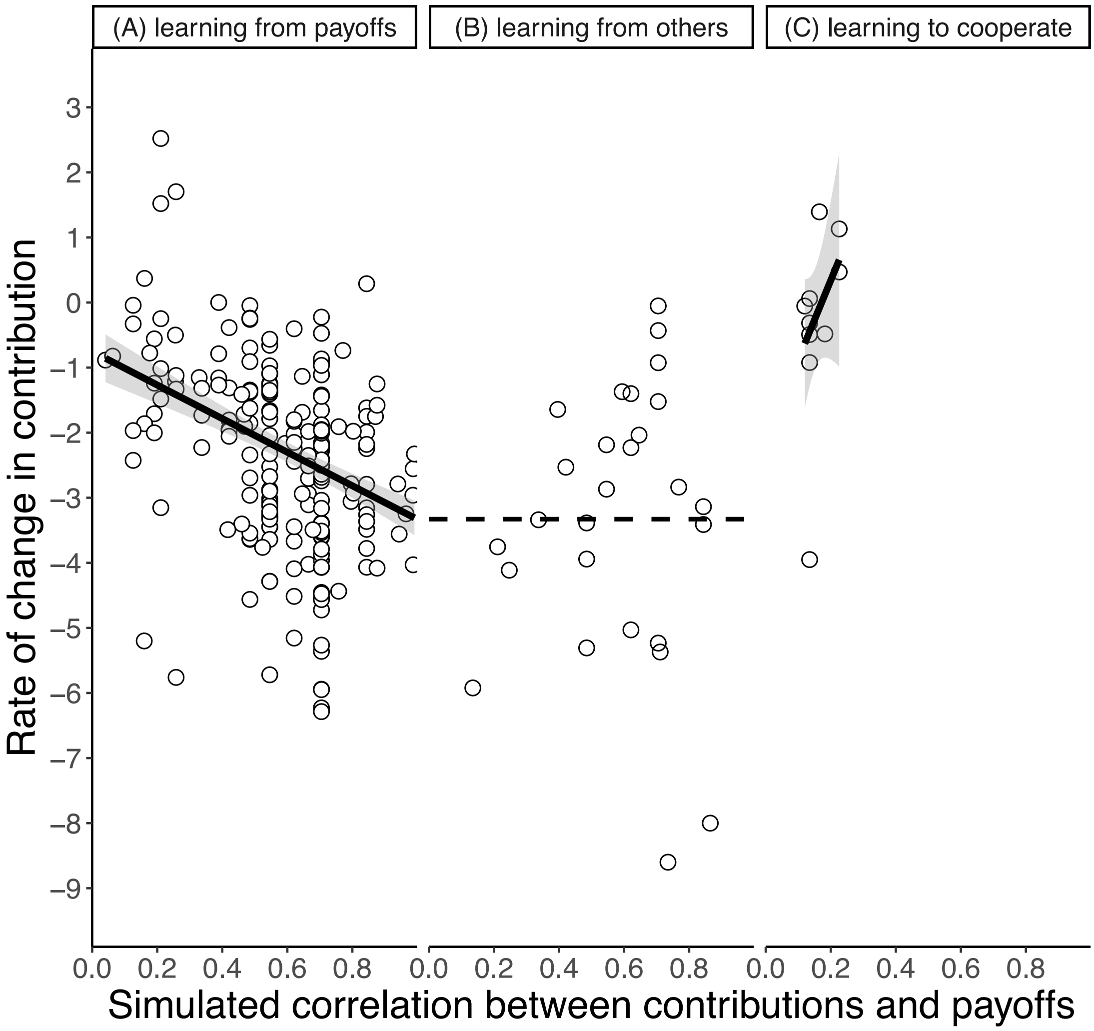

**Supplementary Figure 2.** How the degree of individual influence over own payoffs varies with both the group size (N) and the cost of contributing (the marginal per capita return, MPCR). Data show each of the unique N*MPCR combinations we found in the literature. M = Multiplier, MPCR = M/N. Black data points provided 15 or more independent cases. The most common combination was N = 4 with MPCR = 0.4.



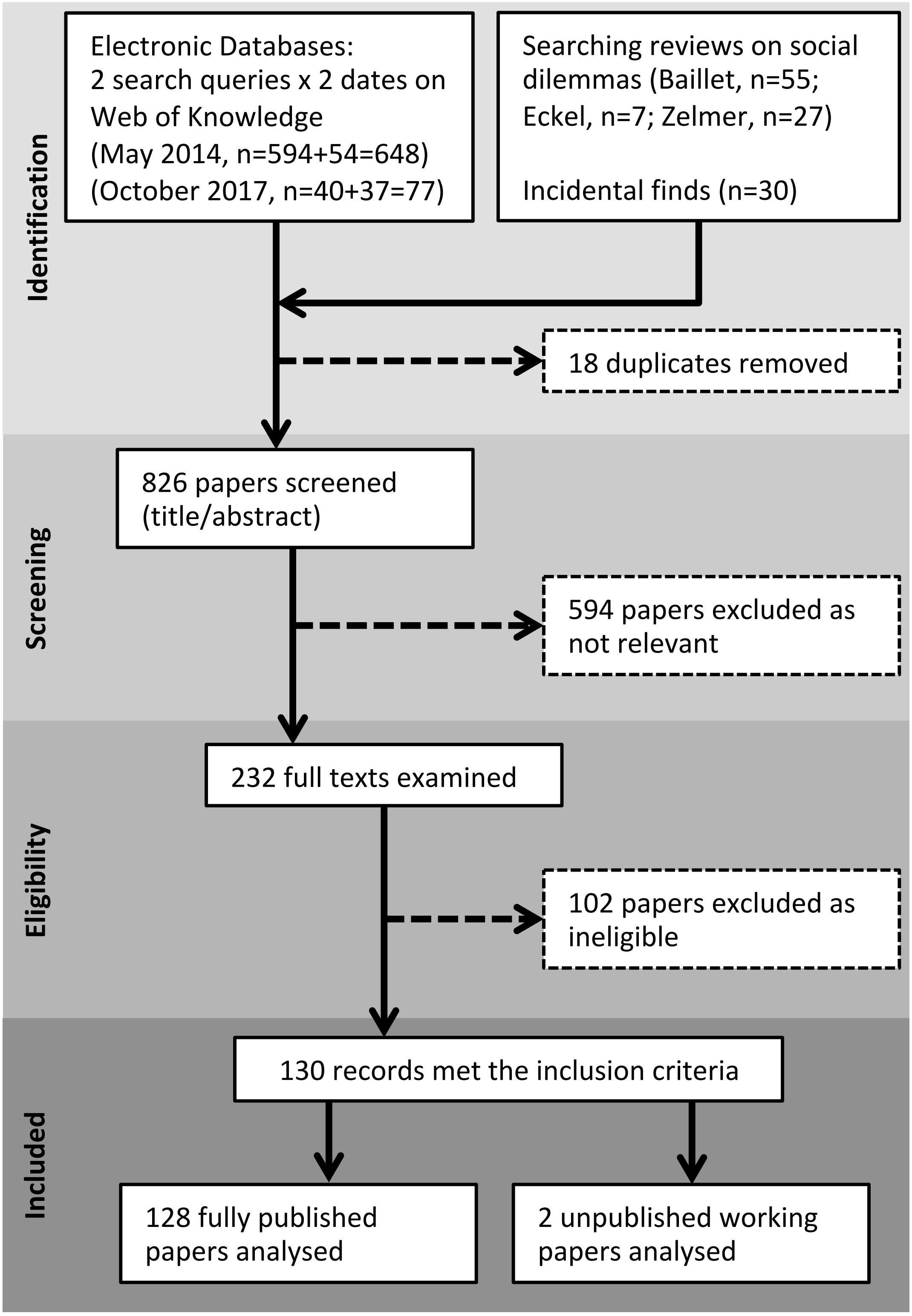

**Supplementary Figure 3. The correlation between simulated contributions and payoffs depending on influence.** Across all 47 unique public-good game settings where the game represented a social dilemma (MPCR < 1), the correlation between simulated contributions and payoffs was stronger when players had more influence over their own payoffs. Each data point is the average correlation of 10,000 simulations. More influence led to a stronger (more negative) correlation. Shown is the regression plus 95% confidence intervals from a linear model on the means (N=47).




**Supplementary Figure 4. The correlation between black box contributions and payoffs depending on influence.** The amount of influence players had over their own payoffs significantly explained the correlation between their contributions and their payoffs in the black box experiment. More influence led to a stronger (more negative) correlation. Shown is the regression, plus 95% confidence intervals from a linear model (N = 211. Each treatment had 72 players but 5 players are omitted here because they only contributed a constant amount so their correlation could not be calculated). Filled in data points represent significant individual correlations (jittered slightly to avoid over-plotting), some players in the High MPCR treatment experienced significantly positive correlations; the three large data points are the mean values for each treatment (Magenta, High MPCR: N = 3, MPCR = 0.8, i = 0.11; blue, Large groups: N = 12, MPCR = 0.4, i = 0.12; green, Small groups & low MPCR: N = 3, MPCR = 0.4, i = 0.43).




***Supplementary Figure 5abc. The learning environment explains variation in the rate at which contributions change.*** *Each data point shows the percentage point change in contributions per round in: public goods games where (A) players could only see their own payoff (MPCR/N <1, N = 210); or; (B) they could also see the individual payoffs and actions of their groupmates (MPCR/N <1, N = 27); or (C) public delight games (MPCR/N>1; N = 10 games). In (A), contributions declined more quickly when there was a greater simulated correlation between contributions and payoffs; in (B), where individuals could learn by observing the perfect correlation between contributions and payoffs among their groupmates, the simulated correlation was not significant; in (C) the rate of change was more positive when there was a greater correlation, meaning that in both types of games (public good and public delight), the rate of change was greater, and individuals were quicker to approach income-maximizing behaviour, when the simulation estimated a greater estimated correlation between contributions and payoffs, which is likely to facilitate payoff based learning. Solid lines = significant regression estimate, Shaded areas represent 95% confidence intervals. Dashed line = intercept only model as regression was non-significant. This figure is for visualization purposes and does not account for the effects of covariates.*




**Supplementary Figure 6.** A Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) plot of how we conducted our literature search.