Supporting Information

Burton-Chellew and West 10.1073/pnas.1210960110

SI Results

Fig. S4 *A* and *B* shows the percentage of "free riders" and "cooperators" over time for each treatment. Although Fig. S4*A* shows that there were more extreme free riders (contributing 0 MU) in the public-goods games than in the black-box game, this difference is no longer present when free riders are defined as contributing 0–10 MU (0–25%). This pattern is largely because the participants playing the black-box game were less inclined to input 0 MU even when they had learned that low contributions were most profitable.

Experienced vs. Naïve Participants. Fig. S2 reveals that there was no difference in how participants played the costly black-box game depending on whether their session had just played the public-goods games beforehand or not [linear mixed model (LMM): $F_{1,14} = 0.1$, $P = 0.772$]. None of the participants had ever participated in a public-goods game at the CESS laboratory before our experiment.

When only analyzing the data generated from participants who were naïve with respect to the other game (i.e., those who if they were playing the black-box game had never played the public-goods game, and vice versa), we found results that were qualitatively similar to those in the main text (Fig. S3). Although with these data our statistical power was reduced to just four sessions each of the public-goods games (standard information and enhanced information) and eight sessions of the black-box game, we still found a significant reduction in cooperation when participants received the enhanced information compared with the standard information (LMM: $F_{1,6} = 8.3$, $P = 0.028$) and compared with the black-box game (LMM: $F_{1,10} = 5.4$, $P = 0.043$). In contrast, there was no significant difference between the black-box game and the standard-information treatment (LMM: $F_{1,10} = 2.1$, $P = 0.177$).

Nonparametric Tests. Still only using the data from participants who were naïve about the other game, we also used nonparametric Mann-Whitney *U* tests and Kolmogorov-Smirnov tests (KS) to compare the individual decisions by treatment in each time period and thus gain more statistical power. We found the same qualitative results as presented in the main text. These analyses further confirmed the damaging effect of the enhanced information; participants in the enhanced-information treatment were found to be less cooperative than those given the standard information in all 19 (18 KS) of the 19 rounds after round one. They also confirmed the similarity between the black-box and the standard-information treatments, which differed in only one (five KS) of the 19 repeated rounds. We can also confirm that this lack of difference was not due to a lack of statistical power to compare the two games, because participants in the black-box treatment were significantly more cooperative in 15 (12 KS) of the 19 rounds compared with participants in the enhanced-information treatment.

We also used nonparametric tests for the profitable controls and found the same qualitative results. These analyses again further confirmed the damaging effect of the enhanced information; players were found to be less cooperative than those given standard information in 14 (14 KS) of the 19 rounds after round one. However, participants in the black-box treatment were less cooperative in 19 (19 KS) and 12 (13 KS) of the 19 rounds compared with those who participated in the standard-information and the enhanced-information treatments, respectively.

SI Discussion

The level of information in our standard and enhanced-information treatments is, although different, also equivocal. This is because the information we present in the enhanced-information game on the earnings of groupmates can be computed from the distribution of decisions, which is presented in both treatments. Consequently, the model of a rational but prosocial actor that has been suggested would predict no difference in behavior between these two treatments (1–3). In addition, any behavior that is postulated to be a response to the decisions of a participant's groupmates should be equally predicted in both treatments and therefore cannot explain the difference between our treatments. For example, any reduction in cooperation in response to the cooperation of others should be the same for the two treatments, be it a postulated "social" response to "free riders" or a postulated "antisocial" response to "high cooperators." The equivalence of our treatments also means that the fact that repeated interactions were not entirely ruled out in our treatments should not affect one treatment more or less than another, and any qualitative comparisons still stand.

The focus of our study was a qualitative comparison of different treatments. The results of economic games can be interpreted with either a qualitative or a quantitative approach (4). The qualitative approach examines differences in behavior between treatments, which typically have different payoff structures for the game that is being played, but may, as in our case, just be "framed" differently. In contrast, the quantitative approach compares the quantitative level of behavior within a specific game or treatment with that predicted by theoretical models (5–7). The deductions from this quantitative approach typically rely on the implicit assumption that individuals are rational and fully aware of all of the consequences (for themselves and for others) of their decisions (2, 8). The quantitative approach can make no predictions for a difference between our standard and enhanced-information treatments.

This does not mean that psychological concerns and emotions are not driving people's responses to our games. Rather, it means that to assume a set of a participant's preferences based on the payoff consequences of his or her decision for both him- or herself and others is unlikely to be correct. For example, as suggested by the comparison of our black-box and standard-information treatments, participants may only be trying to affect their own payoffs, and their effect on others is a mere byproduct. Alternatively, participants may be responding emotionally to the payoffs of others, as in our enhanced-information treatment, but not the decisions of others, even those these equate to the same information. This is suggested by a comparison of our standard- and enhanced-information treatments, in which case participants can no longer be assumed to have been responding to the earnings of others in the standard-information treatment, which is the same level of information as presented in ref. 9.

In summary, if participants are responding to the decisions of others, there should be no difference between our standard- and enhanced-information treatments, whether costly or profitable. Conversely, if participants are reacting to the presented information on payoffs in our enhanced-information treatment, then previous explanations that assumed participants calculated such earnings from the distribution of decisions and acted accordingly to reduce inequity are false.

Finally, it has been observed that people contribute more in public-goods games when the benefit to others is increased. This is because contributions are, on average over time, higher when the marginal per-capita return (MPCR) is higher (10). It might be argued that this suggests higher cooperation when the benefits to others are higher, implying a concern for others. However, this pattern can also be explained by the fact that a higher MPCR results in cooperation's being cheaper, the losses incurred from incorrect strategies (from an income-maximizing point of view) being lesser, and the scope for learning over time being reduced. Learning is impeded because as the MPCR tends toward 1.0, the effect one's contributions have on one's own income diminishes, and so payoffs are increasingly random with respect to one's own decisions.

SI Methods

Table S1 details the order of treatments by session. Fig. S1 shows a graphical display of the different information we gave to our participants per treatment. *SI Appendix* is a complete copy of the black-box instructions.

SI Appendix

Black-Box Instructions. Participants received the following on-screen instructions (in z-Tree) at the start of the Black Box game and had to click an on-screen button saying "I confirm I understand the instructions" before the game would begin.

Instructions. Welcome to the experiment. You have been given 40 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.

During the experiment we shall not speak of £ Pounds or Pence but rather of "Coins". During the experiment your entire earnings will be calculated in Coins. At the end of the experiment the total amount of Coins you have earned will be converted to Pence at the following rate: 100 Coins = 15 Pence. In total, each person today will be given 3,200 coins (£4.80) with which to make decisions over two economic experiments and their final totals, which may go up or down, will depend on these decisions.

Decision. You can choose to keep your coins (in which case they will be 'banked' into your private account, which you will receive at the end of the experiment), or you can choose to put some or all of them into a *'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 function contains a random component, so if two people were to put the same amount of coins into the '*black box*', they would not necessarily get the same output. The number outputted may be more or less than the number you put in, but it will never be a negative number, so the lowest outcome possible is to get 0 (zero) back. If you choose to input 0 (zero) coins, you may still get some back from the box.

Any coins outputted will also be 'banked' and go into your private account. So, your final income will be the initial 40 coins, minus any you put into the '*black box*', plus all of the coins you get back from the '*black box*'.

You will play this game 20 times. Each time you will be given a **new set** of 40 coins to use. Each game is separate but the '*black box*' remains the same. This means you cannot play with money gained from previous turns, and the maximum you can ever put into the '*black box*' will be 40 coins. And you will never run out of money to play with as you get a new set of coins for each go. The mathematical function will not change over time, so it is the same for all 20 turns. However, as the function contains a random component, the output is not guaranteed to stay the same if you put the same amount in each time.

After you have finished your 20 turns, you will play one further series of 20 turns but with a new, and potentially different '*black box*'. The two boxes may or may not have the same mathematical function as each other, but the functions will always contain a random component, and the functions will always remain the same for the 20 turns. You will be told when the 20 turns 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.

I confirm I understand the instructions.

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5. Levine DK (1998) Modeling altruism and spitefulness in experiments. *Rev Econ Dyn* 1(3):593–622.
6. Fehr E, Fischbacher U (2003) The nature of human altruism. *Nature* 425(6960):785–791.
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(a)

GAME SUMMARY	Number of Coins
Initial Coins	40
Minus (-) your input	15
Plus (+) the output returned	24
Your final number of coins	49

This screen lists your decisions and the results, along with your income (for this turn).

(b)

Player Name	Contribution (0-40)
You	15
player A	10
player B	30
player C	5
Total contributions	60
Total after growth	96

This screen lists the decisions of you and the other players (in random order) in your group (for this round). Remember the terms Player A, B, & C **are meaningless** as you play with randomly selected people in each round. The group's total contributions and the new total after the 'growth' stage are also shown.

(c)

Player Name	Contribution (0-40)	Player Income =	Credits retained	+ Credits returned	= Total credits
You	15	For you =	25	24	49
player A	10	player A	30	24	54
player B	30	player B	10	24	34
player C	5	player C	35	24	59

Your income from your group's contributions and subsequent 'growth' is shown.

This screen lists the decisions and earnings of you and the other players (in random order) in your group (for this round).

Remember the terms Player A, B, & C **are meaningless** as you play with randomly selected people in each round.

Fig. S1. (*A*) The postdecision feedback information that participants received in the black-box treatment. (*B*) The first feedback screen in both the standard- and the enhanced-information treatments. (*C*) The second feedback screen, which differed between the two treatments (not shown in black-box treatment). Dashed lines border the information that was only shown in the enhanced-information treatment.

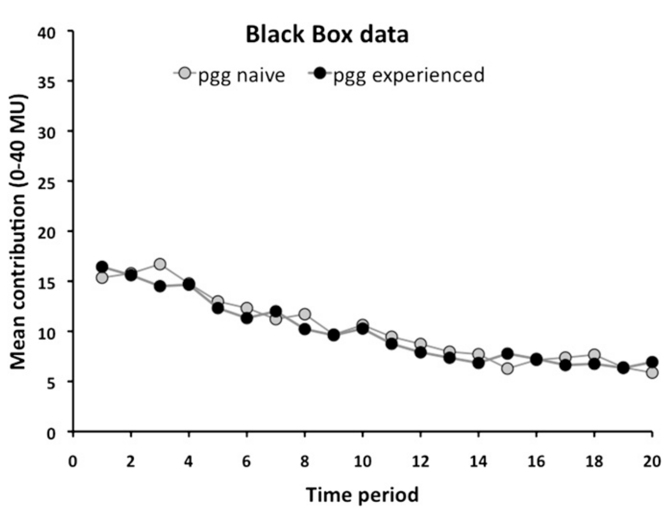

Fig. S2. The mean contributions into the costly black box, both when the session of participants were either naïve to public-goods games (ppg naïve, gray filled circles) or experienced in public-goods games (ppg experienced, black filled circles).

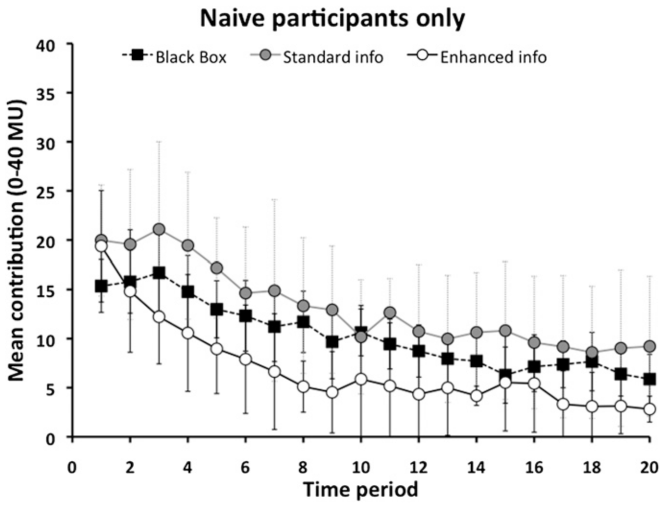

Fig. S3. The mean contributions in the costly public-goods game for all three treatments when the participants had not played any versions of the other game (black-box or public-goods game) beforehand ($n = 4$ for the standard-information and enhanced-information treatments and $n = 8$ for the black-box treatment).

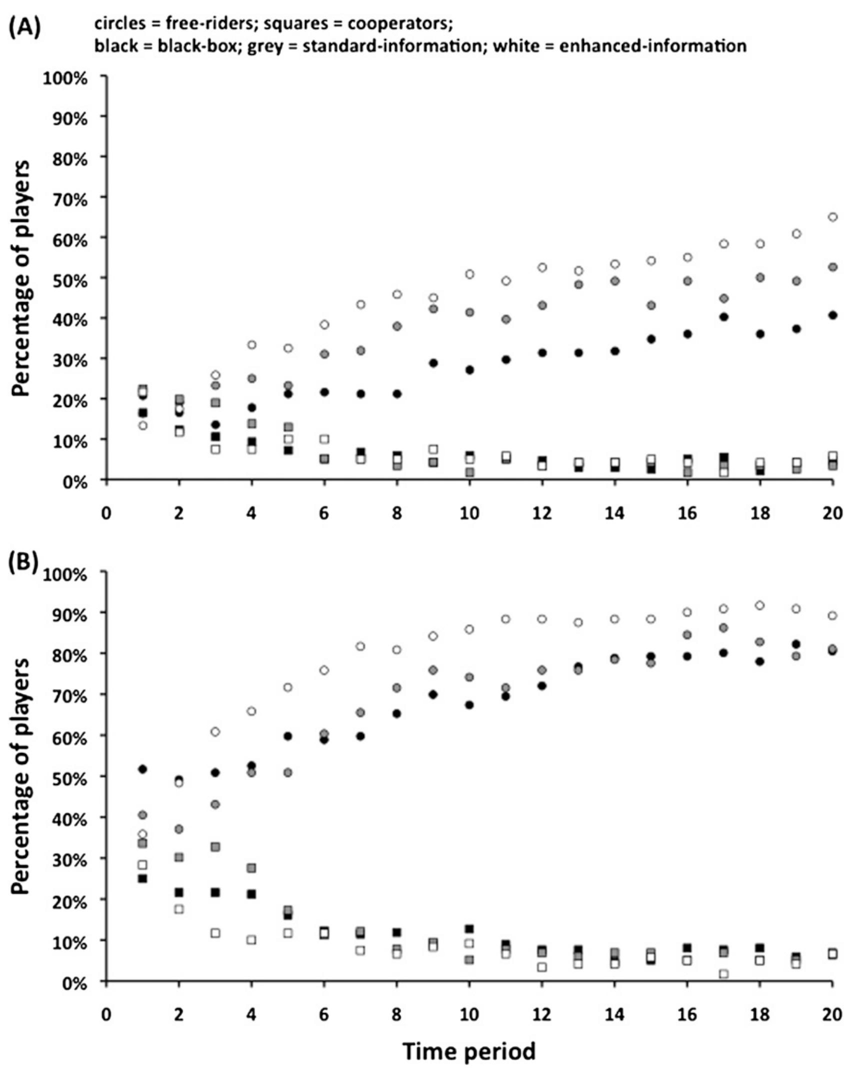

Fig. S4. The percentage of "cooperators" and "free riders" over time for the three different treatments in the costly public-goods game (where the return to the individual from each monetary unit invested in the public-good = 0.4 and the return to the group = 1.6). In *A*, "cooperators" are defined narrowly as those that contributed 40 MU (100%) and "free riders" are defined narrowly as those that contributed 0 MU (0%). In *B*, "cooperators" are defined more broadly as those that contributed 30–40 MU (75–100%) and "free riders" as those that contributed 0–10 MU (0–25%).

Table S1. Experimental design detailing order of treatments for each of the 16 sessions

Experiment 1 (2 x 20 rounds)		Experiment 2 (2 x 20 rounds)	
Treatment 1	Treatment 2	Treatment 3	Treatment 4
Black box (–)	Black box (+)	Standard (–)	Standard (+)
Black box (+)	Black box (–)	Standard (+)	Standard (–)
Black box (–)	Black box (+)	Enhanced (–)	Enhanced (+)
Black box (+)	Black box (–)	Enhanced (+)	Enhanced (–)
Black box (–)	Black box (+)	Standard (+)	Standard (–)
Black box (+)	Black box (–)	Standard (–)	Standard (+)
Black box (–)	Black box (+)	Enhanced (+)	Enhanced (–)
Black box (+)	Black box (–)	Enhanced (–)	Enhanced (+)
Standard (–)	Standard (+)	Black box (–)	Black box (+)
Standard (+)	Standard (–)	Black box (–)	Black box (+)
Standard (–)	Standard (+)	Black box (+)	Black box (–)
Standard (+)	Standard (–)	Black box (+)	Black box (–)
Enhanced (–)	Enhanced (+)	Black box (–)	Black box (+)
Enhanced (+)	Enhanced (–)	Black box (–)	Black box (+)
Enhanced (–)	Enhanced (+)	Black box (+)	Black box (–)
Enhanced (+)	Enhanced (–)	Black box (+)	Black box (–)

Each row corresponds to a unique session. The (–) refers to the costly public-goods games and the (+) to the profitable versions.