Commitment and evolution
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Appendix A

First we calculate the expected number of times that a trigger player will help a trigger player, $n_h$, and multiply this by the costs of giving help, $f_d$. This yields the total loss, $n_h \cdot f_h$, of playing trigger against trigger (which is not incurred by an ALLD player playing against trigger).

Let $n_{TT}$ be the expected number of times before both players revert to eternal defection, i.e. before both trigger players get into distress simultaneously:

$$n_{TT} = \frac{1}{P^2_d} - 1$$

Let $n_h$ be the number of those rounds within these initial $n_{TT}$ rounds that the trigger alter is in distress, while ego is not. Then

$$n_h = P_h \cdot n_{TT}$$

where

$$P_h = \frac{P_d(1-P_d)}{1-P^2_d}$$

The conditional probability $P_h$ is calculated as follows. The unconditional probability of the event "alter in distress while ego not" is $P_d(1-P_d)$ but what we need to know is the probability that this event occurs under the condition that the event "both are in distress" has not yet occurred. To obtain this, we divide the unconditional probability by the probability that the condition occurs.

Next, we calculate the expected number of times $n_d$ that an ALLD player does not get help from a trigger opponent, while a trigger player would get help at the same time. Multiplied with the costs of not getting help, $f_d$, this amounts to the expected loss, $n_d \cdot f_d$, that an ALLD player incurs which is not incurred by a trigger player.

Let $n'_{DT}$ be the length of the period in which a trigger player has not yet lost the help of his opponent, while an ALLD player gets no more help. Let $P_n$ be the probability that in any single round of this part of the game, the ALLD ego is in distress, while alter is not. Then

$$n_d = n'_{DT} \cdot P_n$$

where

$$P_n = \frac{P_d(1-P_d)}{1-P^2_d}$$
Here \( P_n \) is obtained in the same way as \( P_h \) above, only this time the roles of ego and alter are reverted (ego in need but alter not), which does not affect the result in this case.

To obtain \( n'_{DT} \), we need to find the difference between \( n_{TT} \), the expected duration until a trigger player would stop getting help from his trigger opponent, and \( n_{DT} \), the number of times until an ALLD player would stop getting help from this opponent.

Furthermore, we need to take into account that, if there is a second phase of the game, the first round of that second phase cannot be a round in which an ALLD ego is refused by alter because it is the round in which ego reveals itself as a defector, i.e. ego cannot be in distress. Hence, to obtain \( n'_{DT} \) we need to subtract from \( n_{TT} - n_{DT} \) exactly that probability.

To obtain that probability, we need to consider that there may never be a second phase of the game in which an ALLD player would not get help, because the first phase may already end with a round in which both players get into distress simultaneously, in which case also a trigger player would get no more help. The probability for that latter event is again obtained as a conditional probability as follows: the unconditional probability that alter gets into distress, but ego not, is \( P_d(1 - P_d) \). There are only two possible events that can occur in the first round after the first phase of the game. Either it is the first round of the second phase, with an unconditional probability of \( P_d(1 - P_d) \), or there is no second phase and both players are in distress simultaneously, with probability \( P_d^2 \). All other events are excluded by virtue of the precondition that this is the round following the first phase of the game. So the probability we need to subtract from \( n_{TT} - n_{DT} \) is \( P_d(1 - P_d) \) divided by the probability that the condition occurs, \( P_d(1 - P_d) + P_d^2 \). All in all this amounts to

\[
n'_{DT} = n_{TT} - n_{DT} - \frac{P_d(1 - P_d)}{P_d(1 - P_d) + P_d^2}
\]

where

\[
n_{DT} = \frac{1}{P_d} - 1
\]

Finally, we need to find the condition under which the loss of a trigger player against trigger is equal to that of an ALLD player against trigger. That is, we need to solve

\[
n_d \cdot f_d = n_h \cdot f_h
\]

This condition yields after some rearrangement the following result:

\[
f_h = f_d(1 - P_d)\]
Appendix B

Parameter values used in ecological simulations

We acquired and tested our results using the following parameters:

**Model parameters**

- probability of distress ($P_d$) = 0.05, 0.2, 0.5
- probability of decision making error ($P_e$) = 0.0, 0.05, 0.1, 0.5
- cost of helping ($f_h$, measured in fitness) = 1
- cost of not getting help ($f_d$, measured in fitness) = 5, 10, 20
- initial fitness ($f_i$, measured in fitness) = 50, 100, 200
- critical fitness ($f_c$, measured in fitness) = 0
- group size ($N$) = 10, 25, 50
- number of sub-rounds in a round ($m$) = 1, 2, 3

**Simulation parameters**

- number of rounds in a run = variable, depending on how long it took the winning strategy to push its opponent(s) out
- number of runs in an experiment = 2000
Appendix C

Pseudocode of simulation core

```plaintext
/**
 * Main cycle of simulation
 */
begin simulation
    for each experiment
        initialize result variables and charts
        for each run
            initialize parameters, run-level result variables, charts
            initialize society
            for each round
                initialize round-level result variables
                for each agent A
                    generate a random event R with probability P_d
                    if R occurs distress A
                end for
                for each subround
                    for each agent A
                        if A is distressed
                            call decideWhomToAskForHelp of A
                        end for
                        for each agent A
                            call decideWhomToGiveHelp of A
                        end for
                    end for
                    for each agent A
                        update fitness
                        if fitness < f_c remove A from society
                    end for
                end for
                call replicator_dynamics()
                update round-level result variables
                update charts if necessary
            end for
        end for
    end for
end simulation
```
end simulation
/**
 * Agent deciding whether/whom to give help.
 */
begin decideWhomToGiveHelp
  if nobody asked for help return nobody
  if agent is distressed return nobody
  if agent already gave help return nobody
  generate a random event R with probability P_err
  if R does not occur
    determine group G of agents for whom $U_d$ is maximal
    if $U_d < U_t$ return nobody /* threshold utility */
    else return random agent from G
  else
    return random agent from {helpseekers+nobody}
end if
end decideWhomToGiveHelp
/**
 * Agent deciding whom to ask for help.
 */
begin decideWhomToAskForHelp
  remove itself from possible helpers
  remove those who refused before in this round
  if possible helpers is empty return nobody
  generate a random event R with probability P_err
  if R does not occur
    determine group G of agents for whom $U_s$ is maximal
    return random agent from G
  else
    return random agent from possible helpers
end if
end decideWhomToAskForHelp
/**
 * Evolutionary selection process (based on the replicator dynamics)
 */
begin replicator_dynamics
for each dead agent
  calculate society_fitness_sum
  for each strategy $S$ in society
    calculate strategy_fitness_sum
    generate a random event R with...
    probability strategy_fitness_sum / society_fitness_sum
    if R occurs create and add agent A with...
    strategy $S$ to new_generation
    /* in order to condition successive probability calculations on previous ones */
  else decrease society_fitness_sum with strategy_fitness_sum
end for
end for
add new_generation to society
end replicator_dynamics
Appendix D

Parameter values used in evolutionary simulations

probability of distress \( (P_d) = 0.1, 0.2, 0.4 \)
probability of decision making error \( (P_e) = 0.05 \)
cost of helping \( (f_h, \text{ measured in fitness} = 1 \)
cost of not getting help \( (f_d, \text{ measured in fitness}) = 5, 10, 20, 30 \)
initial fitness \( (f_i, \text{ measured in fitness}) = 50,100 \)
critical fitness \( (f_c, \text{ measured in fitness}) = 0 \)
group size \( (N) = 25,50 \)
length of simulation runs = 10,000,000 rounds
number of help-seeking subrounds in a round \( (m) = 1,2,3 \)

Parameters of the evolutionary process

evolution frequency min. childbearing age (measured in interactions) = 20
mutation probability \( (P_{\text{mut}}) = 0.05 \)
Appendix E

Pseudocode of evolutionary dynamic

The evolutionary process, executed at the end of each run:

... end of round
begin evolutionary process
  for each dead agent A
    choose with a probability equal to its fitness...
      share among N-old agents an agent B...
      who is alive and is at least N-old
      generate a new agent C with a strategy...
        identical to that of B
      mutate the strategy of C with a probability Pmut
  end for
end evolutionary process
start of new round
...
Appendix F

Experiment instructions

F.1 Initial instructions

Dear Respondent,

Thank you for participating in our experiment. The goal of this experiment is to study how people make decisions in certain situations. For the success of the experiment, it is important that you always carefully read the instructions. Please also make sure that during the experiment, you never click the Refresh or the Back buttons in your browser. If you do so, you will not be able to continue the experiment and your results will be lost.

If you do not understand something, please feel free to call the instructor by silently raising your hand. The entire experiment should not take longer than 45 minutes.

Your personal respondent code in this experiment is MH 679417. Please note it down now because you will need it after the experiment to collect your payment.

When you are ready, click on the button below to continue.

Start

F.2 Instruction text from the experiment

The experiment takes place in an imaginary market of art. In this market, Artists make paintings and sell them to Collectors.

In the following, all participants will be classified into two groups. Some of the participants will be assigned the role of Artist and some will be assigned the role of Collectors. It is important that you try to imagine yourself in the
role you are assigned to as well as possible. Both Artists and Collectors receive an initial amount of money.

Artists use their money to buy brushes, paint and canvas so they can create a painting and sell it to one of the Collectors. Collectors use their money to buy paintings from the Artists. The experiment consists of 17 rounds. In the beginning of each round Artists create a painting and interested Collectors make a bid. Then Artists decide whom to sell the painting to.

After you press the button below computer will determine whether you have to act as Artist or as Collector.

<CONTINUE, wait for computer to determine assignment to buyer or seller>

You will act as an Artist in the rest of the experiment.

In the beginning of the game you will receive an initial amount of $100. In each round of the game, you create a piece of art at a certain cost price (based on the price of brushes, paint, canvas etc).

Next, you need to sell the painting you created. Out of all Collectors in the experiment, always four are selected to bid on your painting. Collectors are linked to several Artists at the same time and bid on multiple paintings but they cannot see each other’s offers. Moreover, Collectors don’t have information about your cost price but they know something that Artists don’t. They know the objective value of the painting.

When all Collectors made their offers, you have to choose one whom you want to sell your painting to. You always have to sell your painting. After you sell the painting, the amount offered by the Collector is added to you balance, deducting the cost price. After the experiment you will receive $2.6 US dollars for each $100 you make in the experiment.

In each round you sell the painting to one of the Collectors. Those Collectors whose offer you did not accept disappear and are replaced by new ones in the next round. The Collector whose offer you accepted will stay with you in the next round and will make an offer for your next painting as well. Collectors who once disappear may reappear later in the game as Collectors but under a different name. You will also appear to them under a different name, so that you cannot recognize each other.

At different time points during the 17 rounds, the experiment will be briefly paused to ask some questions on screen.

After the last round, you will be asked to answer some final questions.

At first you will play a practice game. The purpose of this practice game for you is to learn how to play the game. The results of this game are discarded and do not count into your final score. You will be clearly notified before the real game begins.
F.3  Screenshot from the experiment game

Please indicate how you feel toward each Collector. Make sure that you fill out all scales.

You
Balance: $140

Painting 12 of 17 created for $70
Appendix G

G.1 Instructions

The game is played against many opponents, for several rounds. In each round you play with only one opponent. In each round both you and your opponent have to make a choice between two moves, A and B.

After each round there is a 50% chance that you will play another round with the same opponent. This means that with a 50% chance the game with that opponent will end.

When the game with an opponent ends, you receive a payment based on your move and your opponent's move in the very last round of the game. Payments will add up from game to game, and after the experiment you will receive the final amount in real money. The following table summarizes the payments you could receive based on your move and the opponent's move: (You don't have to memorize these tables, it will be displayed throughout the entire game.)

<table>
<thead>
<tr>
<th>Opponent</th>
<th>A</th>
<th>B</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>50¢</td>
<td>10¢</td>
</tr>
<tr>
<td>B</td>
<td>100¢</td>
<td>10¢</td>
</tr>
</tbody>
</table>

As you see, if in the last round both of you play A you will receive 50¢. If you play B and your opponent plays A in the last round you receive 100¢, and so on.

Note again, that you don't know in advance how long you will play with each opponent and that you will only receive a payment from the last round. At the end of the game your opponent also receives the payoffs from the last round, which is similar to yours:

<table>
<thead>
<tr>
<th>Opponent's payoffs</th>
<th>A</th>
<th>B</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>50¢</td>
<td>100¢</td>
</tr>
<tr>
<td>B</td>
<td>10¢</td>
<td>10¢</td>
</tr>
</tbody>
</table>

If the game ends you can choose to play the next game with the same opponent or switch to a new opponent, whom you did not play with before. You can always choose to go back to a previous opponent. For example, if you have met 3 opponents before, you have 4 different choices:

unknown player  Player 1
Player 2
Player 3

It is important to know that you will not play against a person present in the lab today but that the behavior of your opponents will closely resemble the way how people played in an earlier similar experiment. Each of your opponents has a different bonus value that is used to multiply your payoffs from the game played with that opponent. For example, if the bonus value of Player 3 is x1.1, then your payoffs will be multiplied like this:

<table>
<thead>
<tr>
<th>Opponent</th>
<th>A</th>
<th>B</th>
</tr>
</thead>
<tbody>
<tr>
<td>A 50¢ x 1.1</td>
<td>10¢ x 1.1</td>
<td></td>
</tr>
<tr>
<td>B 100¢ x 1.1</td>
<td>10¢ x 1.1</td>
<td></td>
</tr>
</tbody>
</table>

The entire experiment will consist of 10 games.
G.2 Screen shots from the experiment

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Game 1 - Round 1</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>You</td>
<td>Player 1</td>
<td></td>
</tr>
<tr>
<td>Balance: 60.00</td>
<td>Bonus: x1.02</td>
<td></td>
</tr>
<tr>
<td>Player 1</td>
<td></td>
<td>Player 1's payoffs</td>
</tr>
<tr>
<td>plays A</td>
<td>50¢, 10¢</td>
<td></td>
</tr>
<tr>
<td>plays B</td>
<td></td>
<td></td>
</tr>
<tr>
<td>you play A</td>
<td></td>
<td></td>
</tr>
<tr>
<td>100¢, 10¢</td>
<td></td>
<td></td>
</tr>
<tr>
<td>you play B</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Your payoffs</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>50¢, 10¢</td>
<td></td>
<td></td>
</tr>
<tr>
<td>100¢, 10¢</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The game with Player 3 is over, your balance increased with 10.5¢! Choose a partner for the next game:

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>You</td>
<td>Player 1</td>
<td>Player 2</td>
</tr>
<tr>
<td>Balance: 2.749</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Player 1</td>
<td>Other players</td>
<td></td>
</tr>
<tr>
<td>50¢, 10¢</td>
<td>plays A</td>
<td></td>
</tr>
<tr>
<td>100¢, 10¢</td>
<td>you play A</td>
<td></td>
</tr>
<tr>
<td>you play B</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10¢</td>
<td>plays B</td>
<td></td>
</tr>
</tbody>
</table>

Previous moves:
- You/A
- Player 2/B

Bonus from Player 2 is x0.94.