Statistical Evaluation of Gamelab Experiments

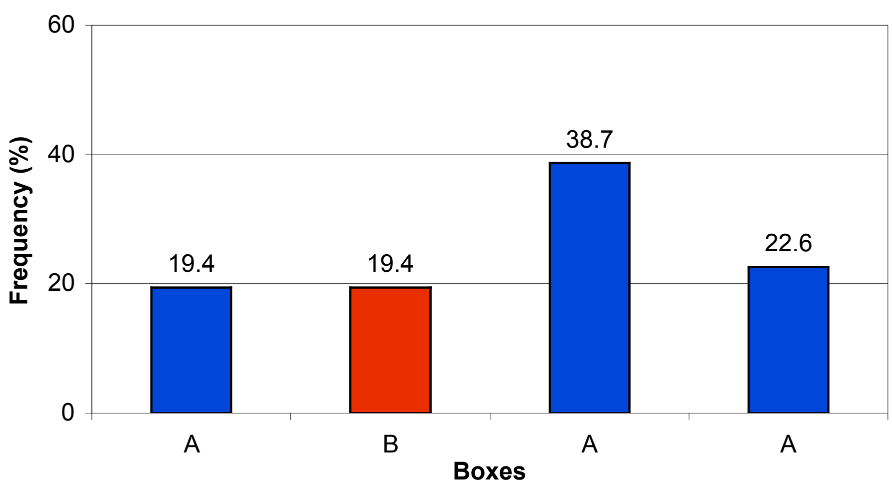
In June 2000, the following game theoretical experiments were carried out over the Internet as an introduction and preparation for all participants in the *European Science Days* in Steyr, Austria on *The Evolution of Cooperation and Communication* organized by Karl Sigmund and Martin A. Nowak. The experiments were designed and evaluated by Karl Sigmund and Christoph Hauert, Department of Mathematics, University of Vienna, Austria.

1. One-Player Games

Guess the Box

Instructions Hide a treasure in one of four boxes placed in a row.
Think for a minute, then choose one of the boxes labeled **A B A A**

Evaluations *Number of players:* 31
Frequency of boxes chosen:

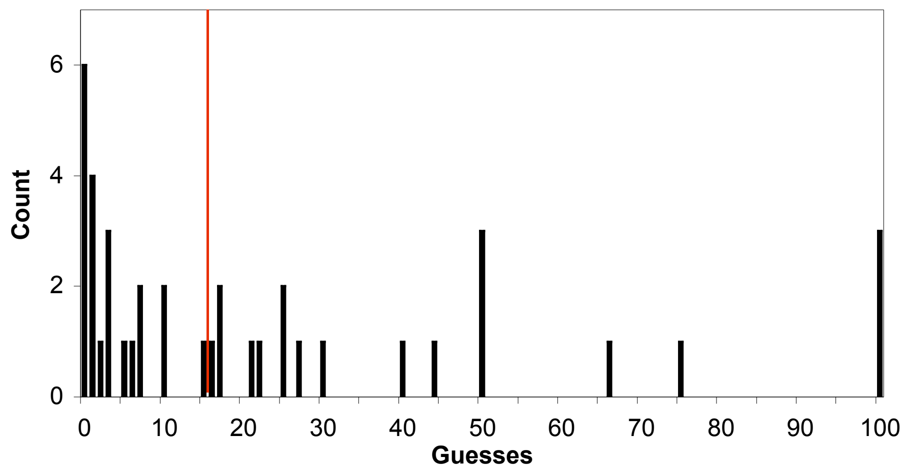


Comments In large scale experiments, most people choose the third box (more than 50%). They do not truly randomize. This consistent bias could be exploited systematically.

Guess Two Thirds

Instructions You have an integer between 0 and 100. Winner is whoever comes closest to $^2/_3$ of the average of all player's guesses.
Think for a minute, then choose a value.

Evaluations *Number of players:* 40 (in two sessions)
Mean guess: 23.75 ±29.4
Winner: 16
Distribution of guesses:



Notes Impossible to analyze the two sessions individually (missing date entry).
6 players chose the rational solution of zero.
8 players guessed 50 or above.

Comments Usually the winner is close to 18 or 20 although equilibrium predicts 0. This means that if all players had been rational, all would have chosen zero.

Allais Paradox

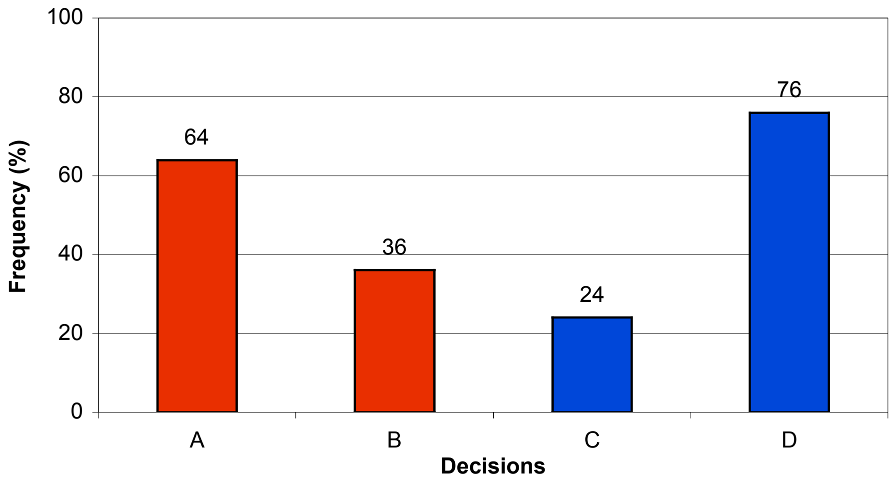
Instructions

Please choose between:
A: A chance of winning 4000 Euro with probability 0.2 (expected value 800 Euro)
B: A chance of winning 3000 Euro with probability 0.25 (expected value 750 Euro)

Please choose between:
C: A chance of winning 4000 Euro with probability 0.8 (expected value 3200 Euro)
D: A chance of winning 3000 Euro with certainty.

Evaluations

Number of players: 25
Frequency of different decisions:



Comments

In large scale experiments, most players (about 70%) choose 4000 Euro with probability 0.2 (A) rather than 3000 Euro with probability 0.25 (B). And indeed, the expected value 4000 Euro with probability 0.2 (800 Euro) is larger than of 3000 Euro with probability 0.25 (750 Euro). In the second decision, most choose 3000 Euro with certainty (D). This is paradox. First of all, the expected value of C, 4000 Euro with probability 0.8 (3200 Euro), is larger than that of D, 3000 Euro with certainty (3000 Euro). More puzzling still, the values in the first decision are obtained from those in the second decision simply by reducing the odds by the factor 4. It is as if we first tossed two coins and do the second decision only if both show heads.

Preference Reversal

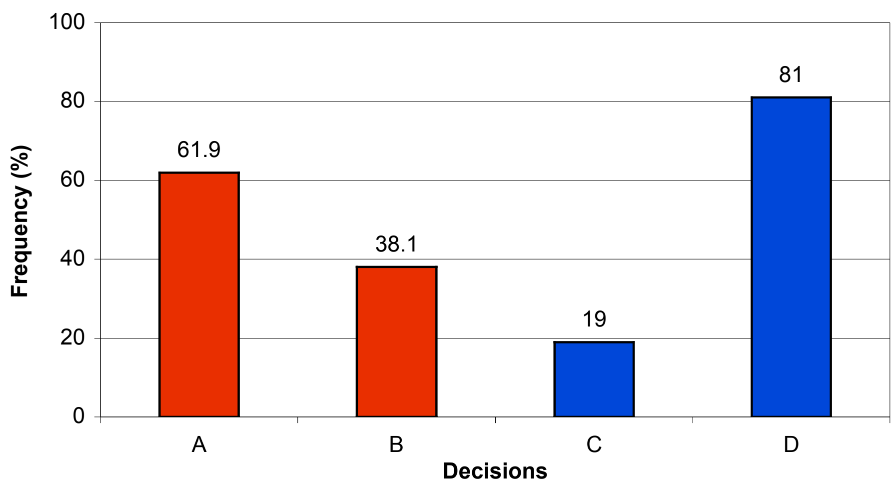
Instructions

Please choose between:
A: Obtaining 240 Euro with certainty (expected value 240 Euro)
B: A chance of winning 1000 Euro with probability 0.25 (expected value 250 Euro)

Please choose between:
C: Losing 750 Euro with certainty (expected loss 750 Euro)
D: A chance of losing 1000 Euro with probability 0.75 (expected loss 750 Euro).

Evaluations

Number of players: 21
Frequency of different decisions:



A: 240 Euro with certainty
B: 1000 Euro with probability 0.25
C: lose 750 Euro with certainty
D: lose 1000 Euro with probability 0.75

Comments

In large scale experiments, 84% prefer A: a sure gain of 240 Euros in step 1, and 87% prefer D: 75 percent chance to lose 1000 euros in step 2. But if people are offered to chose between a sure gain of 240 Euros and a 75% chance to lose 1000 Euros, on the one hand, and a 25% to gain 1000 Euros and a sure loss of 750 Euros on the other, all chose the second option:

- 25% chance to win 240 Euros and 75% to lose 760 Euros.
- 25% chance to win 250 Euros and 75% to lose 750 Euros.

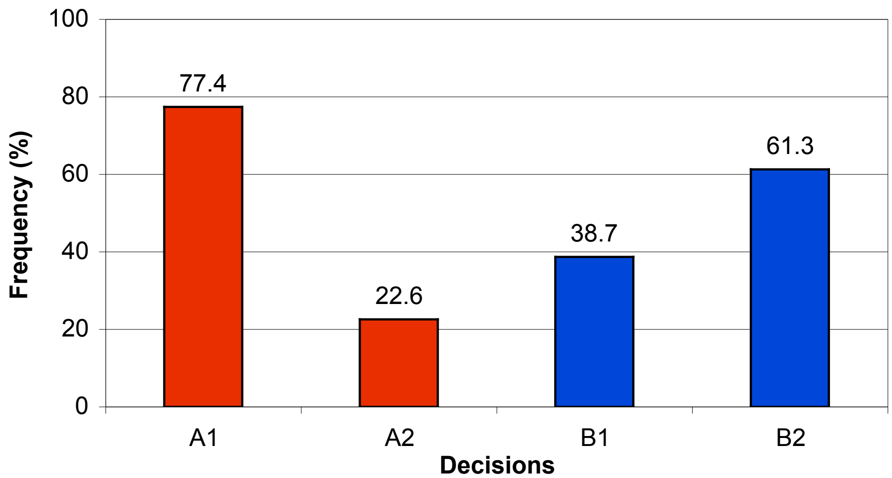
Instructions

Assume you are given 300 Euro. Please choose between
A1: a sure gain of 100 Euro
A2: a 50% chance to gain 200 Euro.

Assume you are given 500 Euro. Please choose between
B1: a sure loss of 100 Euro
B2: a 50% chance to lose 200 Euro

Evaluations

Number of players: 31
Frequency of different decisions:



Comments

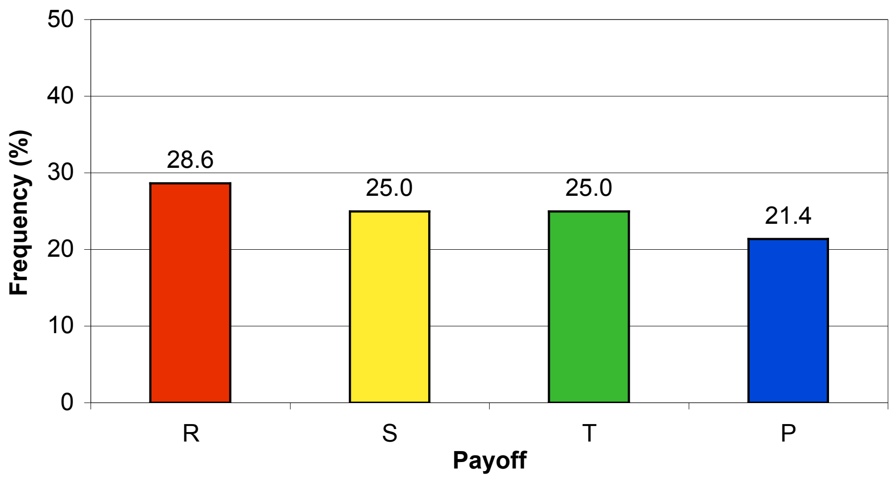
In large scale experiments, it has been found that 74% prefer a sure gain of 100 Euro (A1) to a 50% chance to gain 200 Euro (A2), whereas 64% chose a 50% chance to lose 200 Euro (B1) over a sure loss of 100 Euro (B1).

2. Two-Player Games

Prisoner's Dilemma

Instructions You and a randomly chosen co-player are matched for one round of the prisoner's dilemma game. Each can opt either for cooperation or defection. If both choose to cooperate, both get 3 points each. If you both choose to defect, you get 1 point each. If you choose defect and the other cooperate, you receive 5 points and your co-player nothing. Conversely, if you cooperate and the other defects, you receive nothing and the co-player gets 5 points.

Evaluations *Number of players:* 28 (14 games)
Frequency of payoffs:



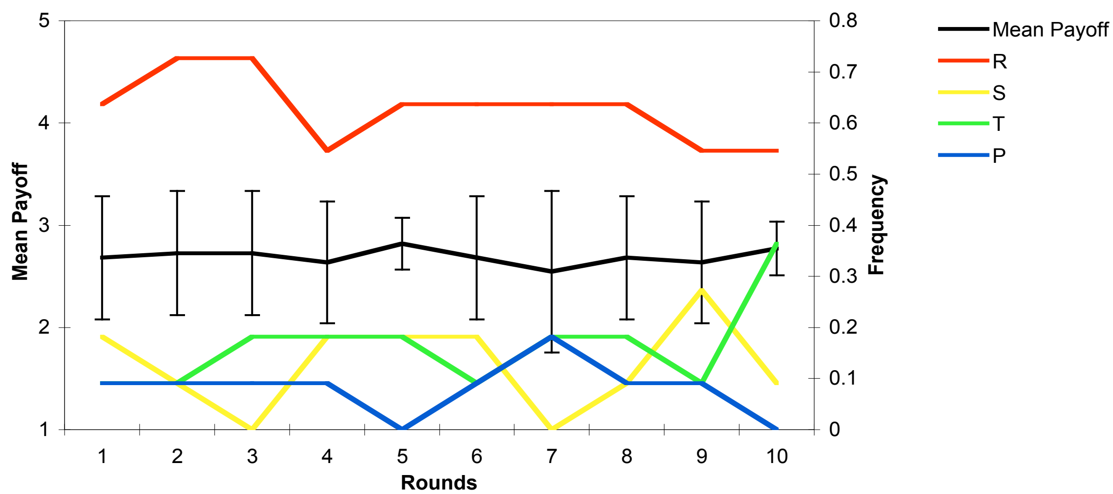
Notes R: Reward S: Sucker's payoff T: Temptation P: Punishment
The players have only weak preferences for cooperation (53.6%)

Comments The rational move is to defect (you get more, no matter what the other player decides to do). A majority chooses to cooperate, however.

Repeated Prisoner's Dilemma

Instructions You and a randomly chosen co-player for several rounds of the prisoner's dilemma game. After each round a dice is thrown: if it shows 6, the game is stopped. Otherwise, you will play another round with the same co-player.
In every round, each can opt either for cooperation or defection. If both choose to cooperate, both get 3 points each. If you both choose to defect, you get 1 point each. If you choose defect and the other cooperate, you receive 5 points and your co-player nothing. Conversely, if you cooperate and the other defects, you receive nothing and the co-player gets 5 points.

Evaluations *Number of players:* 22 (11 games)
Time evolution of mean payoff and frequencies of R, S, T and P:



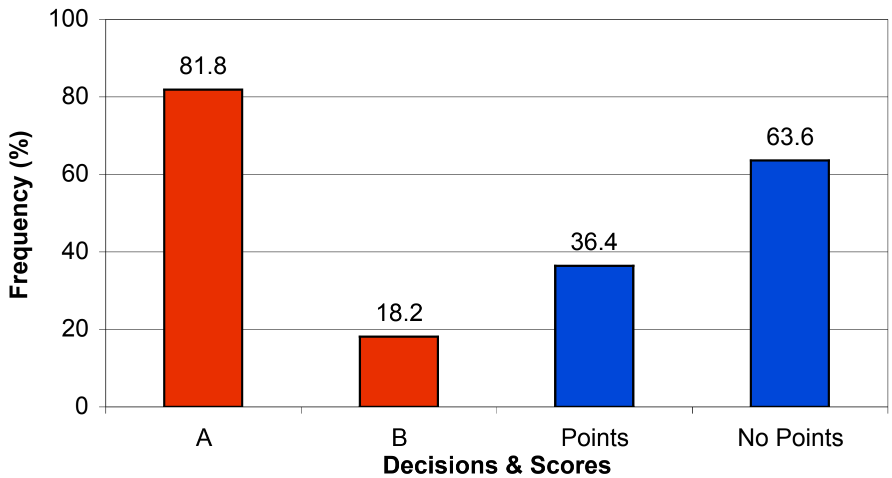
Notes Three games with persistent mutual cooperation.
Two games where a unilateral defect occurred in the last round.
The overall frequency of cooperate and defect is 75% to 25%.
The repetitions increase cooperation from 50% to 75%.

Comments Most players learn during the game to defect. Thereby their payoff decreases. If the game extends further, many learn to cooperate, however.

Battle of the Sexes

Instructions You are matched with a co-player for a so-called Battle of the Sexes game. You both have two options A and B. If you both choose the same option, you will receive nothing. However, if one chooses A and the other B, then the former gets 2 points and the latter receives 1 point.

Evaluations *Number of players:* 22 (11 games)
Frequency of different decisions and interactions achieving points:



Notes No BB-pairings were observed

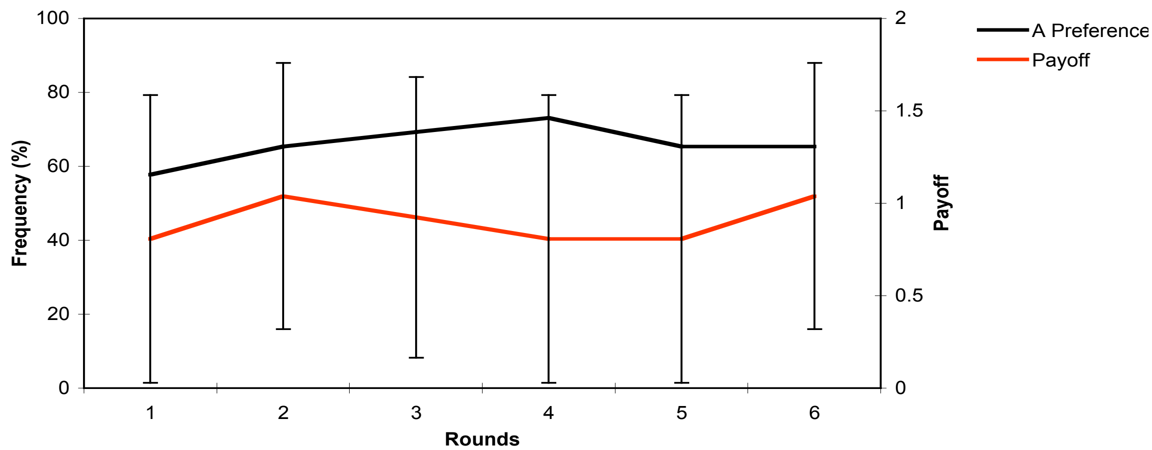
Repeated Battle of the Sexes

Instructions

You are again playing the Battle of the Sexes game. You both have two options A and B. If you both choose the same option, you will receive nothing. However, if one chooses A and the other B, then the former gets 2 points and the latter receives 1 point. This time the game is repeated. More precisely, after each round a dice will be rolled. If it shows **6**, the game is stopped. If not, there is another round.

Evaluations

Number of players: 26 (13 games)
Mean points: 5.42 ± 2.78
Time evolution of mean payoff and preference for A:



Notes

The game was actually played for a fixed number of ten rounds.
Maximal payoff achieved: 9 points each.
Minimal payoff achieved: 1 and 2 points respectively.
Preference for A in first round: 58% - without repetition it was 82%.
7 out of 13 games (53.8%) scored points in the first round - without repetition only 4 out of 11 (36.4%).
No player was ever allowed to get away with 2 points in consecutive rounds.
The small changes of the mean payoff indicate that similar numbers of games lose and achieve synchronization.
Rounds to synchronize:

Rounds	0	1	2	3	4	5	6
Count	7	3	1	1	0	1	0

An amazingly large number of games start synchronized (53.8%).
3 BB pairings occurred, indicating severe synchronization difficulties.

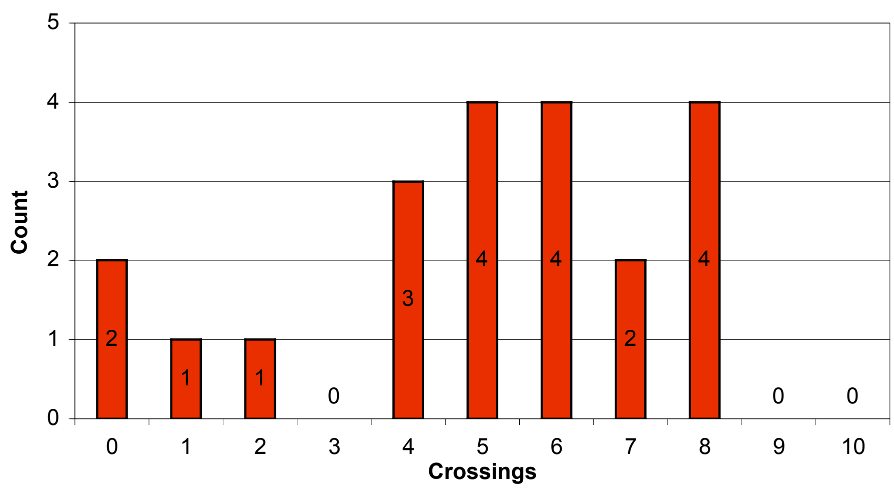
Centipede

Instructions

You an a randomly chosen co-player are sitting at a virtual table facing each other. Next to one of the two players, there are two stacks of money on the table, one smaller than the other. You have a maximum of ten rounds to play. You can either take the larger stack and leave the smaller to your co-player - this ends the game. Or else, you can push both stacks to your co-players side. In this case, both stacks increase by one Euro. It is now the other player who can leave with the larger stack, or push both stacks back towards you (in which case both stacks increase again by one Euro each). The stacks can cross the line at most ten times. At the start, one stack is three, the other one Euro. They increase by one Euro each time they cross mid-table, so that after all ten crossings, one stack contains 13 Euro and the other one 11.

Evaluations

Number of players: 42 (21 games in two sessions)
Mean number of crossings: 5 ± 2.5
Distribution of crossings:



Notes

Impossible to analyze the two sessions individually (missing date entry).
Most players are cooperative and fear only the end of the game.
No game was played to the very end.

Comments

This is an instance of backward induction. No rational player wants to be the last to shift the stacks to the other side. If both players are rational, and are fully aware of this, the game will end in the first round with low payoffs for both sides.

3. Four-Player Games

Conditional Investment Schedules

Instructions

You belong to a randomly formed group of five players. You are given 20 points each and must decide simultaneously on how much to invest to the common pool. The total contribution is multiplied by $^1/_2$ and added to EACH players payoff - independently of whether this player contributed or not*:*

Check:

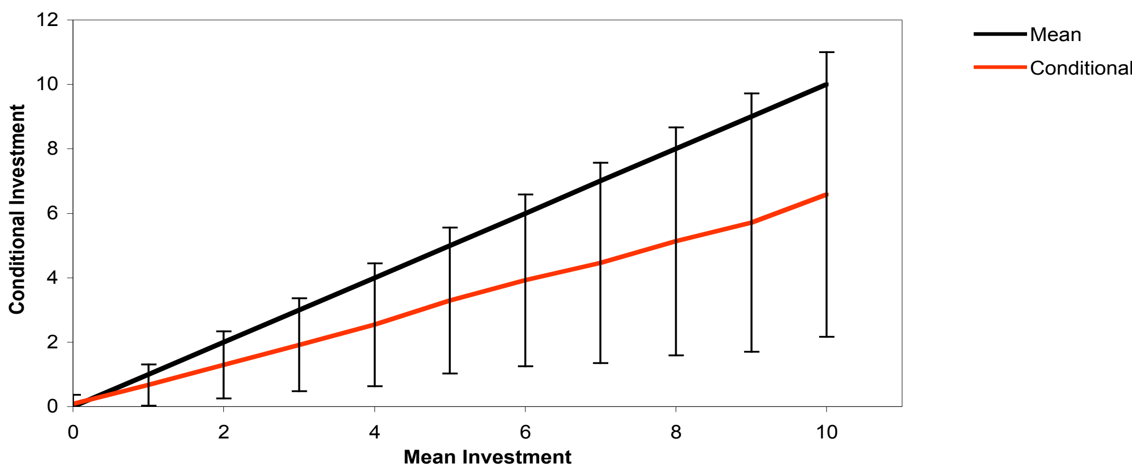
Question: Suppose that players 1, 2 and 3 give 10 points each and players 4 and 5 contribute nothing. What is the common pool? How many points will each player have? *Answer:* 1, 2, and 3 end up with 25 points, the others with 35 points.

Question: What if only player 1 gives 10 points and the others nothing?
Answer: Player 1 ends up with 15 points, the others with 25.

You'll have to give your conditional investment schedule: How much for each level of average investment by the other three players are you willing to invest?

Evaluations

Number of players: 24 (6 games)
Mean unconditional investment: 3.63 ±3.27
Mean conditional investment:



Notes

The readiness to invest increases linearly with the mean investment. Conditional investments are significantly lower than the mean investments.

4. Five-Player Games

Public Goods Game without Punishment

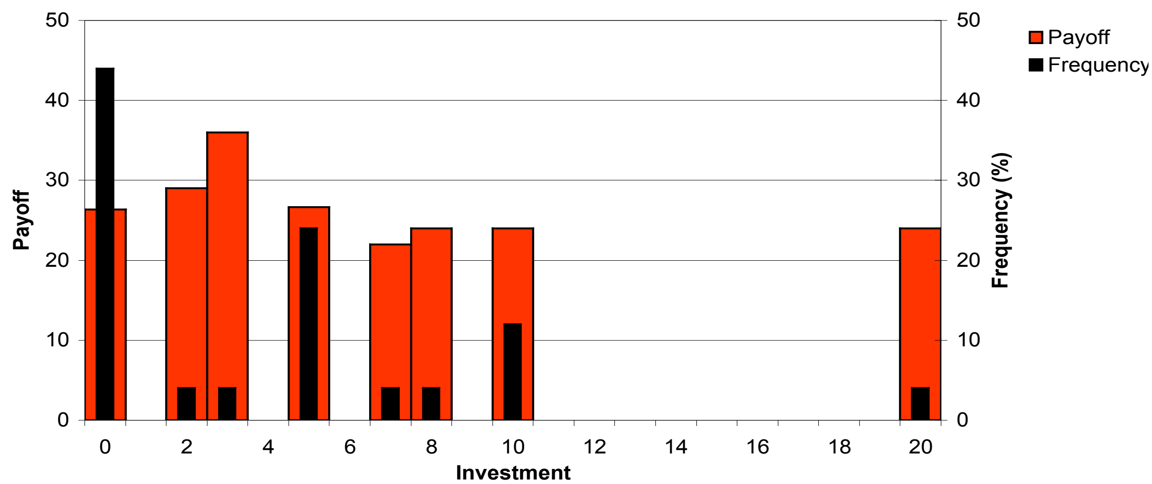
Instructions You belong to a randomly formed group of five players. You are given 20 points each and must decide simultaneously on how much to invest to the common pool. The total contribution is multiplied by $^{1}/_{2}$ and added to EACH players payoff - independently of whether this player contributed or not.

Check:

Question: Suppose that players 1, 2 and 3 give 10 points each and players 4 and 5 contribute nothing. What is the common pool? How many points will each player have? *Answer:* 1, 2, and 3 end up with 25 points, the others with 35 points.

Question: What if only player 1 gives 10 points and the others nothing?
Answer: Player 1 ends up with 15 points, the others with 25.

Evaluations *Number of players:* 25 (5 games)
Mean investment: 4.0 ±4.9
Mean payoff: 26.1 ± 5.6



Note Usually one or two players contributed zero.
In one game nobody contributed anything.
For more information and experimental results on the public good game we refer to the work of Ernst Fehr *et al.*

Repeated Public Goods Game without Punishment

Instructions

You belong to a randomly formed group of five players. You are given 20 points each and must decide simultaneously on how much to invest to the common pool. The total contribution is multiplied by $^1/_2$ and added to EACH players payoff - independently of whether this player contributed or not. There will be six rounds

Check:

Question: Suppose that players 1, 2 and 3 give 10 points each and players 4 and 5 contribute nothing. What is the common pool? How many points will each player have?

Answer: 1, 2, and 3 end up with 25 points, the others with 35 points.

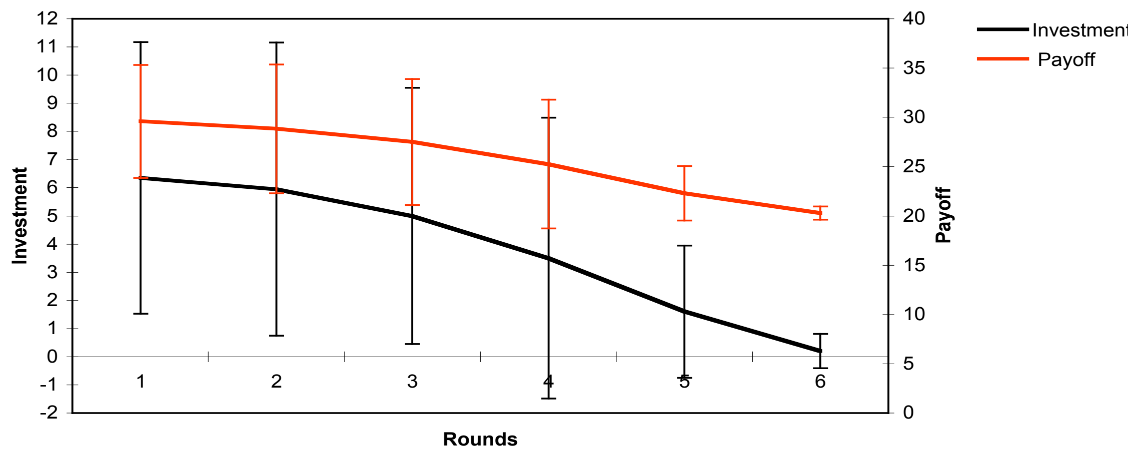
Question: What if only player 1 gives 10 points and the others nothing?

Answer: Player 1 ends up with 15 points, the others with 25.

Evaluations

Number of players: 20 (4 games)

Time evolution of mean investment:



Notes

In the last round all but two players contributed zero.
The two players contributed 2 units each.

Public Goods Game with Punishment

Instructions

You belong to a randomly formed group of five players. You are given 20 points each and must decide simultaneously on how much to invest to the common pool. The total contribution is multiplied by $^{1}/_{2}$ and added to EACH players payoff - independently of whether this player contributed or not. After this one round game, you will be able to punish your partners by reducing their score by a certain number of points at the cost of half the points.

Check:

Question: Suppose that players 1, 2 and 3 give 10 points each and players 4 and 5 contribute nothing. What is the common pool? How many points will each player have?

Answer: 1, 2, and 3 end up with 25 points, the others with 35 points.

Question: What if only player 1 gives 10 points and the others nothing?

Answer: Player 1 ends up with 15 points, the others with 25.

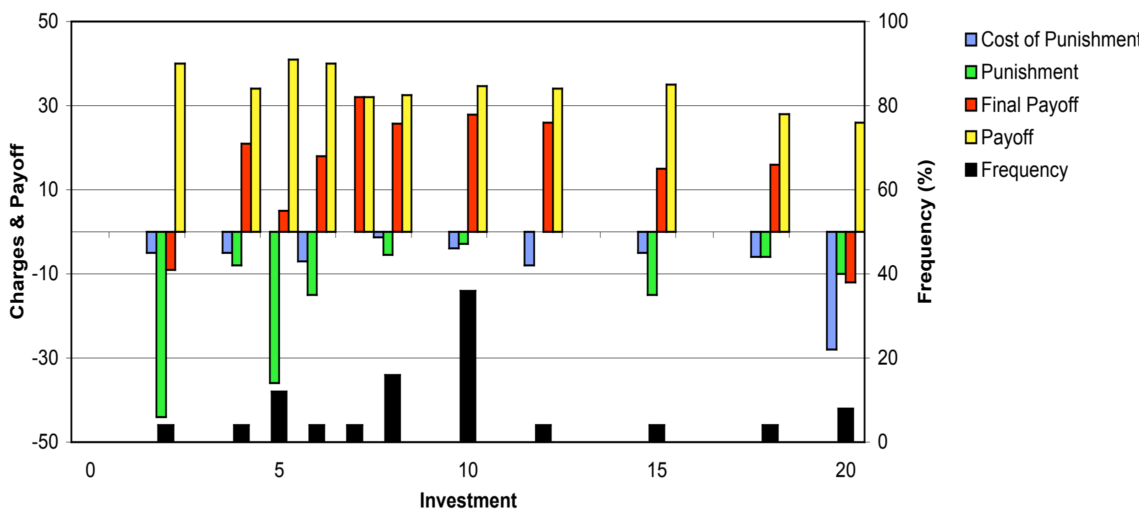
Evaluations

Number of players: 25 (5 games)

Mean investment: 9.6 ±4.6

Mean payoffs: 34.4 ± 5.0 before punishment

18.6 ± 15.9 final



Notes

Punishment increases investment from an average of 4.0 to 9.6.

Final payoffs, however, are lower! (18.6 instead of 26.1)

The minimal investment was 2.

The biggest differences between intermediate and final payoffs occur for very high and very low investors.

Repeated Public Goods Game with Punishment

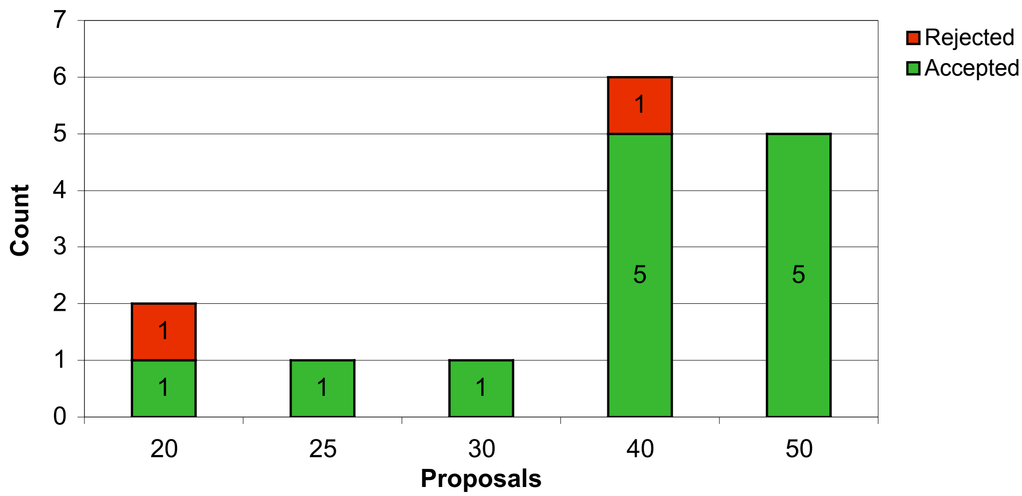
Instructions You belong to a randomly formed group of five players. You are given 20 points each and must decide simultaneously on how much to invest to the common pool. The total contribution is multiplied by $^1/_2$ and added to EACH players payoff - independently of whether this player contributed or not. After this one round game, you will be able to punish your partners. This game lasts six rounds. After each round you will be able to punish your partners by reducing their score by a certain number of points at the cost of half the points.

Comments No data available due to web-server crash

Ultimatum

Instructions Two players are chosen at random, one is designated as the proposer, the other as the responder. The experimenter offers 100 points to the team. The proposer has to propose a share of it to the responder. If the responder accepts, this is how the 100 points are split. However, if he rejects the proposal, none of the players receives anything.

Evaluations *Number of players:* 30 (15 games)
Mean proposal: 39 ± 10.7
Distribution of proposals:



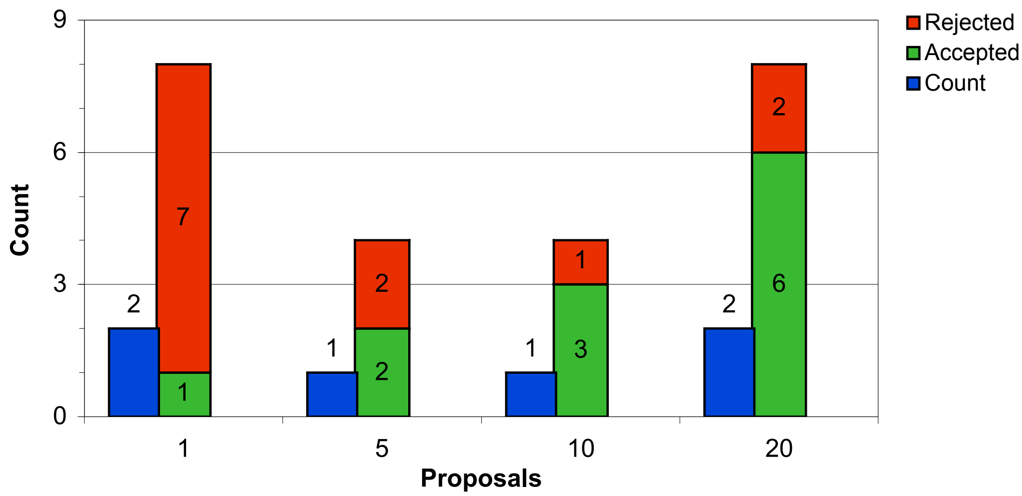
Notes The vast majority (73%) offers 40 or 50 points.
Surprisingly one offer of 40 is rejected

Comments The rational strategy is to offer 1 point, and to accept everything. In reality, offers below 30% get mostly rejected. In a vast majority of studies conducted with different incentives in different countries, some 60-80% of proposers offer between 40% and 50% of the total sum, and only 3% of proposers offer less than 20%. Conversely, some 50% of responders reject offers below 30% of the total.

Ultimatum with Responder Competition

Instructions This is a variant of the Ultimatum game. You belong to a group of five players. One of you will be randomly chosen to be the proposer, the other four are responders. The proposer offers a share of 100 points. Each responder can either accept or reject the offer. If several responders accept an offer, one will be chosen at random and this deal will then be performed, and the others will not (i.e. the other responders get nothing).

Evaluations *Number of players:* 30 (6 games)
Mean proposal: 9.5 ± 8.8
Distribution of proposals:



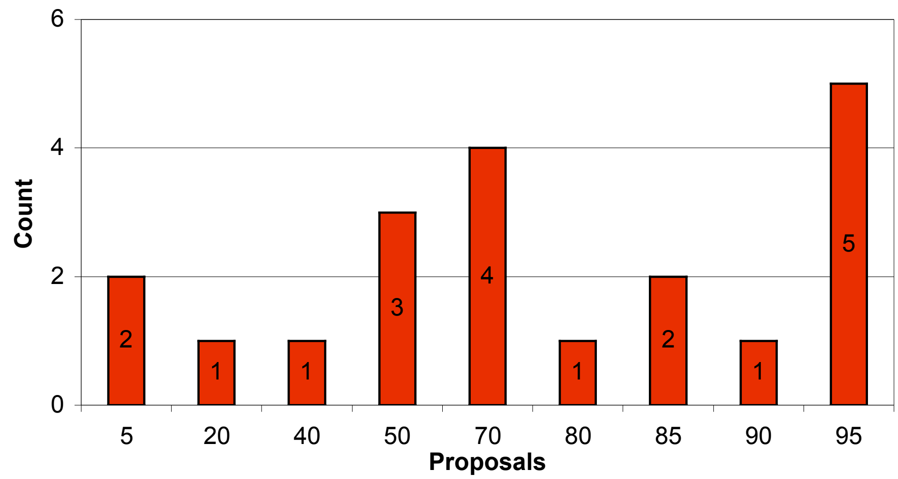
Notes Only one player (out of 8) accepts an offer of 1 unit.
Two players (out of 8) reject even an offer of 20 units.

Comments Usually the proposers offer close to zero points.

Ultimatum with Proposer Competition

Instructions This is a variant of the Ultimatum game. You belong to a group of five players. One of you will be randomly chosen to be the responder, the other four are proposers. Each of the proposers can offer a share of 100 points. The responder can accept at most one offer. If the responder accepts an offer, then this deal will be performed, and the others will not (i.e. the other proposers get nothing).

Evaluations *Number of players:* 25 (5 games)
Mean proposal: 65.8 ± 29.7
Distribution of proposals:



Notes 7 offers (28%) lower or equal to 50.
6 offers (24%) greater or equal to 90

Comments Usually the responder gets offered almost 100 points.

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