Supplemental Material for:
Equitable Burden-Sharing in "Take-One-for-the-Team" Situations: The Role of Coordination

Table of Contents

Study 1

We conducted Study 1 to examine participants' preferences for equity and efficiency in asymmetric volunteer's dilemma games. We preregistered the aim, the experimental design, and the sample size of this study prior to data collection (https://aspredicted.org/PD9_SQT). In the preregistration, we referred to equity as "equal burden" and equality as "equal contribution." The preregistered sample size is different from the required sample size reported in the main text because we decided to consider the effect of perspective after the preregistration.

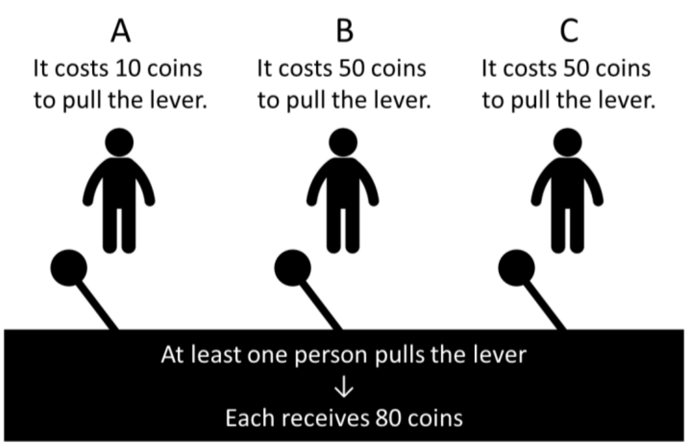
Instructions for the Experiment

Introduction and Comprehension Questions[1]

Imagine a situation where three people who have never met before are working together on a task. Each person takes on the role of Player A, B, or C. The task follows a set of rules, which are outlined below. Please read them carefully and then answer the comprehension questions.

The Rules of the Task

- If at least one player in the group pulls the lever, all players receive 80 coins each.
- Pulling the lever costs 10 coins for Player A, 50 coins for Player B, and 50 coins for Player C.

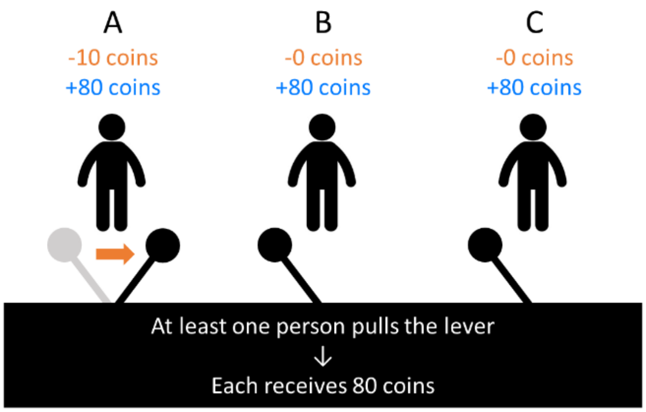


[1] Here we present the instructions in the high asymmetry condition as an example.

If Player A pulls the lever:

Player A pays 10 coins to pull the lever.

Since at least one player has pulled the lever, all players receive 80 coins each.



As a result, each player's net benefit is as follows.

Player A: 70 coins (- 10 coins + 80 coins)

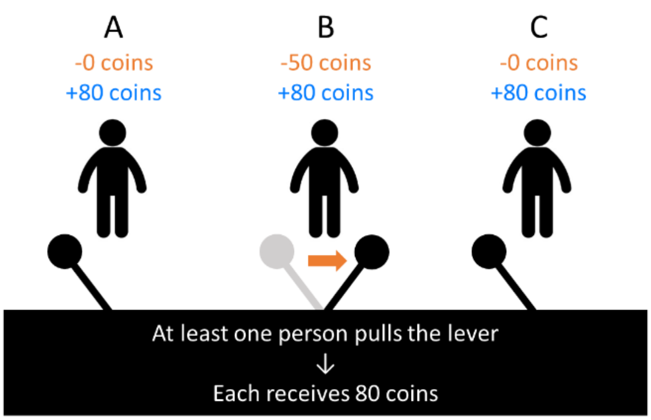
Player B: 80 coins (- 0 coins + 80 coins)

Player C: 80 coins (- 0 coins + 80 coins)

If Player B pulls the lever:

Player B pays 50 coins to pull the lever.

Since at least one player has pulled the lever, all players receive 80 coins each.



As a result, each player's net benefit is as follows.

Player A: 80 coins (- 0 coins + 80 coins)

Player B: 30 coins (- 50 coins + 80 coins)

Player C: 80 coins (- 0 coins + 80 coins)

Here is the summary of the rules (This summary will be displayed on the following pages).

The Rules of the Task

- If at least one player in the group pulls the lever, all players receive 80 coins each.
- Pulling the lever costs 10 coins for Player A, 50 coins for Player B, and 50 coins for Player C.

Please answer these comprehension questions. You can proceed to the next page if you answer all questions correctly.

How many coins does Player A need to pay to pull the lever?

- 10 coins
- 30 coins
- 50 coins
- 80 coins

How many coins does Player B need to pay to pull the lever?

- 10 coins
- 30 coins
- 50 coins
- 80 coins

How many coins does Player C need to pay to pull the lever?

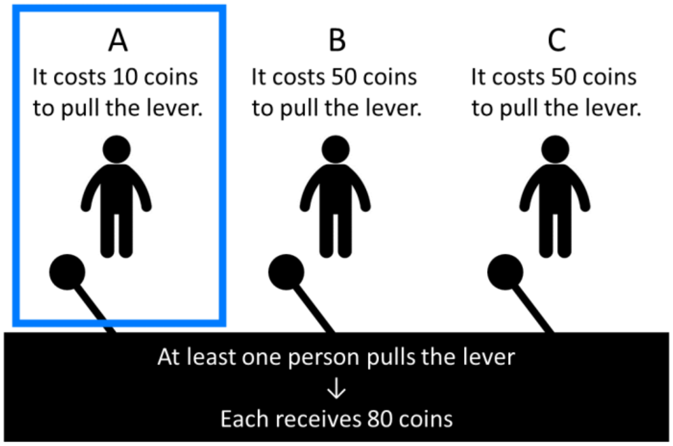
- 10 coins
- 30 coins
- 50 coins
- 80 coins

How many coins will Player B earn if only Player A chooses to pull the lever?

- 10 coins
- 30 coins
- 50 coins
- 80 coins

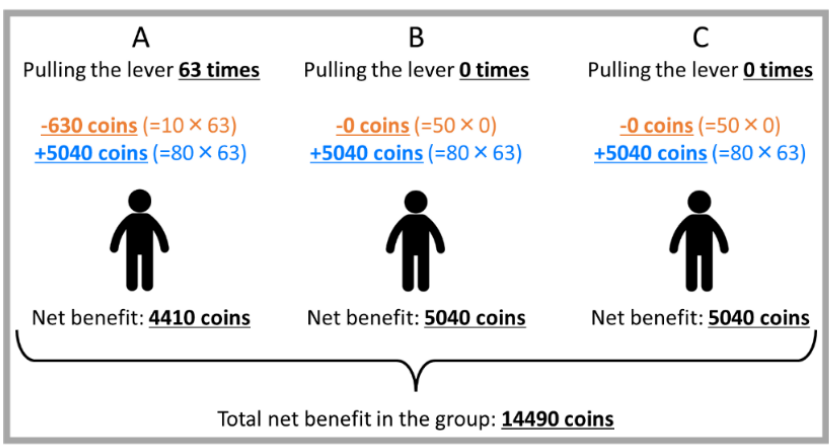
***Focal Questions*[2]**

Imagine that you will participate in the task as Player A.



When this task is repeated for 63 rounds, how many times do you think Players A (you), B, and C should pull the lever? You will be presented with five possible outcomes. Please indicate your opinion on each outcome using a 6-point scale, ranging from "strongly disagree" to "strongly agree."

Outcome 1



Players A (you), B, and C pull the lever 63, 0, and 0 times, respectively.

The net benefit Players A (you), B, and C earn is 4410, 5040, and 5040 coins, respectively.

The total net benefit of the group is 14490 coins.

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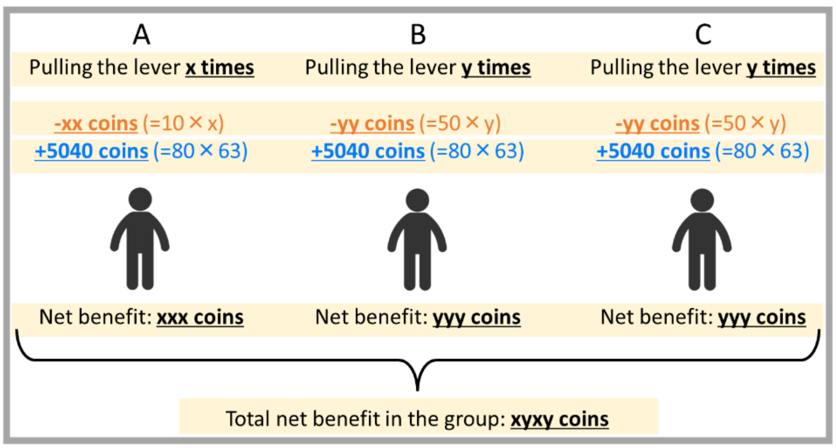
[2] Here we present the image of efficiency that Player A in the high asymmetry condition see as an example. Refer to Table S1-1 at the end of this section for all options used for the focal questions.

Do you think Players A (you), B, and C should pull the lever as depicted in the image above?

- Strongly disagree
- Disagree
- Somewhat disagree
- Somewhat agree
- Agree
- Strongly agree

Additional Questions

When answering the previous questions, which information did you focus on? Please select one or more options from the yellow parts in the image below.



When answering the previous questions, which criteria did you employ? Please select one or more options from the list below.

- To minimize the difference in the number of times each player volunteers
- To minimize the difference in the cost each player incurs
- To minimize the difference in the net benefit each player earns
- To maximize the total net benefit the group earns

When answering the previous questions, which perspective did you take?

- Player A
- Player B
- Player C
- A third person who is not participating in the task

Demographic Questions[3]

What is your gender?

- Man
- Woman
- Other

What is your age?

_____

What is the highest degree or level of education you have completed?

- Elementary or junior high school
- High school
- Technical college
- Junior college
- Bachelor's degree
- Master's degree
- Doctor's degree
- I do not know.
- I do not want to answer.

Which of the following best describes your household income (before deducting taxes) last year? Please include all income from work as well as stock dividends, pensions, real estate income, etc.

- Less than 2,000,000 JPY
- 2,000,000 JPY – 3,999,999 JPY
- 4,000,000 JPY – 5,999,999 JPY
- 6,000,000 JPY – 7,999,999 JPY
- 8,000,000 JPY – 9,999,999 JPY
- 10,000,000 JPY – 14,999,999 JPY
- More than 14,999,999 JPY
- I do not know.
- I do not want to answer.

[3] These demographic questions were asked at the end of all experiments in the present research.

Table S1-1

Outcomes presented in the focal questions (Study 1)

		High asymmetry		Low asymmetry	
Outcome	Player	Frequency of volunteering (times)	Net benefit (coins)	Frequency of volunteering (times)	Net benefit (coins)
Efficiency	A	63	4410	66	3300
	B	0	5040	0	5280
	C	0	5040	0	5280
	(Total)	63	14490	66	13860
Effi-Equi	A	53	4510	48	3840
	B	5	4790	9	4830
	C	5	4790	9	4830
	(Total)	63	14090	66	13500
Equity	A	45	4590	30	4380
	B	9	4590	18	4380
	C	9	4590	18	4380
	(Total)	63	13770	66	13140
Equi-Equa	A	33	4710	26	4500
	B	15	4290	20	4280
	C	15	4290	20	4280
	(Total)	63	13290	66	13060
Equality	A	21	4830	22	4620
	B	21	3990	22	4180
	C	21	3990	22	4180
	(Total)	63	12810	66	12980

Note. Effi-Equi and Equi-Equa indicate a hybrid of efficiency and equity and a hybrid of equity and equality, respectively.

Additional Analyses

Information

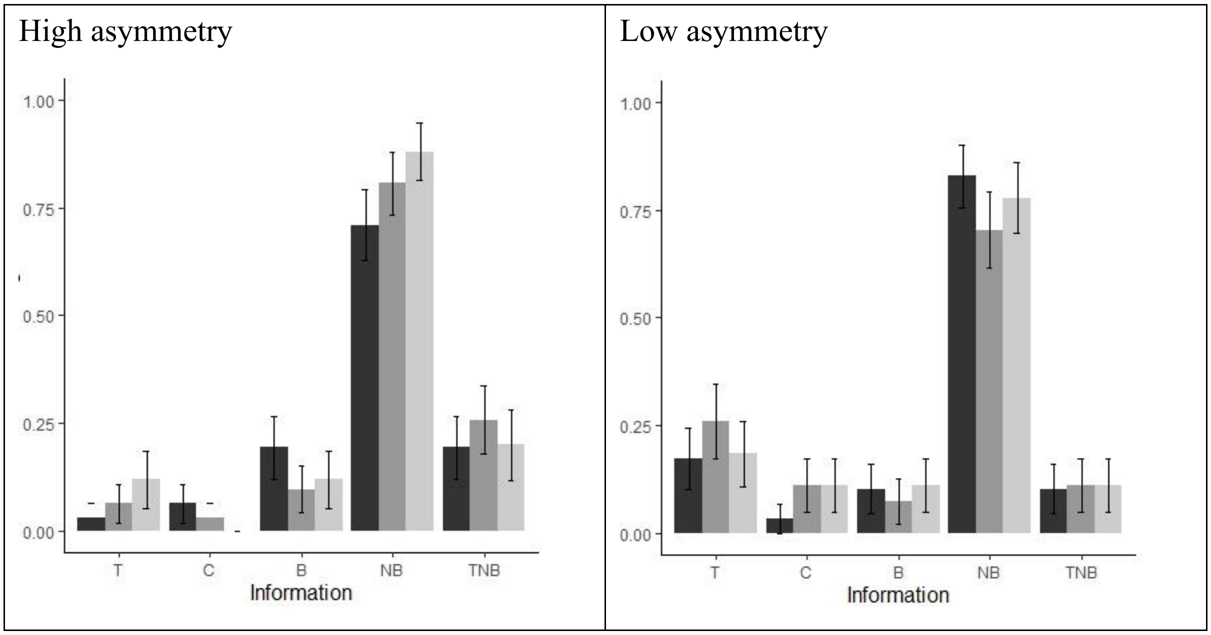
At the end of the experiment, we presented participants with an image including five kinds of information: the number of times each player volunteers, the total cost each player incurs, the total benefit each player receives, the net benefit each player earns, and the total net benefit the group earns. We then asked them "when answering the previous questions, which information did you focus on? Please select one or more options from the yellow parts in the image below."

Figure S1-1 presents the proportion of participants who paid attention to each piece of information. We conducted a 2 (asymmetry degree: high and low) × 3 (perspective: third person, strong player, and weak player) × 5 (information) mixed-model analysis of variance (ANOVA) with the former two variables as between-participants factors and the third variable as a within-participant factor.

The results showed a significant main effect of information (F [3.37, 552.95] = 112.668, η^2 = 0.386, p < .001) but non-significant main effects of perspective (F [2.00, 164.00] = 0.465, η^2 = 0.000, p = .629) and asymmetry degree (F [1.00, 164.00] = 0.012, η^2 = 0.000, p = .912). There was a significant interaction effect between information and asymmetry degree (F [3.37, 552.95] = 2.734, η^2 = 0.015, p = .037). The interaction effects between information and perspective (F [6.74, 552.95] = 0.386, η^2 = 0.004, p = .906), between perspective and asymmetry degree (F [2.00, 164.00] = 0.076, η^2 = 0.000, p = .927), and among the three variables (F [6.74, 552.95] = 0.761, η^2 = 0.008, p = .616) were not significant. Table S1-2 presents the results of post-hoc pairwise comparisons with Bonferroni correction. Overall, participants paid the most attention to the net benefit each player earned, implying that they were interested in equity.

Figure S1-1

Proportion of participants paying attention to each piece of information (Study 1)



Note. T, C, B, NB, and TNB indicate the number of times each player volunteers, the total cost each player incurs, the total benefit each player receives, the net benefit each player earns, and the total net benefit the group earns, respectively. The black, dark gray, and light gray bars indicate the perspective of third parties, strong players, and weak players, respectively. Error bars are standard errors of the mean.

Table S1-2

Post-hoc pairwise comparisons for the differences in the proportion of participants paying attention to each piece of information (Study 1)

Information 1	Information 2	High asymmetry						Low asymmetry					
		Third person		Strong player		Weak player		Third person		Strong player		Weak player	
T	C	-0.571		0.571		1.809		1.684		1.280		0.811	
T	B	-2.402		-0.441		0.000		0.701		1.727		0.700	
T	NB	-6.974	***	-8.032	***	-7.268	***	-5.747	***	-3.309	*	-4.438	**
T	TNB	-2.402		-1.985		-0.700		0.701		1.442		0.811	
C	B	-1.438		-1.000		-1.809		-1.440		0.440		0.000	
C	NB	-5.906	***	-10.142	***	-13.266	***	-10.360	***	-4.438	**	-5.586	***
C	TNB	-1.438		-2.958		-2.449		-1.000		0.000		0.000	
B	NB	-3.737	**	-6.715	***	-7.268	***	-7.392	***	-5.792	***	-5.586	***
B	TNB	0.000		-1.541		-0.811		0.000		-0.440		0.000	
NB	TNB	4.246	**	4.522	***	5.421	***	6.594	***	4.841	***	5.586	***

Note. *** $p < .001$, ** $p < .01$, * $p < .05$. The values indicate adjusted t-values. T, C, B, NB, and TNB indicate the number of times each player volunteers, the total cost each player incurs, the total benefit each player receives, the net benefit each player earns, and the total net benefit the group earns, respectively.

Criteria

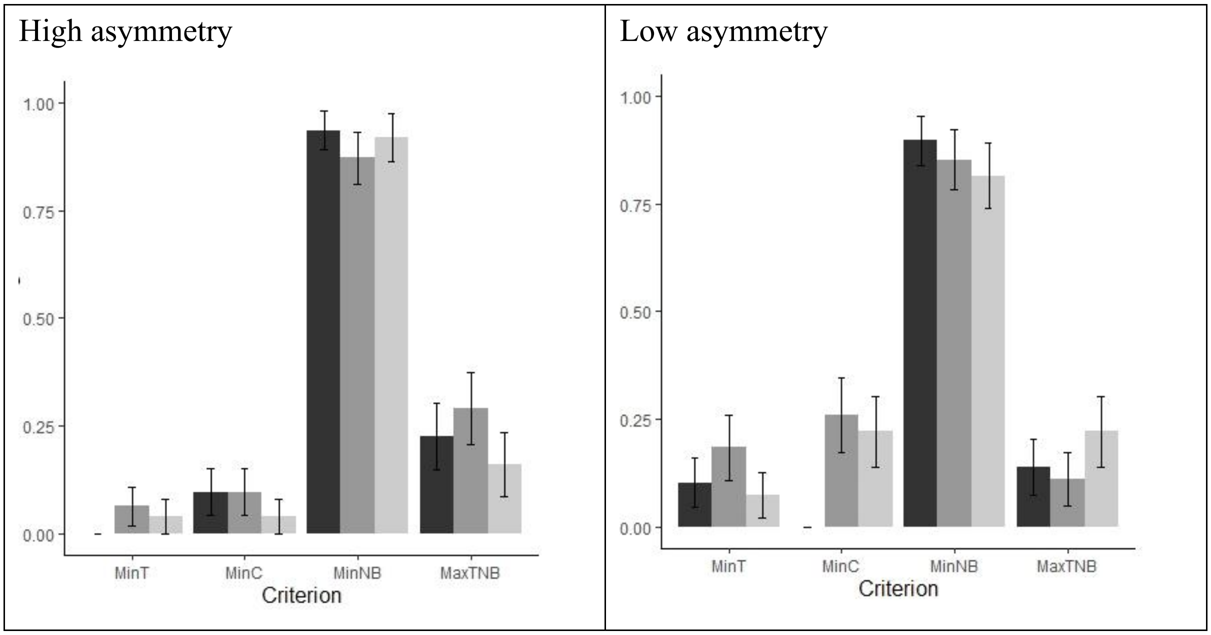
At the end of the experiment, we also asked participants "when answering the previous questions, which criteria did you employ? Please select one or more options from the list below." They had four options: to minimize the difference in the number of times each player volunteers, to minimize the difference in the cost each player incurs, to minimize the difference in the net benefit each player earns, and to maximize the total net benefit the group earns.

Figure S1-2 presents the proportion of participants who employed each criterion. We conducted a 2 (asymmetry degree: high and low) × 3 (perspective: third person, strong player, and weak player) × 4 (criterion) mixed-model ANOVA with the former two variables as between-participants factors and the third variable as a within-participant factor.

The results showed a significant main effect of criterion (F [2.55, 417.48] = 199.063, η^2 = 0.506, p < .001) but non-significant main effects of perspective (F [2.00, 164.00] = 1.601, η^2 = 0.003, p = .205) and asymmetry degree (F [1.00, 164.00] = 0.333, η^2 = 0.000, p = .565). None of the interaction effects were significant (criterion and perspective: F [5.09, 417.48] = 0.818, η^2 = 0.008, p = .539; criterion and asymmetry degree: F [2.55, 417.48] = 2.464, η^2 = 0.013, p = .072; perspective and asymmetry degree: F [2.00, 164.00] = 1.199, η^2 = 0.002, p = .304; criterion, perspective, and asymmetry degree: F [5.09, 417.48] = 1.443, η^2 = 0.015, p = .207). Table S1-3 presents the results of post-hoc pairwise comparisons with Bonferroni correction. Overall, the most employed criterion was whether each outcome minimized the difference in the net benefit each player earned (i.e., whether they aligned with equity).

Figure S1-2

Proportion of participants employing each criterion (Study 1)



Note. MinT, MinC, MinNB, and MaxTNB indicate minimizing the difference in the number of times each player volunteers, minimizing the difference in the cost each player incurs, minimizing the difference in the net benefit each player earns, and maximizing the total net benefit the group earns, respectively. The black, dark gray, and light gray bars indicate the perspective of third parties, strong members, and weak members, respectively. Error bars are standard errors of the mean.

Table S1-3

Post-hoc pairwise comparisons for the differences in the proportion of participants employing each criterion (Study 1)

Criterion 1	Criterion 2	High asymmetry						Low asymmetry					
		Third person		Strong player		Weak player		Third person		Strong player		Weak player	
MinT	MinC	-1.793		-0.571		0.000		1.797		-0.811		-1.688	
MinT	MinNB	-20.857	***	-9.404	***	-13.266	***	-8.693	***	-6.245	***	-8.619	***
MinT	MaxTNB	-2.958	*	-2.244		-1.365		-0.372		0.700		-1.688	
MinC	MinNB	-12.490	***	-8.668	***	-13.266	***	-15.578	***	-4.438	***	-4.841	***
MinC	MaxTNB	-1.278		-1.793		-1.365		-2.117		1.280		0.000	
MinNB	MaxTNB	6.715	***	4.811	***	6.363	***	7.085	***	7.322	***	4.841	***

Note. *** $p < .001$, * $p < .05$. The values indicate adjusted t-values. MinT, MinC, MinNB, and MaxTNB indicate minimizing the difference in the number of times each player volunteers, minimizing the difference in the cost each player incurs, minimizing the difference in the net benefit each player earns, and maximizing the total net benefit the group earns, respectively.

Supplemental Study S1: Pilot Study

We conducted this pilot study prior to Study 1 to examine participants' preferences regarding the trade-off between equity and efficiency. The limitations of this pilot study were that it examined participants' preferences only from a third person's perspective and that it overlooked the possibility that participants may prefer a hybrid of efficiency and equity. We did not preregister this pilot study.

Method

A total of 312 participants (156 men, 154 women, two unidentified; $M_{age} = 39.88$, $SD = 9.62$) participated. They received 125 yen for their participation. As in Study 1, participants were randomly assigned to the high or low asymmetry condition and read the rules of the asymmetric volunteer's dilemma game. After answering comprehension questions correctly, they were asked to imagine that the game was repeated for 22 rounds. Participants were presented with three images, each of which represented efficiency, equity, or equality (Figure S1-3). They saw all possible pairs of the images (three pairs in total) one by one in random order and indicated which was more desirable from a third-party perspective. At the end of the study, participants reported the information they had focused on and the criteria they had employed when making decisions.

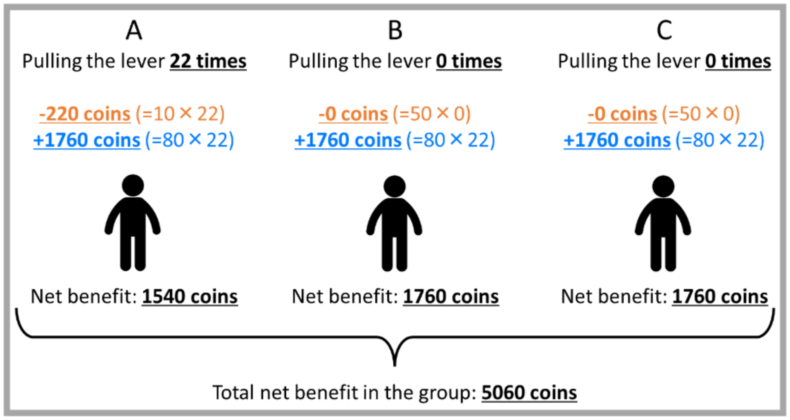
Results

We applied a pattern approach to analyze the paired comparison data, using the R package "prefmod" (Hatzinger & Maier, 2017). In the analysis, we set efficiency as the reference object (0). In the high asymmetry condition, the parameter estimate (i.e., the relative preference) of equity was 0.652 ($SE = 0.151$, $p < .001$), and that of equality was −0.356 ($SE = 0.078$, $p < .001$). Similarly, in the low asymmetry condition, the parameter estimate of equity was 0.825 ($SE = 0.127$, $p < .001$), and that of equality was −0.225 ($SE = 0.104$, $p < .001$). Therefore, equity was deemed most desirable, irrespective of asymmetry degree, as in Study 1.

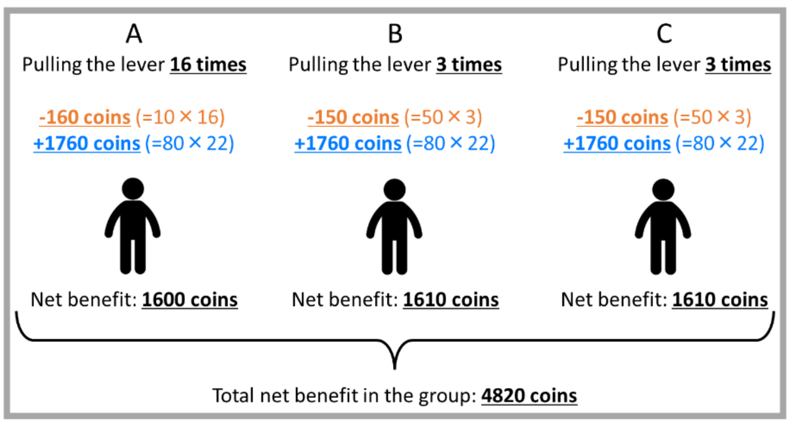
Figure S1-3

Images representing (a) efficiency, (b) equity, or (c) equality in the high asymmetry condition (Study S1)

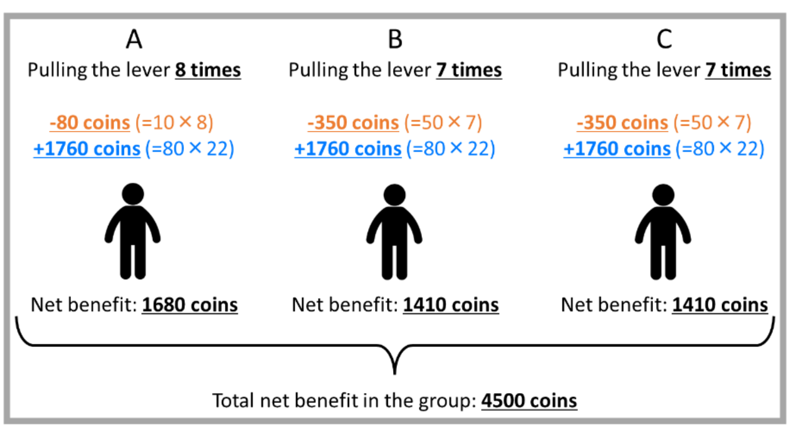
(a) Efficiency



(b) Equity



(c) Equality



Study 2

We conducted Study 2 to examine strong and weak players' volunteer rates in asymmetric volunteer's dilemma games. We preregistered the aim, the experimental design, and the sample size of this study prior to data collection (https://aspredicted.org/B9G_7ZF). In this preregistration, we did not mention the trade-off between equity and efficiency and our plan to conduct *t*-tests, as the main purpose of the present research was not determined at the time of preregistration.

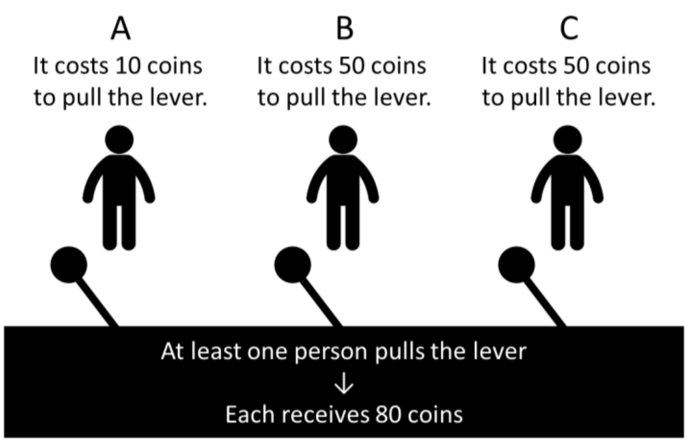
Instructions for the Experiment

Introduction and Comprehension Questions[4]

You will be matched with two other participants and carry out a task as Player A, B, or C. The task follows a set of rules, which are outlined below. Please read them carefully and then answer the comprehension questions.

The Rules of the Task

- If at least one player in the group pulls the lever, all players receive 80 coins each.
- Pulling the lever costs 10 coins for Player A, 50 coins for Player B, and 50 coins for Player C.



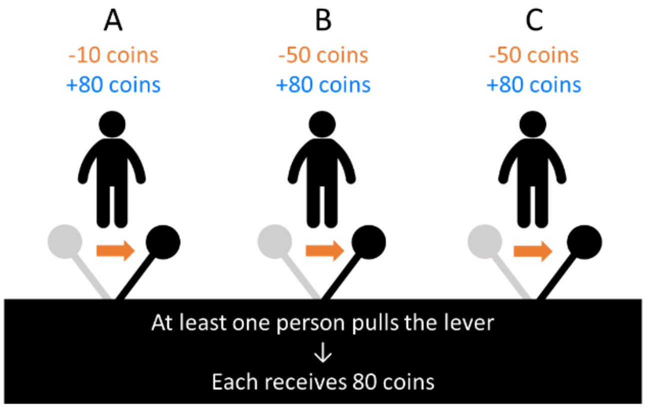
You will not be allowed to communicate with other participants during the task.
You will be informed who has pulled the lever at the end of each round.

[4] Here we present the instructions in the high asymmetry condition as an example.

If everyone pulls the lever:

Player A pays 10 coins, Player B pays 50 coins, and Player C pays 50 coins to pull the lever.

Since at least one player has pulled, all players receive 80 coins each.



As a result, each player's net benefit is as follows.

Player A: 70 coins (- 10 coins + 80 coins)

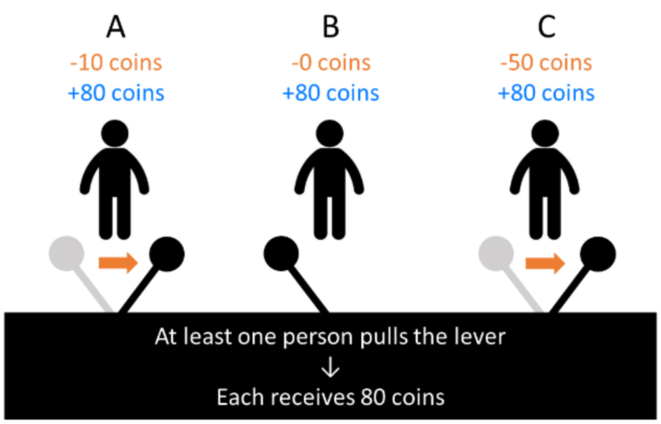
Player B: 30 coins (- 50 coins + 80 coins)

Player C: 30 coins (- 50 coins + 80 coins)

If Players A and C pull the lever:

Player A pays 10 coins, and Player C pays 50 coins to pull the lever.

Since at least one player has pulled the lever, all players receive 80 coins each.



As a result, each player's net benefit is as follows.

Player A: 70 coins (- 10 coins + 80 coins)

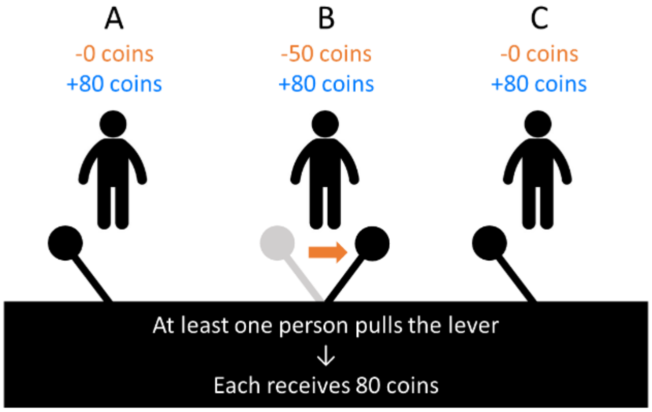
Player B: 80 coins (- 0 coins + 80 coins)

Player C: 30 coins (- 50 coins + 80 coins)

If Player B pulls the lever:

Player B pays 50 coins to pull the lever.

Since at least one player has pulled the lever, all players receive 80 coins each.



As a result, each player's net benefit is as follows.

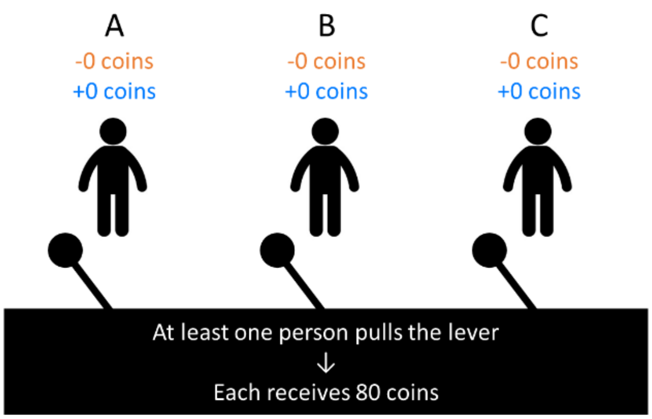
Player A: 80 coins (- 0 coins + 80 coins)

Player B: 30 coins (- 50 coins + 80 coins)

Player C: 80 coins (- 0 coins + 80 coins)

If no one pulls the lever:

Since no one has pulled the lever, no one receives anything.



As a result, each player's net benefit is as follows.

Player A: 0 coins (- 0 coins + 0 coins)

Player B: 0 coins (- 0 coins + 0 coins)

Player C: 0 coins (- 0 coins + 0 coins)

Here is the summary of the rules (This summary will be displayed on the following pages).

The Rules of the Task

- If at least one player in the group pulls the lever, all players receive 80 coins each.
- Pulling the lever costs 10 coins for Player A, 50 coins for Player B, and 50 coins for Player C.

Please answer these comprehension questions. You can proceed to the next page if you answer all questions correctly.

How many coins does Player A need to pay to pull the lever?

- 0 coins
- 10 coins
- 30 coins
- 50 coins
- 80 coins

How many coins does Player B need to pay to pull the lever?

- 0 coins
- 10 coins
- 30 coins
- 50 coins
- 80 coins

How many coins does Player C need to pay to pull the lever?

- 0 coins
- 10 coins
- 30 coins
- 50 coins
- 80 coins

How many coins will Player B earn if Players A and C choose to pull the lever?

- 0 coins
- 10 coins
- 30 coins
- 50 coins

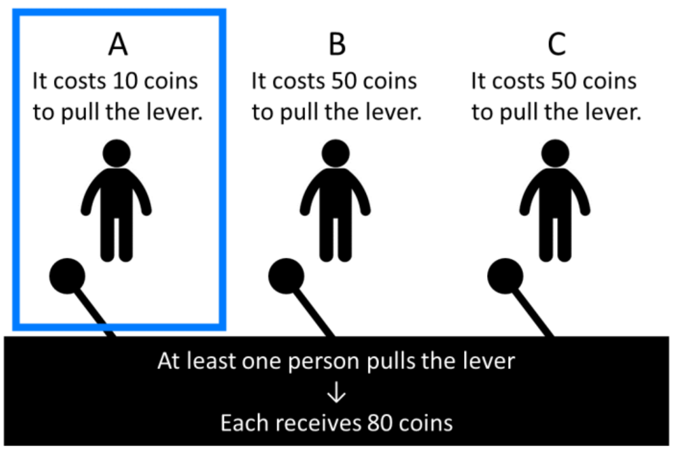
- 80 coins

How many coins will Player B earn if no one chooses to pull the lever?

- 0 coins
- 10 coins
- 30 coins
- 50 coins
- 80 coins

Assignment of a Role[5]

You have been matched with two other participants. You will take the role of **Player A**.



You will participate in the task for between 20 and 30 rounds in this group. You are not allowed to know the exact number of rounds in advance.

Everyone in the group will be told which member has pulled the lever and how much each member has earned at the end of each round.

Neither your group members nor your role (Player A) will change throughout the task.

[5] Here we present the instructions that Player A in the high asymmetry condition see as an example.

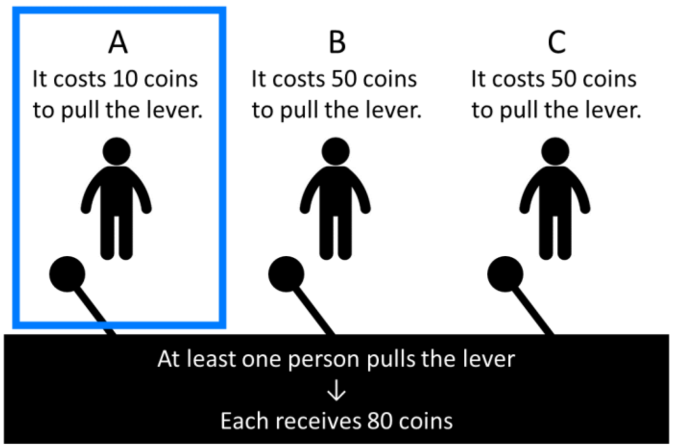
Decision-Making in Each Round[6]

Round 10

The Rules of the Task

- If at least one player in the group pulls the lever, all players receive 80 coins.
- Pulling the lever costs 10 coins for Player A, 50 coins for Player B, and 50 coins for Player C.

You are Player A.



Please decide whether to pull the lever or not.

Please decide within 90 seconds.

Pull the lever

Do not pull the lever

---

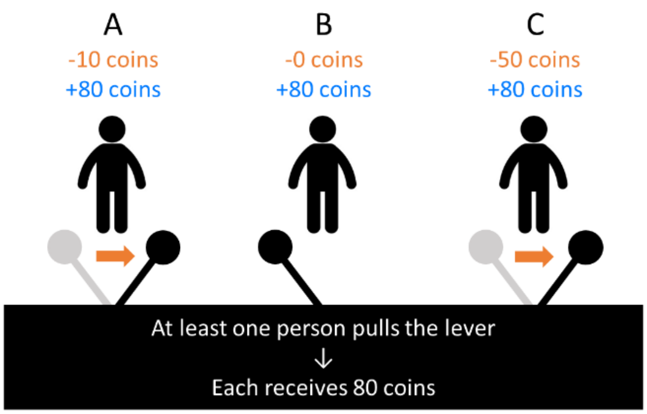
[6] Here we present the instructions that Player A in the high asymmetry condition see in Round 10 as an example.

Result Announcement in Each Round[7]

Result of Round 10

Players A and C have chosen to pull the lever.

Since at least one player has pulled the lever, all players receive 80 coins each.



The number of coins each player has earned in this round:

Player A: 70 coins (- 10 coins + 80 coins)

Player B: 80 coins (- 0 coins + 80 coins)

Player C: 30 coins (- 50 coins + 80 coins)

The coins you (Player A) have earned in this round: 70 coins

The coins you (Player A) have earned in this and the previous rounds: 720 coins

Survey[8]

Thank you very much for participating in the study.

Please answer the following questions. Please be honest, as the answers here will not affect the amount of money you will receive.

How satisfied are you with the number of times that Players A, B, and C pulled the lever?

- Dissatisfied
- Somewhat dissatisfied
- Neither dissatisfied nor satisfied

---

[7] Here we present the instructions that Player A in the high asymmetry condition see in Round 10 if Players A and C have decided to volunteer as an example.

[8] Here we present the instructions in the high asymmetry condition as an example.

- Somewhat satisfied
- Satisfied

How many times do you think Players A, B, and C should have pulled the lever when the task was repeated for 22 rounds? Please enter your answer as a number between 0 and 22.

- The number of times Player A (who needs 10 coins to pull the lever) should have pulled the lever: _____
- The number of times Player B (who needs 50 coins to pull the lever) should have pulled the lever: _____
- The number of times Player C (who needs 50 coins to pull the lever) should have pulled the lever: _____

Your data will be used for a scientific study. Please let us know if you think there is a problem with it (e.g., owing to a lack of concentration during the task).

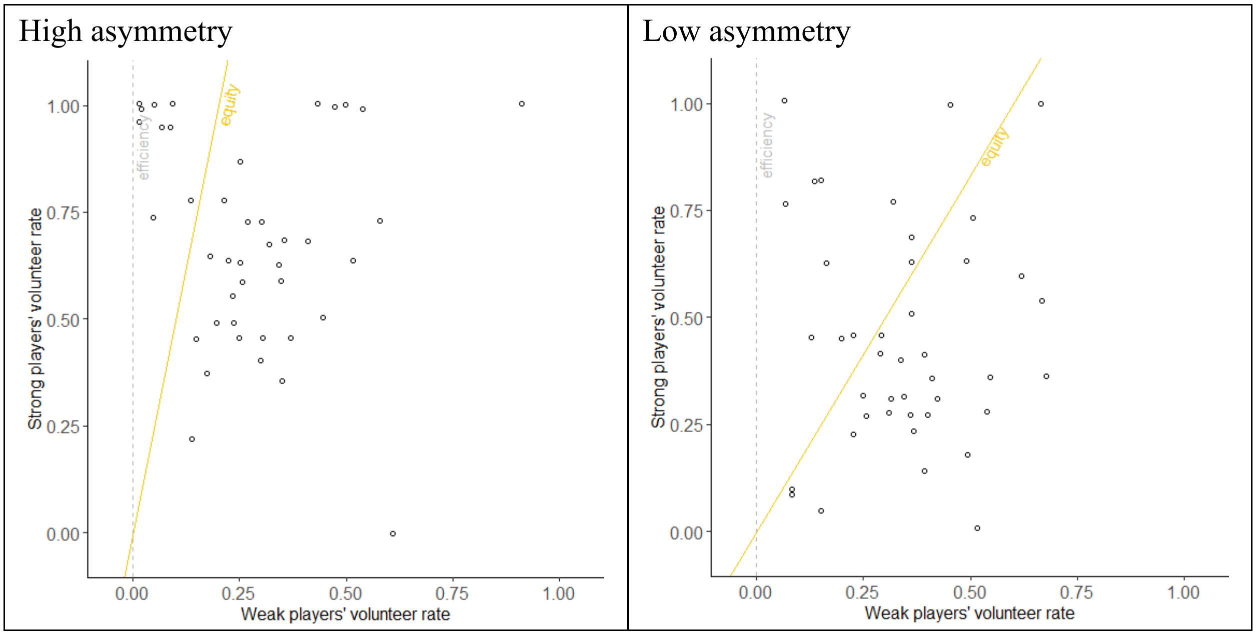
- There may be some problems with using my data for a scientific study.
- There is no problem with using my data for a scientific study.
- I do not know.

Additional Analyses

Volunteer Rates

Figure S2-1

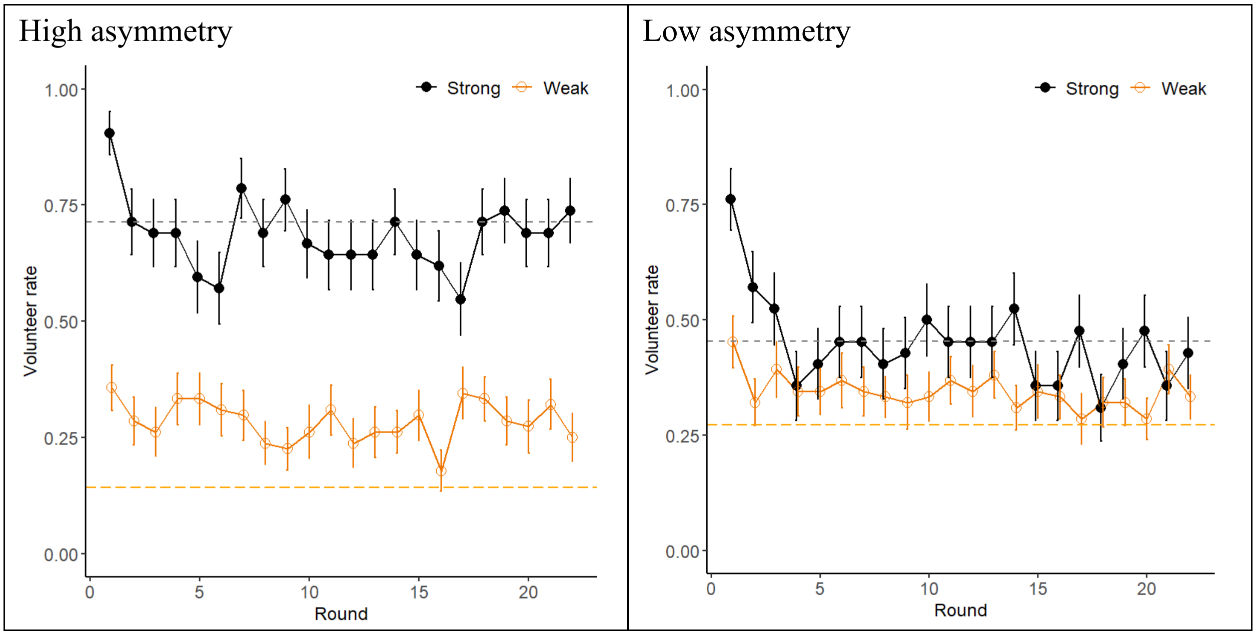
Volunteer rates of strong and weak players across groups (Study 2)



Note. Dots on the gray dashed lines represent groups where only strong players volunteered, while dots on the yellow lines represent groups where equitable burden-sharing was achieved.

Figure S2-2

Volunteer rates of strong and weak players per round (Study 2)



Note. Error bars indicate standard errors. The dashed gray lines indicate the volunteer rates that strong players should reach to realize equity (71.4% in the high asymmetry condition and 45.5% in the low asymmetry condition), and the long-dashed orange lines indicate the volunteer rates that weak players should reach to realize equity (14.3% in the high asymmetry condition and 27.3% in the low asymmetry condition).

Analyses Without the First-Round Data

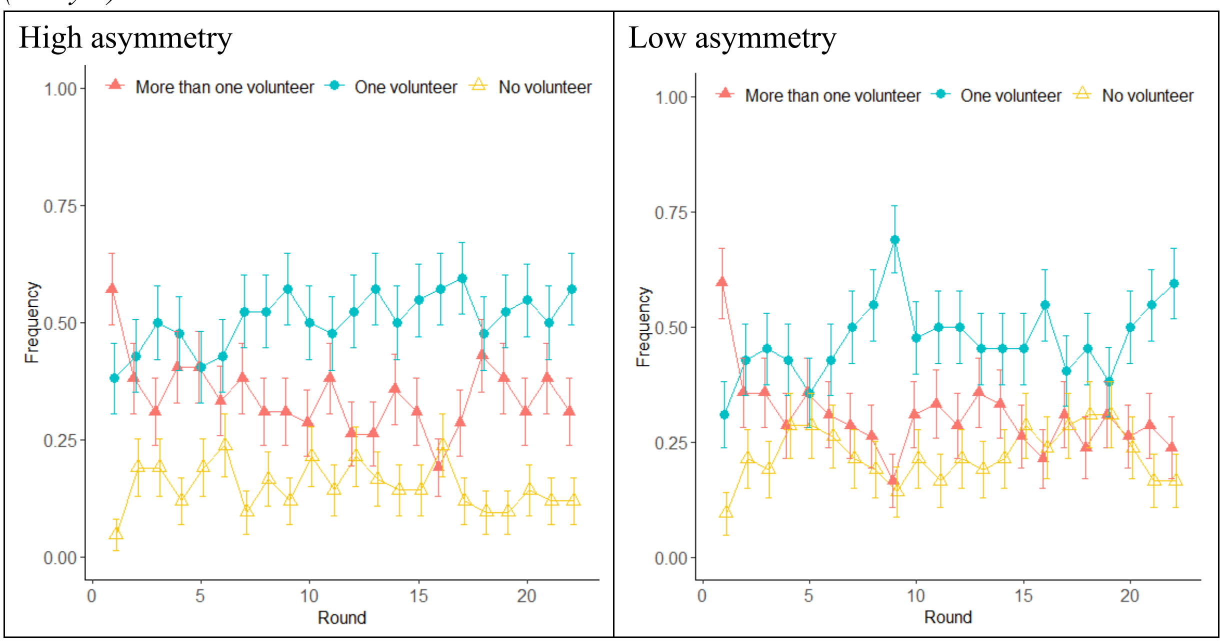
Figure S2-2 shows high volunteer rates, particularly in the first round of the games. To confirm that the conclusions remained consistent with and without first-round data, we conducted one-sample two-tailed sign-tests, excluding data from the first round. The results indicated no difference in the conclusions drawn from the analyses with or without the first-round data. Specifically, the additional analysis revealed that strong players' volunteer rates aligned with equity while weak players' volunteer rates were higher than the level of equity. Strong players' mean volunteer rate was 67.6% (95% CI [0.597, 0.755]; median 66.7%, 95% CI [0.571, 0.762]) in the high asymmetry condition, and this was not significantly different from the level of equity (71.4%) (z = 1.136, p = .256, Cohen's g = 0.105). Strong players' mean volunteer rate was 43.5% (95% CI [0.352, 0.519]; median 38.1%, 95% CI [0.286, 0.476]) in the low asymmetry condition, and this was not significantly different from the level of equity (45.5%) (z = 1.080, p = .280, g = 0.100). Weak players' mean volunteer rate was 28.1% (95% CI [0.221, 0.341]; median 26.2%, 95% CI [0.214, 0.310]) in the high asymmetry condition, which was significantly higher than the level of equity (14.3%) (z = 3.320, p < .001, g = 0.275). Weak players' mean volunteer rate was 34.0% (95% CI [0.285, 0.394]; median 33.3%, 95% CI [0.286, 0.405]) in the low asymmetry condition, which was significantly higher than the level of equity (27.3%) (z = 2.006, p = .044, g = 0.167).

Coordination of Action

Figure S2-3 demonstrates the proportion of groups in which nobody, one player, or more than one player volunteered per round. We used a linear mixed-effects model with a random intercept and slope for each group to examine whether the likelihood of only one member volunteering (i.e., coordination success) increased over time. The model included time, asymmetry degree, and their interaction as independent variables, and whether groups had only one volunteer as the dependent variable. The results showed no significant effect of time (b = 0.036, SE = 0.026, z = 1.407, p = .159), asymmetry degree (b = −0.150, SE = 0.720, z = −0.208, p = .835), or their interaction (b = −0.021, SE = 0.057, z = −0.372; p = .710). This implies that the success rate of coordination did not significantly increase over time.

Figure S2-3

Proportion of groups in which nobody, one player, or more than one player volunteered per round (Study 2)



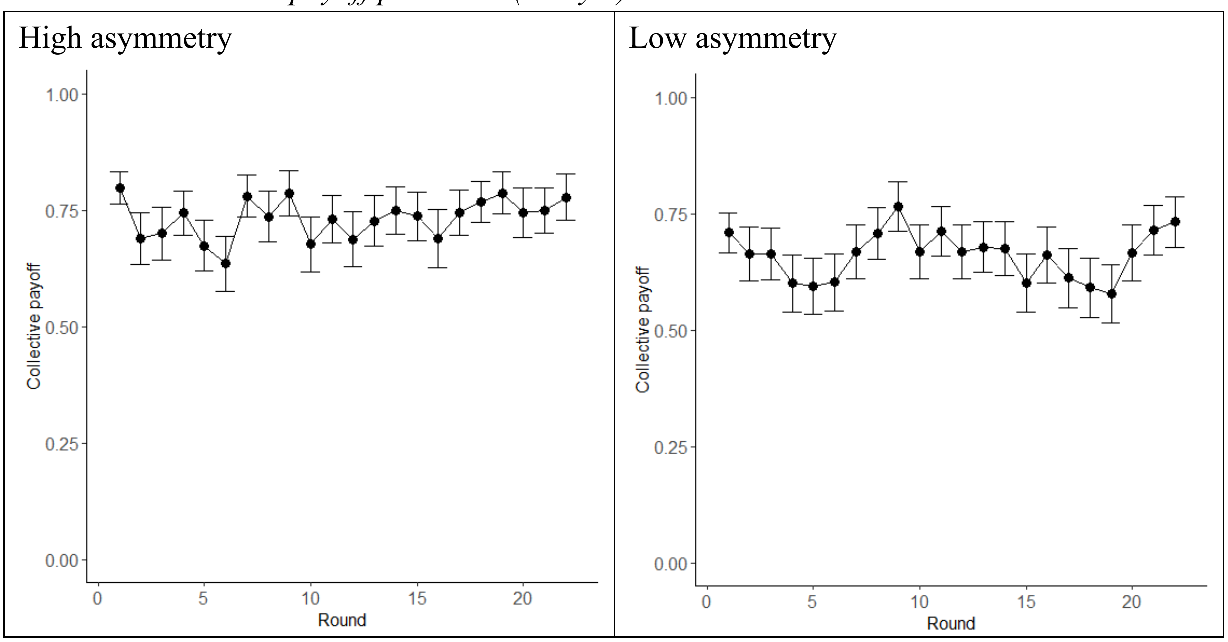
Note. Error bars indicate standard errors of the mean.

Collective Payoff

Figure S2-4 presents the normalized average collective payoff per round, with values ranging from 0 (lowest possible payoff) to 1 (highest possible payoff). We used a linear mixed-effects model with a random intercept and slope for each group to examine whether the normalized collective payoffs increased over time. The model included time, asymmetry degree, and their interaction as independent variables, and the normalized collective payoff as the dependent variable. The results showed no significant effect of time (b = 0.003, SE = 0.003, df = 156.24, t = 0.950, p = .344), asymmetry degree (b = −0.120, SE = 0.098, df = 156.26, t = 1.223, p = .223), or their interaction (b = −0.005, SE = 0.007, df = 156.24, t = 0.714, p = .476).

Figure S2-4

Normalized collective payoff per round (Study 2)



Note. Error bars indicate standard errors of the mean.

Satisfaction

At the end of the games, participants rated their satisfaction with the results on a 5-point scale. To examine how satisfaction was influenced by participants' roles and relative volunteer rates (the number of times the strong player volunteered divided by the total number of times all group members volunteered), we used a linear mixed-effects model with a random intercept and slope for each group. The model included role (weak and strong), relative volunteer rate, their interaction, and asymmetry degree (low and high) as independent variables, and satisfaction as the dependent variable. The results showed the positive effect of role ($b = 1.122$, $SE = 0.355$, $df = 157.62$, $t = 3.162$, $p = .002$), the positive effect of relative volunteer rate ($b = 1.828$, $SE = 0.466$, $df = 119.65$, $t = 3.923$, $p < .001$), and their interaction effect ($b = -2.400$, $SE = 0.677$, $df = 157.62$, $t = 3.547$, $p < .001$). The effect of asymmetry degree was not significant ($b = -0.112$, $SE = 0.178$, $df = 84.81$, $t = 0.629$, $p = .531$). Simple slope analyses showed that the effect of relative volunteer rate was significant for weak players ($b = 1.828$, $SE = 0.466$, $df = 119.65$, $t = 3.923$, $p < .001$) but not for strong players ($b = -0.572$, $SE = 0.625$, $df = 75.63$, $t = 0.915$, $p = .363$). These results indicate that overall, weak players experienced lower satisfaction than strong players. In addition, this tendency was more salient when their group deviated from group-level equity and they incurred greater costs than strong players.

Study 3

We conducted Study 3 to test two hypotheses to examine the mechanisms underlying weak players' deviation from equity. We preregistered the aim, the experimental design, and the sample size of this study prior to data collection (https://aspredicted.org/37H_RJ7). In the preregistration, we referred to equity as "net-benefit equality," equality as "output equality," the goal-coordination-failure hypothesis as the "preference-misunderstanding hypothesis," and the action-coordination-failure hypothesis as the "coordination-failure hypothesis."

Instructions for the Experiment

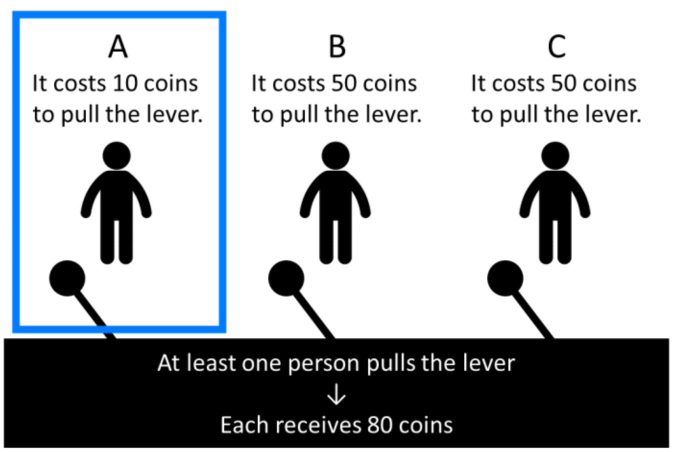
Introduction and Comprehension Questions

The introduction and comprehension questions were presented in the same way as in Study 2.

Assignment of a Role[9]

You have been matched with two other participants.

Your role: Player A



The number of rounds: 20–30 rounds

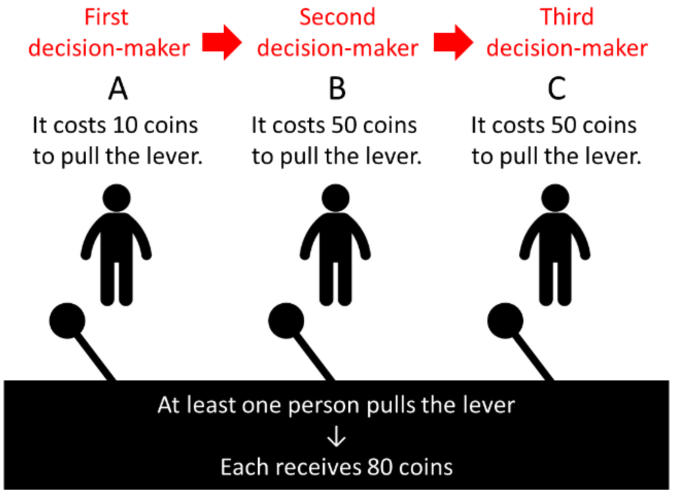
The procedure in each round:

1. Player A decides whether to pull the lever or not first.
2. After seeing Player A's choice, Player B decides whether to pull the lever or not.
3. After seeing Player A and B's choices, Player C decides whether to pull the lever or not.

---

[9] Here we present the instructions that Player A in the high asymmetry condition and the SP-first condition see as an example.

4. Once all players have made their decisions, they are informed about who pulled the lever and how much each player earned.



Neither your group members, your role (Player A), nor the decision-making order will change throughout the task.

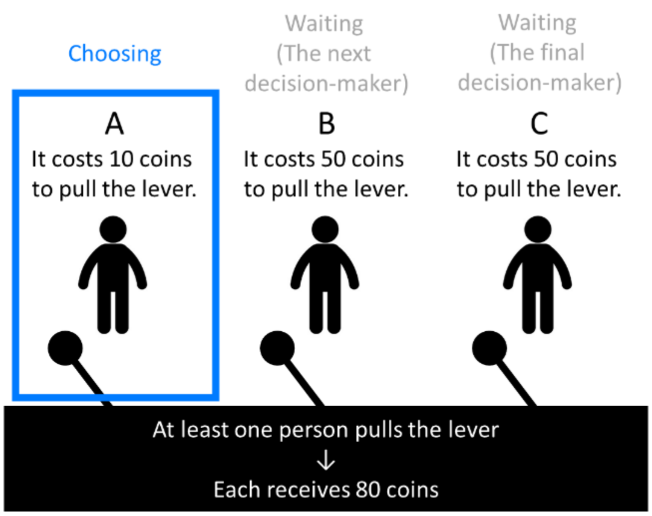
Decision-Making in Each Round[10]

Round 10

The Rules of the Task
● If at least one player in the group pulls the lever, all players receive 80 coins.
● Pulling the lever costs 10 coins for Player A, 50 coins for Player B, and 50 coins for Player C.

You are Player A.

[10] Here we present the instructions that Player A in the high asymmetry condition see in Round 10 as an example.



Please decide whether to pull the lever or not.

Player B will decide whether to pull the lever or not after seeing your choice.

Please decide within 90 seconds.

Pull the lever

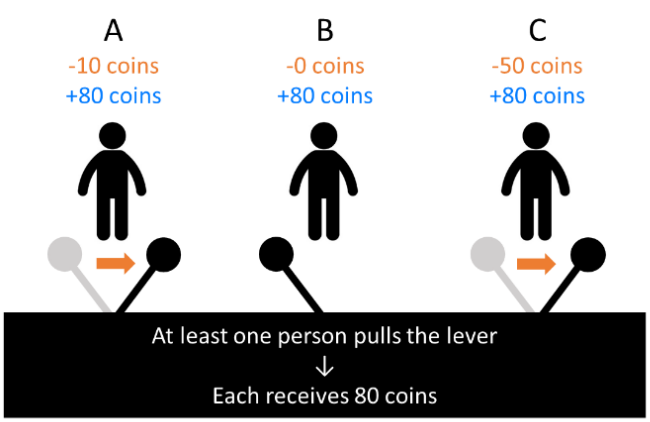
Do not pull the lever

Result Announcement in Each Round[11]

Result of Round 10

Players A and C have chosen to pull the lever.

Since at least one player has pulled the lever, all players receive 80 coins each.



[11] Here we present the instructions that Player A in the high asymmetry condition see in Round 10 if Players A and C have decided to volunteer as an example.

The number of coins each player has earned in this round:
Player A: 70 coins (- 10 coins + 80 coins)
Player B: 80 coins (- 0 coins + 80 coins)
Player C: 30 coins (- 50 coins + 80 coins)
Total: 180 coins

The number of times each player has pulled the lever in this and the previous rounds:
Player A: 8 times
Player B: 1 time
Player C: 5 times

The number of coins each player has earned in this and the previous rounds:
Player A: 720 coins
Player B: 750 coins
Player C: 550 coins
Total: 2020 coins

Survey[12]

Participants were presented with the same questions in Study 2. In addition, they answered the following questions in Study 3.

During the task, you were presented with results as follows. Which part did you look at most often?

[12] Here we present the instructions in the high asymmetry condition as an example.

Players A, B, and C have chosen to pull the lever.
Since at least one player has pulled the lever, all players receive 80 coins each.

The number of coins each player has earned in this round:
Player A: 70 coins (- 10 coins + 80 coins)
Player B: 30 coins (- 50 coins + 80 coins)
Player C: 30 coins (- 50 coins + 80 coins)
Total: 130 coins

The number of times each player has pulled the lever in this and the previous rounds:

$$\left.\begin{array}{l}\text{Player A: 1 time}\\ \text{Player B: 1 time}\\ \text{Player C: 1 time}\end{array}\right\}①$$

The number of coins each player has earned in this and the previous rounds:

$$\left.\begin{array}{l}\text{Player A: 70 coins}\\ \text{Player B: 30 coins}\\ \text{Player C: 30 coins}\end{array}\right\}②$$

$$\text{Total: 130 coins}\ \}③$$

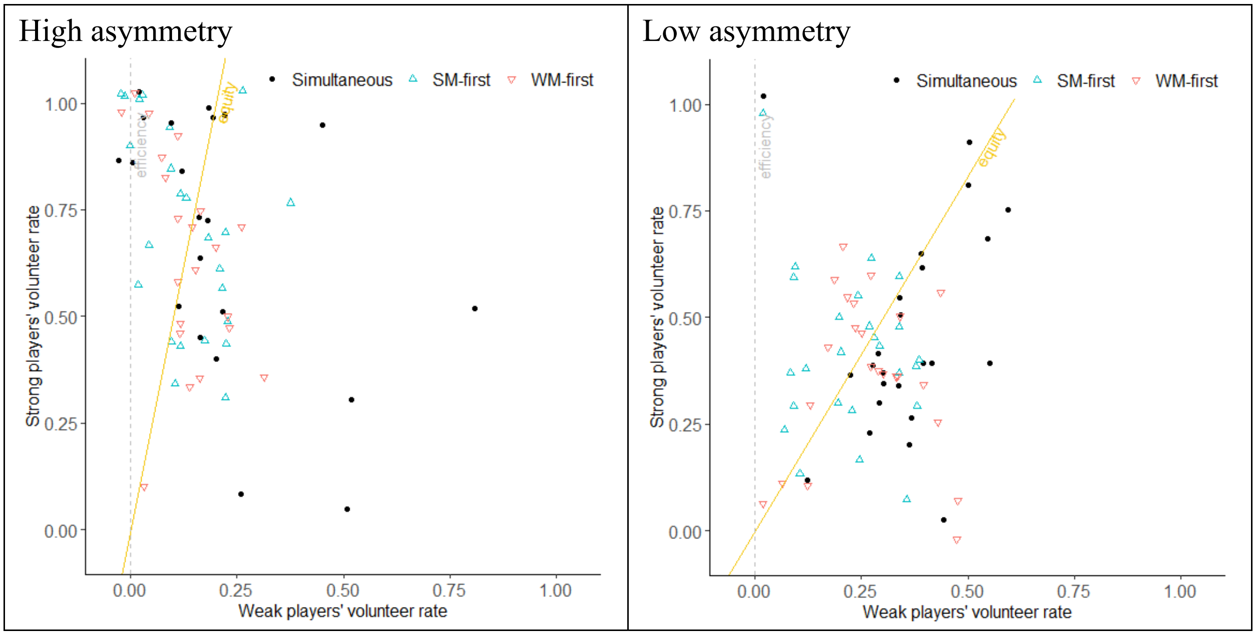
- 1. The number of times each player has pulled the lever in that and the previous rounds
- 2. The number of coins each player has earned in that and the previous rounds
- 3. The total number of coins the group has earned in that and the previous rounds

Additional Analyses

Volunteer Rates

Figure S3-1

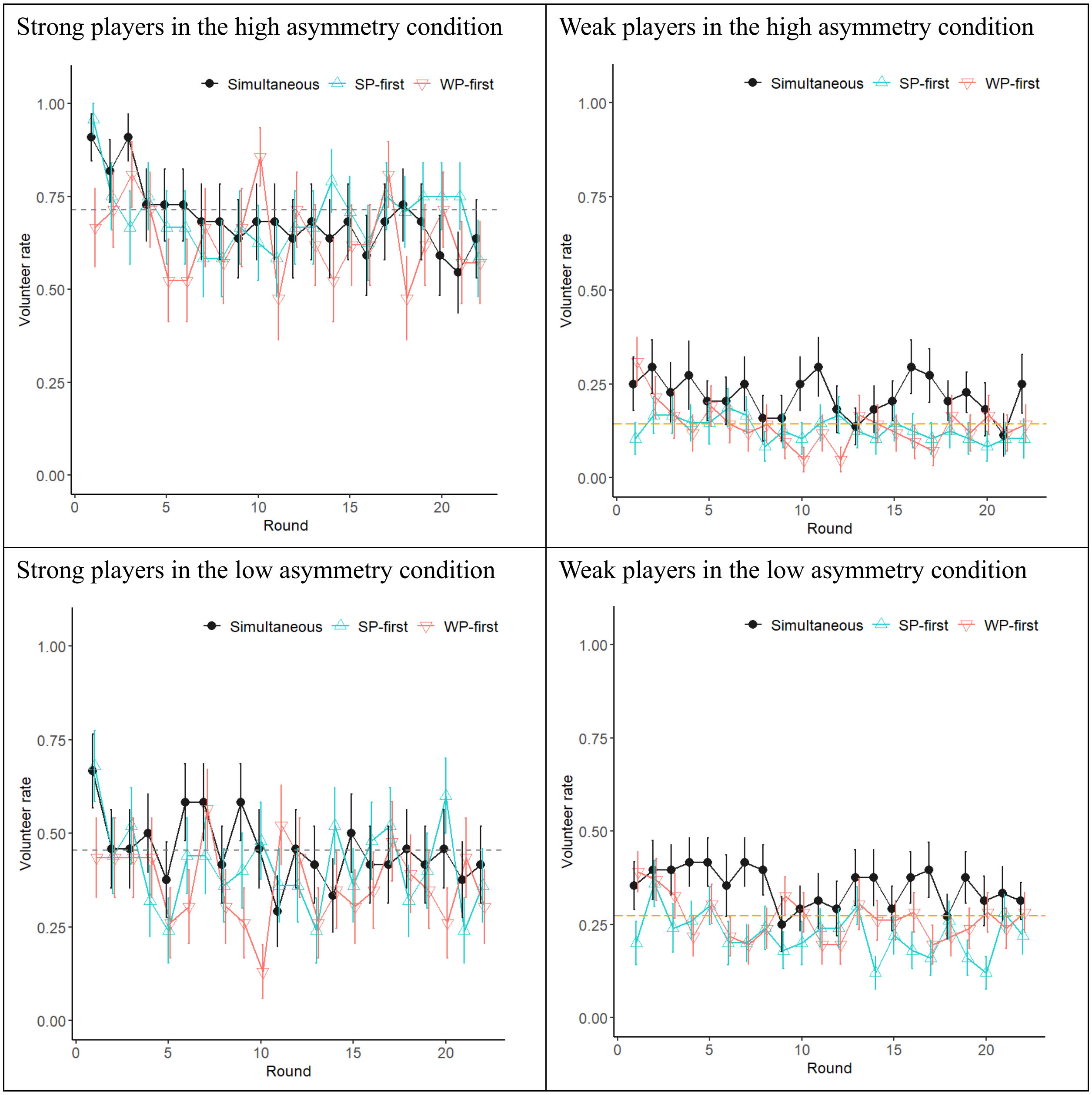
Volunteer rates of strong and weak players across groups (Study 3)



Note. Dots on the gray dashed lines represent groups where only strong players volunteered, while dots on the yellow lines represent groups where equitable burden-sharing was achieved.

Figure S3-2

Volunteer rates of strong and weak players per round (Study 3)



Note. Error bars indicate standard errors. The dashed gray lines indicate the volunteer rates that strong players should reach to realize equity (71.4% in the high asymmetry condition and 45.5% in the low asymmetry condition), and the long-dashed orange lines indicate the volunteer rates that weak players should reach to realize equity (14.3% in the high asymmetry condition and 27.3% in the low asymmetry condition).

Table S3-1

Linear mixed-effects model assessing the effects of experimental conditions on weak players' volunteer rates (Study 3)

	b	*SE*	*df*	*t*	*p*
Intercept	0.433	0.069	127	6.285	<.001
Order (simultaneous = 0)					
SP-first	-0.182	0.108	127	-1.696	0.092
WP-first	-0.215	0.104	127	-2.072	0.040
Asymmetry degree (high = 0, low = 1)	-0.127	0.088	127	-1.440	0.152
The strong player's volunteer rates	-0.308	0.091	127	-3.371	0.001
Order (SP-first) × Asymmetry degree	0.163	0.135	127	1.208	0.229
Order (WP-first) × Asymmetry degree	0.187	0.131	127	1.424	0.157
Order (SP-first) × The strong player's volunteer rates	0.132	0.146	127	0.911	0.364
Order (WP-first) × The strong player's volunteer rates	0.182	0.146	127	1.249	0.214
Asymmetry degree × The strong player's volunteer rates	0.406	0.141	127	2.880	0.005
Order (SP-first) × Asymmetry degree × The strong player's volunteer rates	-0.388	0.225	127	-1.725	0.087
Order (WP-first) × Asymmetry degree × The strong player's volunteer rates	-0.315	0.230	127	-1.366	0.174

Note. The model was specified as follows: Weak players' volunteer rates ~ order (simultaneous, SP-first, WP-first) * asymmetry degree (high and low) * the strong player's volunteer rate + (1 | groups).

Analyses Without the First-Round Data

Figure S3-2 shows that volunteer rates tend to be high, particularly in the first round of the games. To confirm that the conclusions remained consistent with and without first-round data, we conducted one-sample two-tailed sign-tests, excluding data from the first round. The results indicated no difference in the conclusions drawn from the analyses with or without the first-round data.

The additional analysis revealed that, in the simultaneous condition, strong players' volunteer rates aligned with equity, and weak players' volunteer rates were higher than the level of equity. The mean volunteer rate of strong players in the high asymmetry condition was 68.4% (95% CI [0.547, 0.821]; median 76.2%, 95% CI [0.476, 0.952]), and this was not significantly different from the level of equity (71.4%) (z = 0.224, p = .824, g = 0.050). Likewise, the mean volunteer rate of strong players in the low asymmetry condition was 44.6% (95% CI [0.343, 0.550]; median 38.1%, 95% CI [0.333, 0.571]), and this was not significantly different from the level of equity (45.5%) (z = 1.021, p = .308, g = 0.125). The mean volunteer rate of weak players in the high asymmetry condition was 21.8% (95% CI [0.129, 0.306]; median 17.9%, 95% CI [0.095, 0.238]), which was higher than the level of equity (14.3%) but failed to reach the conventional significance level (z = 0.873, p = .383, g = 0.119). The mean volunteer rate of weak players in the low asymmetry condition was 35.0% (95% CI [0.292, 0.408]; median 33.3%, 95% CI [0.286, 0.405]), and this was significantly higher than the level of equity (27.3%) (z = 2.654, p = .007, g = 0.292).

In the WP-first condition, strong and weak players' volunteer rates aligned with equity, consistent with the action-coordination-failure hypothesis. The mean volunteer rate of strong players in the high asymmetry condition was 63.7% (95% CI [0.520, 0.754]; median 66.7%, 95% CI [0.429, 0.857]), and this was not significantly different from the level of equity (71.4%) (z = 0.707, p = .481, g = 0.111). Likewise, the mean volunteer rate of strong players in the low asymmetry condition was 36.2% (95% CI [0.275, 0.445]; median 38.1%, 95% CI [0.286, 0.476]), and this was not significantly different from the level of equity (45.5%) (z = 0.834, p = .405, g = 0.109). The mean volunteer rate of weak players in the high asymmetry condition was 12.9% (95% CI [0.095, 0.164]; median 14.3%, 95% CI [0.071, 0.167]), which was not significantly different from the level of equity (14.3%) (z = 0.236, p = .815, g = 0.056), and the mean volunteer rate of weak players in the low asymmetry condition was 25.9% (95% CI [0.204, 0.314]; median 26.2%, 95% CI [0.190, 0.310]), which was not significantly different from the level of equity (27.3%) (z = 0.834, p = .405, g = 0.109).

Similarly, in the SP-first condition, strong and weak players' volunteer rates aligned with equity. The mean volunteer rate of strong players in the high asymmetry condition was 68.1% (95% CI [0.579, 0.782]; median 66.7%, 95% CI [0.524, 0.905]), and this was not significantly different from the level of equity (71.4%) (z = 0.204, p = .839, g = 0.042). The mean volunteer rate of strong players in the low asymmetry condition was 40.0% (95% CI [0.321, 0.479]; median 38.1%, 95% CI [0.333, 0.476]), and this was not significantly different from the level of equity (45.5%) (z = 1.200, p = .230, g = 0.140). The mean volunteer rate of weak players in the high asymmetry condition was 13.0% (95% CI [0.085, 0.174]; median 11.9%, 95% CI [0.048, 0.214]), which was not significantly different from the level of equity (14.3%) (z = 0.417, p = .678, g = 0.065). The mean volunteer rate of weak players in the low asymmetry condition was 22.3% (95% CI [0.177, 0.269]; median 23.8%, 95% CI [0.119, 0.286]), and this was not significantly different from the level of equity (27.3%) (z = 1.200, p = .230, g = 0.140).

Coordination of Action

Figure S3-3 presents the proportion of groups in which nobody, one player, or more than one player volunteered in each round. We used a linear mixed-effects model with a random intercept and slope for each group to examine whether the likelihood of only one member volunteering (i.e., coordination success) increased over time. The model included time, asymmetry degree, order, and their interactions as independent variables, and whether groups had only one volunteer as the dependent variable. As Table S3-2 shows, the effect of time, the interaction effect between time and asymmetry degree, and the interaction effect between time and order were not significant. These results imply that the success rate of coordination did not significantly increase over time in any condition. In contrast, there was a significant difference in the success rate of coordination between the simultaneous and SP-first conditions and between the simultaneous and WP-first conditions; participants succeeded in coordination more in the SP-first and WP-first conditions than in the simultaneous condition.

Figure S3-3

Proportion of groups in which nobody, one player, or more than one player volunteered per round (Study 3)

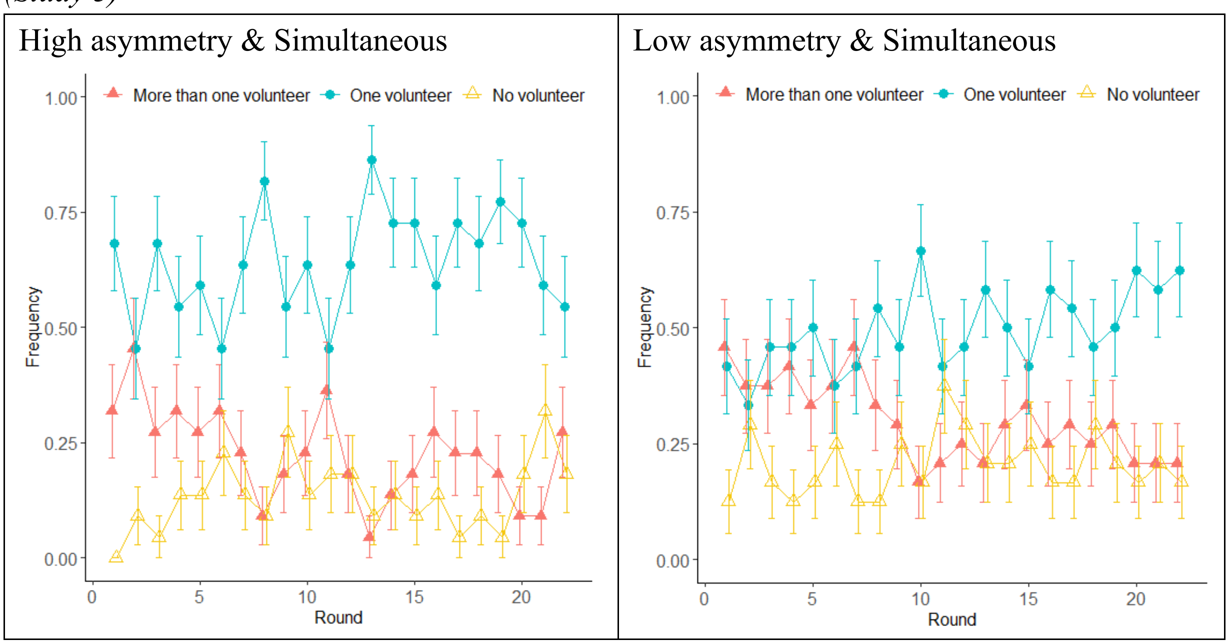
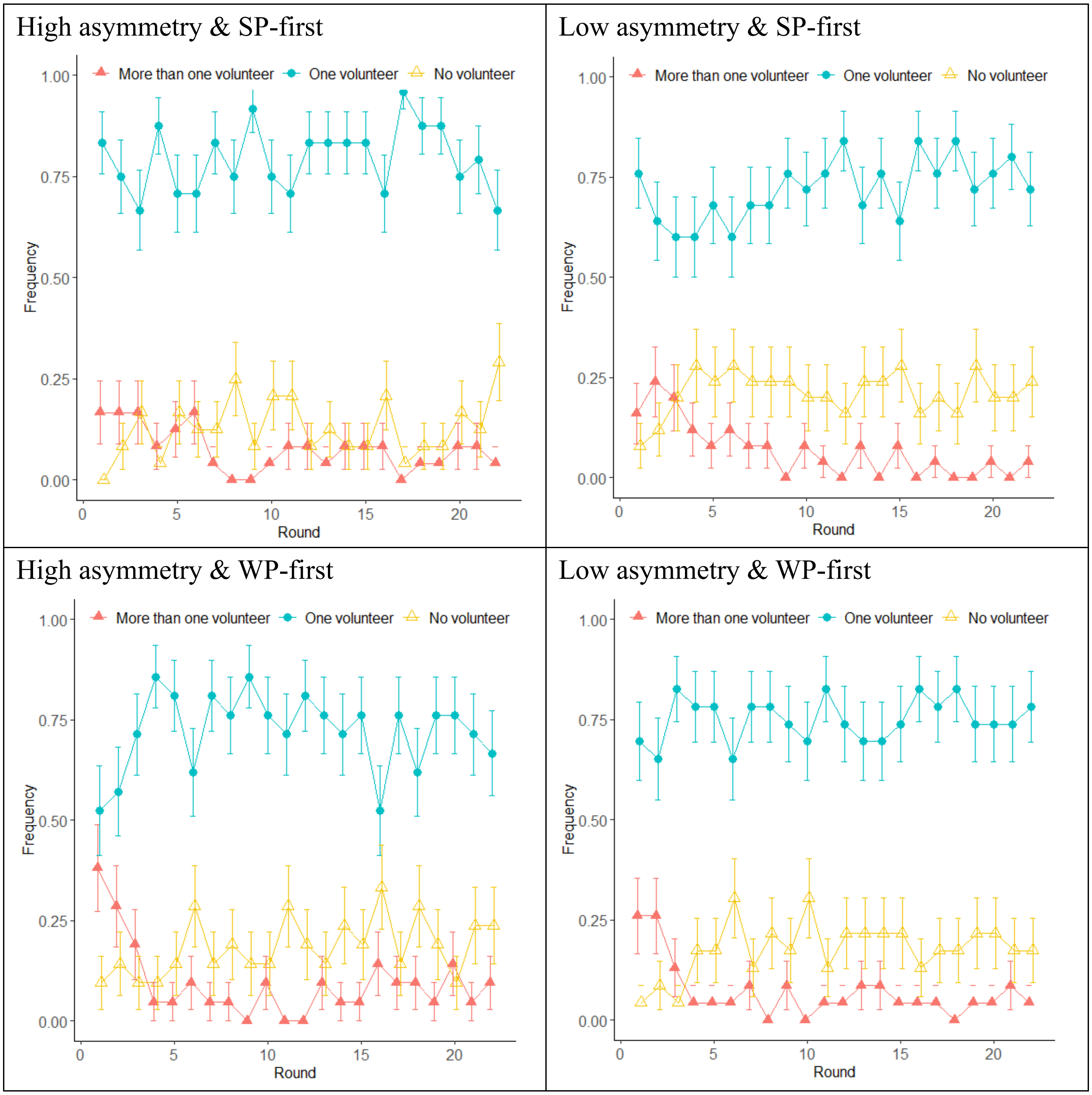


Figure S3-3 (continued)



Note. Error bars indicate standard errors of the mean.

Table S3-2

Logistic regression analyses assessing the effect of time and experimental conditions on the likelihood of only one member volunteering (Study 3)

	Estimate	*SE*	*z*	*p*
Intercept	0.229	0.264	0.869	0.385
Time	0.030	0.020	1.474	0.140
Order (simultaneous = 0)				
SP-first	1.075	0.322	3.335	0.001
WP-first	1.247	0.337	3.696	0.000
Asymmetry degree (high = 0, low = 1)	-0.571	0.269	-2.121	0.034
Time × Order (SP-first)	0.017	0.025	0.688	0.492
Time × Order (WP-first)	0.002	0.026	0.076	0.940
Time × Asymmetry degree	0.018	0.021	0.849	0.396

Collective Payoff

Figure S3-4 presents the normalized average collective payoff per round, with values ranging from 0 (lowest possible payoff) to 1 (highest possible payoff). We used a linear mixed-effects model with a random intercept and slope for each group to examine whether the normalized collective payoffs increased over time. The model included time, asymmetry degree, order, and their interactions as independent variables, and the normalized collective payoff as the dependent variable. As Table S3-3 shows, the effect of time, the interaction effect between time and asymmetry degree, and the interaction effect between time and order were not significant. These results indicate that collective payoffs did not significantly increase over time in any condition.

Figure S3-4

Normalized collective payoff per round (Study 3)

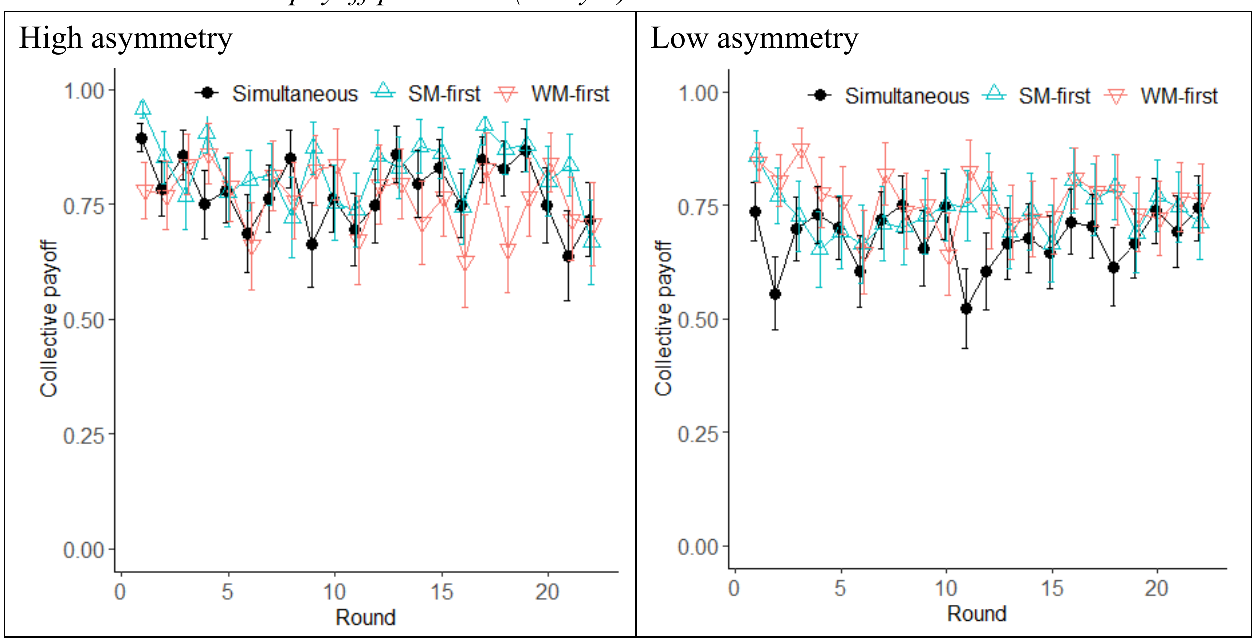


Table S3-3

Logistic regression analyses assessing the effect of time and experimental conditions on the normalized collective payoff (Study 3)

	b	*SE*	*df*	*t*	*p*
Intercept	0.777	0.035	196.4	22.298	<.001
Time	-0.002	0.002	196.4	-0.647	0.519
Asymmetry degree (high = 0, low = 1)	-0.088	0.034	196.4	-2.570	0.011
Order (simultaneous = 0)					
SP-first	0.054	0.042	196.4	1.291	0.198
WP-first	0.065	0.043	196.4	1.516	0.131
Time × Order (SP-first)	0.000	0.003	196.4	-0.049	0.961
Time × Order (WP-first)	-0.002	0.003	196.4	-0.830	0.408
Time × Asymmetry degree	0.002	0.002	196.4	0.877	0.382

Satisfaction

At the end of the games, participants rated their satisfaction with the results on a 5-point scale. To examine how satisfaction was influenced by participants' roles and relative volunteer rates (the number of times the strong player volunteered divided by the total number of times all group members volunteered), we used a linear mixed-effects model with a random intercept and slope for each group. The model included role, relative volunteer rate, their interaction, asymmetry degree, and order as independent variables, and satisfaction as the dependent variable. As presented in Table S3-4, the results showed the positive effect of role (b = 1.620, SE = 0.292, df = 268.63, t = 5.542, p < .001), the positive effect of relative volunteer rate (b = 1.857, SE = 0.416, df = 150.00, t = 4.465, p < .001), and their interaction effect (b = −3.118, SE = 0.487, df = 268.63, t = 6.406, p < .001). Simple slope analyses showed that the effect of relative volunteer rate was significantly positive for weak players (b = 1.857, SE = 0.416, df = 150.00, t = 4.465, p < .001) and significantly negative for strong players (b = −1.261, SE = 0.521, df = 171.71, t = 2.419, p = .017). These results indicate that, first, weak players generally experienced lower satisfaction than strong players. Second, this tendency was more salient when their group deviated from group-level equity and they incurred greater costs than strong players. Finally, strong players also experienced lower satisfaction when their group deviated from group-level equity and they incurred greater costs than weak players.

Table S3-4

Linear mixed-effects model assessing the effects of role and relative volunteer rate on satisfaction (Study 3)

	b	*SE*	*df*	*t*	*p*
Intercept	2.482	0.304	105	8.163	<.001
Role (weak = 0, strong = 1)	1.620	0.292	269	5.542	<.001
Relative volunteer rate	1.857	0.416	150	4.465	<.001
Asymmetry degree (high = 0, low = 1)	-0.184	0.178	133	-1.033	0.304
Order (simultaneous = 0)					
SP-first	-0.249	0.183	134	-1.357	0.177
WP-first	-0.038	0.185	134	-0.208	0.836
Role × Relative volunteer rate	-3.118	0.487	269	-6.406	<.001

Supplemental Study S2: Pilot Study

We conducted this pilot study prior to Study 3. Like Study 3, Study S2 addressed the goal-coordination-failure hypothesis and the action-coordination-failure hypothesis by comparing three conditions regarding decision-making order: simultaneous, SP-first, and WP-first. While participants in Study 3 played a game in a three-person group, those in Study S2 played a game in a dyad that consisted of one strong player and one weak player. We examined dyads because it would allow for a more direct examination of the effect of decision-making order. We preregistered the aim, the experimental design, and the sample size of Study S2 prior to data collection (https://aspredicted.org/DBS_9G8). In the preregistration, we referred to equity as "equal burden" and equality as "equal contribution."

Method

A total of 342 participants (173 women, 168 men, one unidentified; *M* age = 41.05, *SD* age = 10.01) participated. We retained data from 326 participants (163 women, 163 men; M_{age} = 41.00, *SD* = 9.92) after discarding eight dyads based on the same exclusion criteria used in Study 2. Participants received 550 yen for their participation. Those who earned 1300 coins or more in the experiment (*N* = 198) received 30 yen as a bonus. The average number of coins earned was 1333.87 (*SD* = 398.92).

The procedure was the same as in Study 3, except that participants played the game in a dyad for 24 rounds. In the simultaneous condition, participants made decisions simultaneously with their partner. In the SP-first (WP-first) condition, the strong (weak) player made their decision first, and then the weak (strong) player made their decision after being informed of the strong (weak) player's decision in each round. After completing the 24 rounds of the game, participants answered how satisfied they and their partner were with the result of the game, how many times they and their partner thought each player should have pulled the lever, and to which information they paid the most attention during the game.

Results

Table SS2-1 presents the overall volunteer rate of strong and weak players in each condition and whether they deviated from equity. As shown in the table, weak players' volunteer rates in the WP-first condition aligned with equity, consistent with the action-coordination-failure hypothesis. However, weak players' volunteer rates in the simultaneous condition also aligned with equity. In other words, the findings in Study 2 were not replicated. We also examined whether the difference in weak players' volunteer rates between the simultaneous and WP-first conditions was significant. We conducted a regression analysis and found no significant difference between the simultaneous and WP-first conditions (Table SS2-2).

One possible explanation for weak players' volunteer rates aligning with equity in the simultaneous condition is that the dyadic game substantially reduced the difficulty of the coordination of action; weak players may have needed less coordination effort in Study S2, when there was only one weak player in each dyad, than in Study 2, when there were two weak players in each group. Although this explanation is consistent with the action-coordination-failure hypothesis, it is hard to conclude that the hypothesis was supported because of the replication failure. Therefore, we conducted the same experiment in a three-person group setting in Study 3 to examine whether weak players' volunteer rates in the WP-first condition align with equity while those in the simultaneous condition are higher than the level of equity.

Table SS2-1

Volunteer rate per condition and whether it deviated from equity (Study S2)

(a) High asymmetry

	Strong players		Weak players	
	Mean (95% CI) and Median (95% CI)	Deviation from equity (83.3%)	Mean (95% CI) and Median (95% CI)	Deviation from equity (16.7%)
Simultaneous	76.2% (0.663, 0.861) 83.3% (0.625, 1.000)	z = 0.204, p = .839, g = 0.042	26.1% (0.166, 0.356) 20.8% (0.125, 0.292)	z = 1.200, p = .115, g = 0.140
SP-first	78.0% (0.693, 0.866) 83.3% (0.792, 0.875)	z = -0.213, p = .832, g = 0.045	17.9% (0.117, 0.240) 16.7% (0.125, 0.167)	z = -0.873, p = .905, g = 0.119
WP-first	76.9% (0.693, 0.845) 83.3% (0.750, 0.875)	z = 0.213, p > .999, g < 0.001	17.3% (0.119, 0.226) 16.7% (0.125, 0.166)	z = -1.179, p = .952, g = 0.167

(b) Low asymmetry

	Strong players		Weak players	
	Mean (95% CI) and Median (95% CI)	Deviation from equity (62.5%)	Mean (95% CI) and Median (95% CI)	Deviation from equity (37.5%)
Simultaneous	60.0% (0.478, 0.722) 58.3% (0.500, 0.750)	z = -0.400, p = .690, g = 0.060	36.3% (0.260, 0.466) 33.3% (0.250, 0.458)	z = -0.417, p = .798, g = 0.065
SP-first	59.7% (0.501, 0.692) 58.3% (0.542, 0.667)	z = -0.800, p = .424, g = 0.100	27.7% (0.204, 0.349) 31.3% (0.125, 0.375)	z = -2.085, p = .995, g = 0.239
WP-first	62.2% (0.556, 0.688) 62.5% (0.500, 0.708)	z = -0.417, p = .678, g = 0.065	32.7% (0.259, 0.395) 37.5% (0.292, 0.417)	z = -0.224, p = .748, g = 0.050

Note. "Deviation from equity" of strong players indicates the results of one-sample two-tailed sign-tests. A significant result indicates that strong players did not act according to equity. "Deviation from equity" of weak players indicates the results of one-sample one-tailed sign-tests. A significant result indicates that weak players volunteered more times than necessary to realize equity as in Study 2.

Table SS2-2

Linear mixed-effects model assessing the effects of experimental conditions on weak players' volunteer rates (Study S2)

	b	*SE*	*df*	*t*	*p*
Intercept	0.549	0.115	151	4.767	<.001
Order (simultaneous = 0)					
SP-first	-0.200	0.172	151	-1.158	0.249
WP-first	0.042	0.183	151	0.232	0.817
Asymmetry degree (high = 0, low = 1)	-0.345	0.143	151	-2.417	0.017
The strong player's volunteer rates	-0.378	0.144	151	-2.627	0.009
Order (SP-first) × Asymmetry degree	0.393	0.213	151	1.843	0.067
Order (WP-first) × Asymmetry degree	0.174	0.244	151	0.713	0.477
Order (SP-first) × The strong player's volunteer rates	0.159	0.214	151	0.743	0.458
Order (WP-first) × The strong player's volunteer rates	-0.166	0.230	151	-0.723	0.471
Asymmetry degree × The strong player's volunteer rates	0.644	0.192	151	3.359	0.001
Order (SP-first) × Asymmetry degree × The strong player's volunteer rates	-0.626	0.287	151	-2.180	0.031
Order (WP-first) × Asymmetry degree × The strong player's volunteer rates	-0.250	0.339	151	-0.736	0.463

Note. The model was specified as follows: Weak players' volunteer rates ~ order (simultaneous, SP-first, and WP-first) * asymmetry degree (high and low) * the strong player's volunteer rate.

Supplemental Study S3: Examining an Alternative Explanation

Studies 3 and S2 tested the action-coordination-failure hypothesis and the goal-coordination-failure hypothesis to explore the mechanisms underlying the discrepancy between weak players' volunteer rates and the equity principle. While these hypotheses focus on interpersonal factors, Study S3 examined an alternative explanation regarding an intrapersonal factor. Specifically, Study S3 tested the calculation-failure hypothesis, which posits that weak players deviate from the equity principle due to the difficulty of calculating how frequently each player should volunteer to achieve equity. We preregistered the aim, the experimental design, and the sample size of this study prior to data collection (https://aspredicted.org/8R2_Y8B). Although we initially planned to measure participants' personality traits, this measurement was not included in the experiment.

Sharing indivisible objects generally involves more limitations than sharing divisible objects (Brams & Taylor, 1996). For instance, while 100 dollars can be split between two people, a car cannot be shared in the same manner. In the context of volunteer's dilemmas, a task that requires one member's contribution cannot be divided equitably within a single round. Consider the game presented in Figure 1 in the main text. It is impossible to allocate 5/11 of the task to Player A, 3/11 to Player B, and 3/11 to Player C within a round. Although equitable burden-sharing is achievable over repeated rounds, it can be challenging because it requires calculating how frequently each player needs to volunteer to realize equity. Specifically, in the game of Figure 1, players need to calculate that the frequency ratio of Players A, B, and C should be 5:3:3 to realize equity.

To test the calculation-failure hypothesis, we conducted the asymmetric volunteer's dilemma games. In addition to comparing the high and low asymmetry conditions, we compared two conditions that manipulated the necessity of calculation. In the information-present condition, players were informed of each group member's cumulative net benefits at the end of each round. This information assisted them in acting according to equity without complex calculations. Specifically, players were able to realize equity only by scanning the information and volunteering when their cumulative net benefits exceeded those of other group members. Conversely, in the information-absent condition, players were not presented with information about their group members' cumulative net benefits; they needed to independently calculate how frequently each player should volunteer to realize equity. The calculation-failure hypothesis predicts that the volunteer rates in the information-present condition will align with equity, while those in the information-absent condition will deviate from equity, as observed in Study 2.

Method

A total of 318 participants (163 women, 151 men, two unidentified; M_{age} = 40.55, SD = 9.84) participated. We retained data from 312 participants (160 women, 150 men, two unidentified; M_{age} = 40.44, SD = 9.84) after discarding two groups based on the same exclusion criteria used in Study

2. Participants received 500 yen for their participation. Those who earned 1200 coins or more in the experiment (*N* = 131) received 30 yen as a bonus. The average number of coins earned was 1145.83 (*SD* = 307.37).

As in Study 2, participants read the rules of the asymmetric volunteer's dilemma game, answered comprehension questions, matched with two other participants, and played the game for 22 rounds. Groups were assigned to either the high or low asymmetry condition and either the information-absent or information-present condition. In the information-absent condition, participants were provided with the following information at the end of each round: who had pulled the lever in the round, how many tokens each player had earned in the round, and the total number of tokens the group had earned in the round. Participants in the information-present condition were additionally provided with information about the previous rounds: the cumulative number of times that each player had pulled the lever (which assists in achieving superficial equality), the cumulative number of tokens that each player had earned (which assists in achieving equity), and the cumulative number of tokens that the group as a whole had earned (which assists in achieving efficiency). After the game, participants answered how satisfied they were with the result of the game, how many times they thought each player should have pulled the lever, and to which information they paid attention during the game.

Results

We examined whether there was a significant difference in weak players' volunteer rates between the information-absent and information-present conditions. We analyzed weak players' volunteer rates using a linear mixed-effects model with a random intercept for each group. The independent variables were information (absent and present), asymmetry degree (high and low), the strong player's volunteer rate, and their interactions. The results showed no significant effect of information (Table SS3-1), which is against the calculation-failure hypothesis. While we found a significant interaction effect among the three variables, a simple slope analysis did not indicate any significant effect of information. Instead, it indicated that the effect of the strong player's volunteer rate was significantly negative only in the information-absent condition and the low asymmetry condition.

Table SS3-1

Linear mixed-effects model assessing the effects of experimental conditions on weak players' volunteer rates (Study S3)

	b	*SE*	*df*	*t*	*p*
Intercept	0.230	0.083	96	2.755	0.007
Information (absent = 0, present = 1)	0.102	0.123	96	0.832	0.408
Asymmetry degree (high = 0, low = 1)	0.189	0.103	96	1.831	0.070
The strong player's volunteer rates	0.020	0.111	96	0.182	0.856
Information × Asymmetry degree	-0.291	0.148	96	-1.963	0.053
Information × The strong player's volunteer rates	-0.160	0.172	96	-0.930	0.355
Asymmetry degree × The strong player's volunteer rates	-0.268	0.155	96	-1.732	0.087
Information × Asymmetry degree × The strong player's volunteer rates	0.510	0.229	96	2.221	0.029

Note. The model was specified as follows: Weak players' volunteer rates ~ Information (absent and present) * asymmetry degree (high and low) * the strong player's volunteer rate.

Latent Norm Index

Since previous studies on repeated asymmetric volunteer's dilemmas examined the latent norm index (LNI) (Diekmann & Przepiorka, 2016; Przepiorka et al., 2021, 2022), we examined it as well. The LNI, developed by Diekmann and Przepiorka (2016), quantifies the frequency of a behavioral pattern (or convention) that may emerge in repeated volunteer's dilemmas. A detailed explanation of the LNI is as follows:

> A sequence of m interactions with n actors is specified by $(x_1, x_2, \ldots, x_i, \ldots, x_n)_1, \ldots, (x_1, x_2, \ldots, x_i, \ldots, x_n)_j, \ldots, (x_1, x_2, \ldots, x_i, \ldots, x_n)_m$, where $x_i = 0$ if actor i chose D and $x_i = 1$ if actor i chose C. We denote efficient outcomes by the "position" of the single cooperative actor, that is, $(1, 0, \ldots, 0) = 1, (0, 1, 0, \ldots, 0) = 2, \ldots, (0, \ldots, 0, 1) = n$, and denote inefficient outcomes, where either all actors chose D or more than one actor chose C, by -1. Moreover, with regard to turn-taking, we denote the size of the subset of actors taking turns by $h = 1, 2, \ldots, n$. For example, in a group of size $n = 3$, where actors 1 and 3 take turns in volunteering while actor 2 free-rides, actors 1 and 3 are in the subset of turn-taking actors, and thus, $h = 2$. Correspondingly, $h = 1$ denotes solitary volunteering. We define $\lambda_{h,n}$ as the length of a type-h sequence in a group of size n and the latent norm index as $\mathrm{LNI}_{h,n} = 100 \times \lambda_{h,n}/m$, where an observed sequence registered by the index should be at least as long as the number of actors in the group. This last restriction makes it harder to identify behavioral patterns in larger groups but at the same time helps avoid the measurement of pseudo patterns. In short, the $\mathrm{LNI}_{h,n}$ is the percentage of interactions of a type-h sequence and ranges between 0 and 100.
>
> The following example illustrates how the LNI is applied on two made-up series of $m = 10$ interactions of $n = 3$ actors: 2 1 1 3 2 1 –1 1 2 3 and –1 2 1 2 1 2 2 2 1 3. Recall that –1 denotes an interaction in which either all actors chose D or more than one actor chose C and therefore is not counted as part of a sequence. In the first series, there is one 1-sequence of length two (1 1), and there are six 2-sequences of length two (2 1, 1 3, 3 2, 2 1, 1 2, and 2 3). Since the length of each of these sequences is smaller than n, $\mathrm{LNI}_{1,3}$ and $\mathrm{LNI}_{2,3}$ are both zero. The first series also contains one 3-sequence of length four (1 3 2 1) and another 3-sequence of length three (1 2 3). Since the length of each of these sequences is larger or equal to n, $\mathrm{LNI}_{3,3} = 100 \times (4 + 3)/10 = 70$. The second series contains one 1-sequence of length three (2 2 2), one 2-sequence of length five (2 1 2 1 2), two 2-sequences of length two (2 1 and 1 3), which are not part

> of a longer 2-sequence, and one 3-sequence of length three (2 1 3). Hence, $\mathrm{LNI}_{1,3} = 100 \times 3/10 = 30$, $\mathrm{LNI}_{2,3} = 100 \times 5/10 = 50$, and $\mathrm{LNI}_{3,3} = 100 \times 3/10 = 30$. Note that, as in this example, sequences of different types can overlap but overlaps cannot be longer than n. (Diekmann & Przepiorka, 2016, pp. 1318–1319)

Table S4-1 summarizes the mean values of $\mathrm{LNI}_{1,3}$, $\mathrm{LNI}_{2,3}$, and $\mathrm{LNI}_{3,3}$ in Studies 2 and 3 in our work, along with Experiment 1 in Diekmann and Przepiorka (2016). These studies employed three-person repeated asymmetric volunteer's dilemma games, with the cost ratio of Players A, B, and C set at 10:50:50 in the high asymmetry condition and 30:50:50 in the low asymmetry condition. Although the LNI was not normally distributed (Figure S4-1), the means of $\mathrm{LNI}_{1,3}$, $\mathrm{LNI}_{2,3}$, and $\mathrm{LNI}_{3,3}$ across these studies revealed the following findings. First, consistent with Diekmann and Przepiorka (2016), $\mathrm{LNI}_{1,3}$—the frequency of solitary volunteering (i.e., a behavioral pattern where a single group member always volunteers while the others abstain)—was higher in the high asymmetry condition than in the low asymmetry condition. Conversely, $\mathrm{LNI}_{3,3}$—the frequency of three-person turn-taking (i.e., a behavioral pattern where all group members take turns in volunteering)—was higher in the low asymmetry condition than in the high asymmetry condition.

Second, we found that both $\mathrm{LNI}_{2,3}$—the frequency of two-person turn-taking (i.e., a behavioral pattern where the same two players take turns in volunteering)—and $\mathrm{LNI}_{3,3}$ were higher when players made decisions sequentially rather than simultaneously. These increases suggest that sequential decision-making made turn-taking easier. They may also indicate that players were not aiming for the most efficient outcome (where only the strong player consistently volunteers) when turn-taking was easy. However, it remains difficult to determine whether players were attempting to equalize net benefits within the group based on LNI. Therefore, in the main text, we focus on volunteer rates to examine whether participants acted in line with the equity principle.

Table S4-1

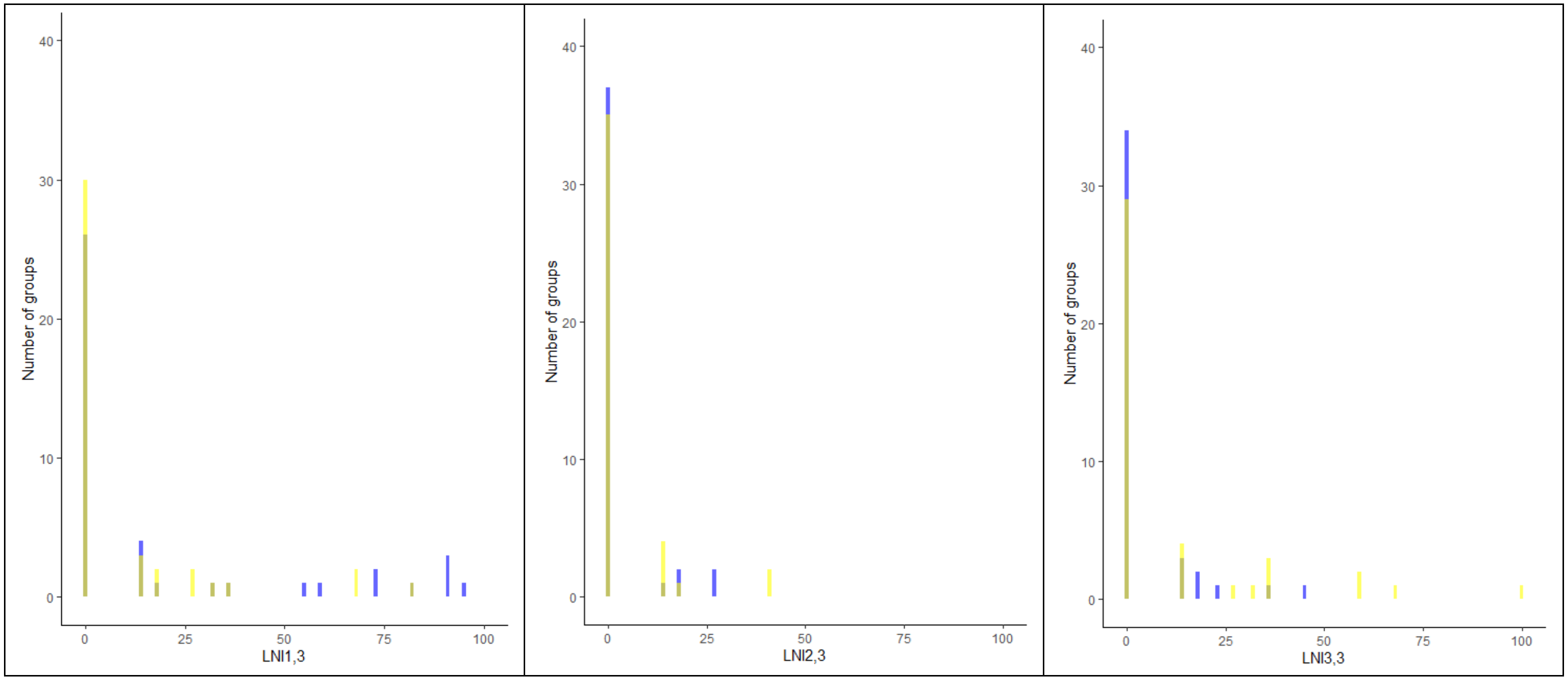
Mean of $LNI_{1,3}$, $LNI_{2,3}$, *and* $LNI_{3,3}$ *(Studies 2 and 3)*

				High asymmetry			Low asymmetry		
	Number of rounds	Number of groups	Decision-making	$LNI_{1,3}$	$LNI_{2,3}$	$LNI_{3,3}$	$LNI_{1,3}$	$LNI_{2,3}$	$LNI_{3,3}$
Diekmann & Przepiorka (2016)[a]	56	20	Simultaneous	61.6	0.5	2.1	32.9	2.0	15.7
Study 2	22	84	Simultaneous	20.2	2.5	4.3	10.0	3.7	12.1
Study 3 (Simultaneous condition)	22	46	Simultaneous	42.4	1.9	0.0	4.7	4.6	12.9
Study 3 (SP-first condition)	22	49	Sequential	41.5	18.8	11.9	9.8	22.0	27.3
Study 3 (WP-first condition)	22	44	Sequential	38.3	15.2	9.5	15.8	17.8	34.2

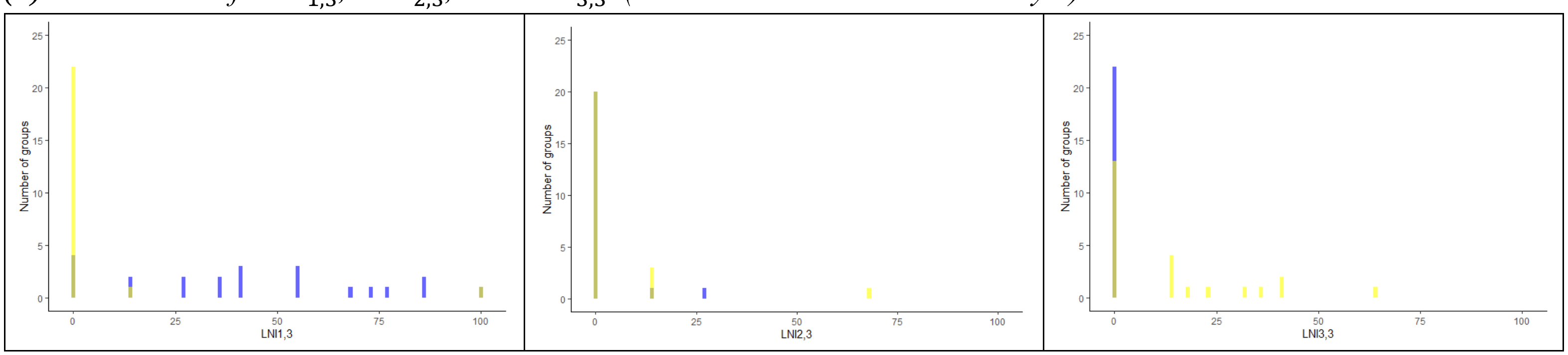
[a] Part 1 in Experiment 1

Figure S4-1

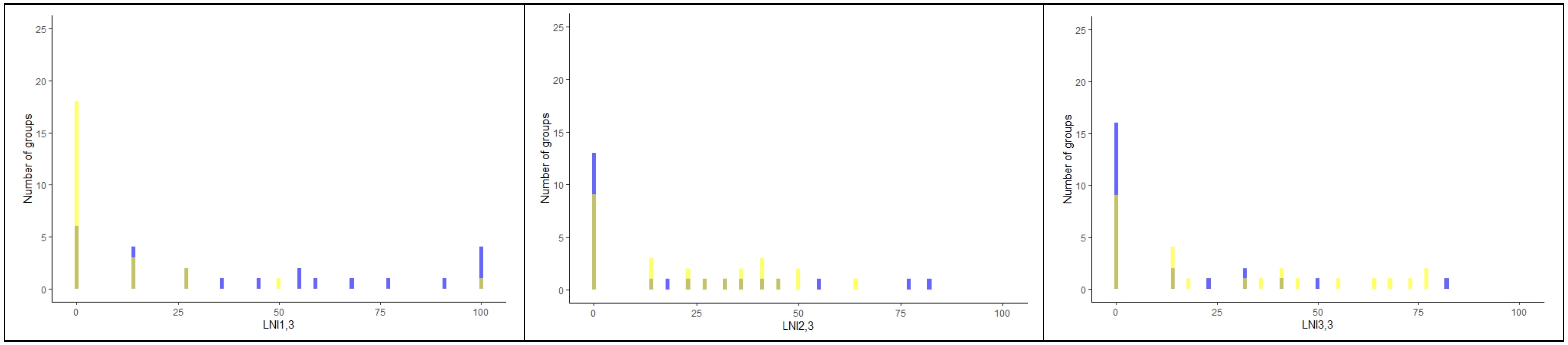
(a) Distribution of $LNI_{1,3}$*,* $LNI_{2,3}$*, and* $LNI_{3,3}$ *(Study 2)*



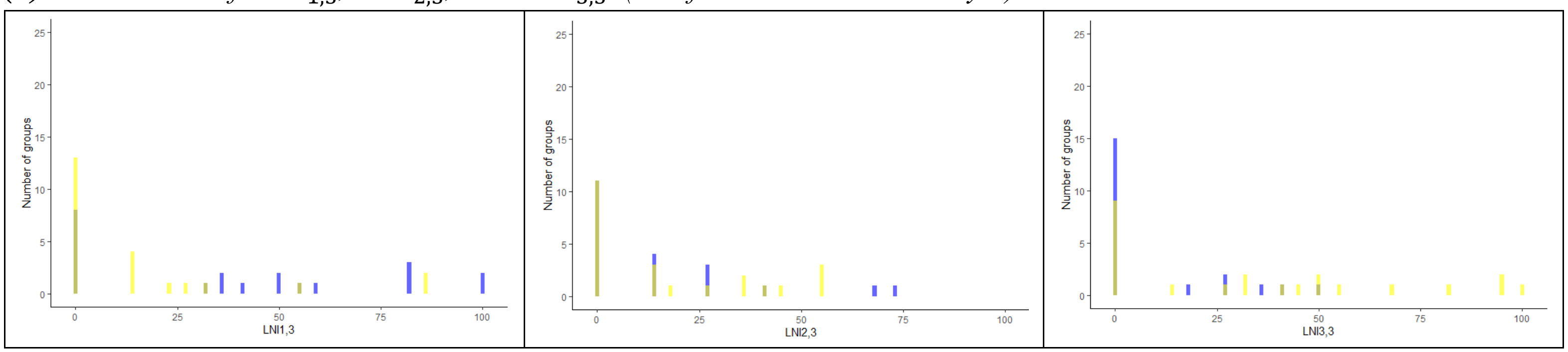
(b) Distribution of $LNI_{1,3}$*,* $LNI_{2,3}$*, and* $LNI_{3,3}$ *(Simultaneous condition in Study 3)*



(c) Distribution of $LNI_{1,3}$, $LNI_{2,3}$, *and* $LNI_{3,3}$ *(SP-first condition in Study 3)*



(d) Distribution of $LNI_{1,3}$, $LNI_{2,3}$, *and* $LNI_{3,3}$ *(WP-first condition in Study 3)*



Note. Blue bars indicate the number of groups in the high asymmetry condition and yellow bars indicate those in the low asymmetry condition.

Equity and Maximin Principles

This section shows that the net benefit of the least well-off player is higher under the equity principle than under the efficiency and equality principles in asymmetric volunteer's dilemmas. Suppose there is a group of $N \geq 2$, consisting of the strongest player whose volunteer cost is $K_S > 0$ and $N-1$ weaker players. Each weak player's volunteering cost is $K_w = K_S \times x_w$, where $w \in \{1, \dots, N-1\}$ and $x_1 \geq x_2 \geq \cdots \geq x_{N-1} > 1$. When efficiency is achieved, the net benefit of the least well-off (i.e., the strongest player) is calculated as:

$$NELW_{EF} = V \times R - K_S \times R,$$

where $V > K_w > K_S$ is a benefit that each player receives when at least one player volunteers, and $R \geq 2$ represents the number of rounds.

When equity, or the equality of net benefit, is achieved, the net benefit of the least well-off (i.e., everyone) is:

$$NELW_{NE} = V \times R - K_S \times \frac{R}{\frac{1}{x_1} + \frac{1}{x_2} + \cdots + \frac{1}{x_{N-1}} + 1}.$$

This value exceeds $NELW_{EF}$ as illustrated by:

$$NELW_{NE} - NELW_{EF} = -K_S \times \frac{R}{\frac{1}{x_1} + \frac{1}{x_2} + \cdots + \frac{1}{x_{N-1}} + 1} + K_S \times R,$$

which simplifies to:

$$K_S \times R \times \left(1 - \frac{1}{\frac{1}{x_1} + \frac{1}{x_2} + \cdots + \frac{1}{x_{N-1}} + 1} \right),$$

and this value is positive because $\frac{1}{x_w} > 0$, and thus, $1 > \frac{1}{\frac{1}{x_1} + \frac{1}{x_2} + \cdots + \frac{1}{x_{N-1}} + 1}$.

When equality is achieved, or when the frequency of volunteering is equalized, the net benefit of the least well-off (i.e., the weakest player, whose cost is $K_1 = K_S \times x_1$) is:

$$NELW_{FE} = V \times R - K_S \times x_1 \times \frac{R}{N}.$$

$NELW_{NE}$ also exceeds $NELW_{FE}$ as illustrated by:

$$NELW_{NE} - NELW_{FE} = -K_S \times \frac{R}{\frac{1}{x_1} + \frac{1}{x_2} + \cdots + \frac{1}{x_{N-1}} + 1} + K_S \times x_1 \times \frac{R}{N},$$

which simplifies to:

$$K_S \times R \times x_1 \times \left(\frac{1}{N} - \frac{1}{1 + \frac{x_1}{x_2} + \cdots + \frac{x_1}{x_{N-1}} + x_1} \right),$$

and this value is positive since $\frac{x_1}{x_w} \geq 1$, and thus, $\frac{1}{N} > \frac{1}{1+\frac{x_1}{x_2}+\cdots+\frac{x_1}{x_{N-1}}+x_1}$.

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