

Monitoring and punishment networks in an experimental common pool resource dilemma

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ONLINE APPENDIX

Appendix A. Instructions

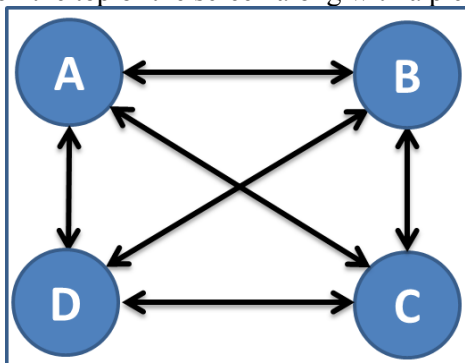
Instructions

This is a study on economic decision making. If you read the following instructions carefully, you can, depending on your decisions and on the decisions of the other participants in the experiment, earn money. All earnings on your computer screen are in experimental tokens. Experimental tokens will be converted to real Great Britain Pounds (GBP) at the end of the experiment at the rate of 25 experimental tokens = GBP 1.

Introduction

In this experiment, you will participate in 15 identical decision-making periods. Each period consists of two decision stages (Stage 1 and 2) which will be described in detail below. Before the first period, you (and all other participants) will be assigned by the computer to one of the four types labelled A, B, C or D. This assignment depends solely upon chance. Each network contains one Type-A player, one Type B player, one Type C player and one Type-D player. There are an equal number of participants of Type-A, Type-B, Type-C and Type-D in the room. Everyone's type will remain the same throughout all 15 periods of the experiment.

The relationship between types is illustrated below. Type-A can observe Type-B, Type-C and Type-D, Type-B can observe Type-C, Type-D and Type-A, Type-C can observe Type-D, Type-A and Type-B, and Type-D can observe Type-A, Type-B and Type-C. When you enter Stage 1 you will be informed of your type in the dialog box on the top of the screen along with a picture of this network.



Every period begins with the computer assigning you to a four-person network or group (yourself and three other participants). Remember that each network contains one Type-A player, one Type B player, one Type C player and one Type-D player. Everyone's type will remain the same throughout all 15 periods of the experiment. In every period one participant of each type is equally likely to be chosen to be in a particular group. The network or group formed in each period depends solely upon chance and does not depend on groups formed in previous periods.

Stage 1

In Stage 1 of every period, you receive an endowment of 25 experimental tokens. You will decide to place your tokens in either or both of two accounts: a Private Account and a Common Account. The total number of tokens you place in either or both accounts must add up to your endowment of 25 tokens. Your total earnings from Stage 1 (for each period) are the sum of your returns from the Private Account and Common Account. Everyone has to make the decision at this stage and has the same returns.

Earnings from your Private Account: For each token you place in the Private Account you generate a return of 5 tokens. Your earnings from the Private Account depend only on the number of tokens you place in your private account and generate a return only to you.

Earnings from the Common Account: Each token placed in the Common Account generates a return that depends on the total number of tokens invested in the common account by all members in your group (including you) and your share of the total tokens placed in the common account in that period. Assume a total of X tokens are placed in the Common Account by all your group members (including you). The return to your entire group from the Common Account is $25X - 0.25X^2$ tokens. For instance, assume a total of $X=4$ tokens are placed in the Common Account by all your group members (including you). The earnings to your whole group from the common account are;

$$25 * (4) - 0.25 * (4)^2 = 96 \text{ tokens}$$

Your share of this total group return equals the number of tokens you placed in the Common Account divided by the total tokens placed in the Common Account by your group (Tokens you place in Common Account/ X).

Following on from the example above, assume you placed 1 token in the Common Account. Then your share of the total Common Account earnings is $\frac{1}{4}$ and your earnings from the Common Account are:

$$(1/4) * 96 = 24 \text{ tokens.}$$

Thus, from stage 1 your total earnings are given by;

$$\begin{aligned} \text{Your Earnings} &= \text{Private Account Earnings} + \text{Common Account Earnings} \\ &= [5 * \text{Tokens you place in Private Account}] \\ &\quad + \left[\frac{\text{Tokens you place in Common Account}}{\text{Total Tokens in Common Account or } X} * (25X - 0.25X^2) \right] \end{aligned}$$

The earnings table attached below describes your total potential earnings (sum of Private Account and Common Account earnings; in tokens) that correspond to different token placements (in steps of five) in the Common Account by you (first row) and the three others in your group (first column). Remember, you can assign any number of tokens into your Private and Common Accounts as long as they add up to your endowment of 25 tokens. All participants use the same earnings table.

On your computer screen during Stage 1, you can calculate your expected earnings from your token allocation to your Private and Common Accounts, and your estimate of the total number of tokens allocated by the three other group members to the Common Account. Use the mouse to click on the Private and Common Account input boxes and use the keyboard to fill in the number (without decimals) of tokens between 0 and 25 that you wish to allocate to that account. Do the same for your estimate of the total number of tokens allocated by the three other group members to the Common Account.

To calculate your expected earnings based on your estimate of the other group members' Common Account token allocation, and your allocation, please press the calculate button. If you are happy with your token allocations, click Confirm and Continue to proceed to next round. If you want to revise your allocations or your estimate, please key in new values and proceed in the same way. Remember, you can only enter your estimate of the total number of tokens allocated by the three other group members to the Common Account. This is not their actual decision.

Table of Total Earnings (Private Accounts + Common Accounts) from Stage 1 by Tokens placed in Common Account

		Number of tokens you place in Common Account →																										
		0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	
Total tokens placed by 3 other group members (without you) in Common Account	0	125	145	164	183	201	219	236	253	269	285	300	315	329	343	356	369	381	393	404	415	425	435	444	453	461	469	
	1	125	145	164	182	200	218	235	251	267	283	298	312	326	340	353	365	377	389	400	410	420	430	439	447	455	463	
	2	125	144	163	181	199	216	233	249	265	280	295	309	323	336	349	361	373	384	395	405	415	424	433	441	449	456	
	:																											
	5	125	144	162	179	196	213	229	244	259	274	288	301	314	327	339	350	361	372	382	391	400	409	417	424	431	438	
	:																											
	10	125	142	159	175	191	206	221	235	249	262	275	287	299	310	321	331	341	350	359	367	375	382	389	395	401	406	
	:																											
	15	125	141	157	172	186	200	214	227	239	251	263	274	284	294	304	313	321	329	337	344	350	356	362	367	371	375	
	:																											
	20	125	140	154	168	181	194	206	218	229	240	250	260	269	278	286	294	301	308	314	320	325	330	334	338	341	344	
	:																											
	25	125	139	152	164	176	188	199	209	219	229	238	246	254	262	269	275	281	287	292	296	300	304	307	309	311	313	
	26	125	138	151	163	175	186	197	207	217	226	235	243	251	258	265	271	277	282	287	291	295	298	301	303	305	306	
	27	125	138	151	163	174	185	196	206	215	224	233	241	248	255	262	268	273	278	283	287	290	293	296	298	299	300	
	:																											
	30	125	137	149	160	171	181	191	200	209	217	225	232	239	245	251	256	261	265	269	272	275	277	279	280	281	281	
	:																											
	35	125	136	147	157	166	175	184	192	199	206	213	219	224	229	234	238	241	244	247	249	250	251	252	252	251	250	
	:																											
	40	125	135	144	153	161	169	176	183	189	195	200	205	209	213	216	219	221	223	224	225	225	225	224	223	221	219	
	:																											
	45	125	134	142	149	156	163	169	174	179	184	188	191	194	197	199	200	201	202	202	201	200	199	197	194	191	188	
	:																											
	50	125	132	139	145	151	156	161	165	169	172	175	177	179	180	181	181	181	180	179	177	175	172	169	165	161	156	
	51	125	132	139	145	150	155	160	164	167	170	173	175	176	177	178	178	177	176	175	173	170	167	164	160	155	150	
52	125	132	138	144	149	154	158	162	165	168	170	172	173	174	174	174	173	172	170	168	165	162	158	154	149	144		
:																												
55	125	131	137	142	146	150	154	157	159	161	163	164	164	164	164	163	161	159	157	154	150	146	142	137	131	125		
:																												
60	125	130	134	138	141	144	146	148	149	150	150	150	149	148	146	144	141	138	134	130	125	120	114	108	101	94		
:																												
65	125	129	132	134	136	138	139	139	139	139	138	136	134	132	129	125	121	117	112	106	100	94	87	79	71	63		
:																												
70	125	127	129	130	131	131	131	130	129	127	125	122	119	115	111	106	101	95	89	82	75	67	59	50	41	31		
:																												
73	125	127	128	128	128	128	127	125	123	121	118	114	110	106	101	95	89	83	76	68	60	52	43	33	23	13		
74	125	126	127	127	127	126	125	123	121	118	115	111	107	102	97	91	85	78	71	63	55	46	37	27	17	6		
75	125	126	127	127	126	125	124	122	119	116	113	109	104	99	94	88	81	74	67	59	50	41	32	22	11	0		

Once you press Confirm and Continue, your decisions cannot be revised. This completes Stage 1 of each period. After all members of your network or group have made their decisions, your earnings from the Stage 1 will be displayed. Please click the Continue button to proceed to the Stage 2.

Stage 2

In Stage 2, you will observe the choices made by the other participants in your network. A line between any two types represents that they are connected and the arrowhead points to the participant whose decision is observed. For instance, if you are a Type-A participant, you can observe the decisions of Type-B, Type-C and Type-D and so on. This information is given to you in the table on your computer screen. Each participant can observe only allocations of those to whom they are connected in the network.

By assigning Deduction Points, you can now decide if and by how much to reduce the earnings of the participant whose allocations you can observe. Each of the other participants will also decide if and by how much to reduce the earnings of the participant whose allocations they can observe.

You must decide by how much you wish to reduce the earnings of each of the other participants with whom you are connected, by filling in the number of Deduction Points for each of them. If you do not wish to reduce the earnings of another participant, you must enter 0. Reducing the earnings of other participants is costly to you. Assigning one deduction point to another participant reduces your earnings by 1 token. Each deduction point received by a participant reduces their earnings by 3 tokens.

Total Cost of Deduction Points you assigned = Sum of Deduction Points assigned

*Total Cost of Deduction Points received = 3 * (Sum of Deduction Points received)*

After, and if you have entered deduction points, click the Calculate button to check the Total Cost of Deduction Points you assigned. If you are want to revise your decision, key in another number. To confirm your decision, press Confirm and Continue. If you cannot observe other's decisions press Confirm and Continue. This completes the Stage 2 of each period.

When a period ends, the computer will inform all participants of their total earnings and the Total Cost of Deduction Points assigned and received. Please click the Continue button to proceed to the next period, which will start with the computer forming new groups of participants in networks. Remember, 15 periods will be conducted and you will receive a new endowment of 25 tokens in each period.

Earnings

Your earnings in each period will be calculated in tokens as follows:

Your Final Earnings

$$\begin{aligned} &= (\text{Your Total Earnings from Stage 1}) \\ &- (\text{Total Cost of deduction points you assigned}) \\ &- (\text{Total Cost of deduction points received}) \end{aligned}$$

This sum is positive or will be zero if it is negative. Thus, if Stage 1 earnings are reduced to below zero through cost of assigned and received deduction points, total earnings for that period will be zero.

At the end of the session, you will be given your earnings from a randomly selected round out of the 15 rounds played. Additionally, players who accurately estimate the expected allocation of each of other three payers will earn 4 tokens for each correct estimate.

Rules

1. Please remain silent until the end of the last period and then wait for further instructions.
2. Please do not talk to anyone during the experiment.
3. Please remain alert during the experiment.
4. If you have any questions, please raise your hand and we will come to you to address any doubts you may have.
5. Your participation and any information about your earnings will be kept strictly confidential.

Test Questions

1. Please write down how much to invest in your private and the common account.
2. How much should the sum of your token placement in your private and common accounts add up to?
3. What are your earnings from your private account?
4. What are your total earnings (earnings from private + earnings from common account; consult earnings table) if the three other participants place 0 in the common account?
5. If you invest 25 tokens in the Common Account and the three other participants invest a total of 75 tokens, what are your total earnings?

Appendix B: Snapshots of the experimental interface

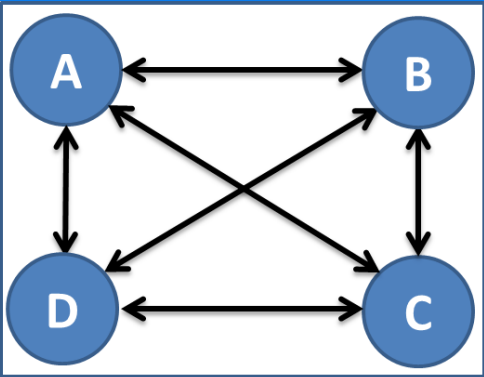
Figure B1. Page 1: Appropriation decision and beliefs

Period

1 out of 15

Remaining Time [sec]: 0

Your role is Player C.
Choose how many tokens you want to place in your Private account and the Common Account.
Enter your expectations of other player's token placement in the Common Account.



Your Endowment 25

Number of tokens into your private account

Number of tokens into the common account

Number of tokens you expect player A to place in the common account

Number of tokens you expect player B to place in the common account

Number of tokens you expect player D to place in the common account

Your Expected Total Earnings are 177

Figure B2. Page 2: Feedback on subject's earnings from private account, common account and stage 1

Period

1 out of 15

Remaining Time [sec]: 24

Your Actual Earnings from Stage 1 are:

Your Earnings from the Private Account	80
Your Earnings from the Common Account	140
Your Total Earnings from Stage 1 (Private Account Earnings + Common Account Earnings)	220

OK

Figure B3. Page 3: Punishment decisions

Period
1 out of 15
Remaining Time [sec]: 10

Your role is Player D.

You can choose assign deduction points to decrease earnings of the other player(s).

If you choose to assign deduction points, please enter a number. If you choose not to, please enter '0'.

Your Actual Total Earnings from Stage 1 are 230

```

graph TD
    A((A)) <--> B((B))
    A((A)) <--> C((C))
    A((A)) <--> D((D))
    B((B)) <--> C((C))
    B((B)) <--> D((D))
    C((C)) <--> D((D))
            
```

Participants	Tokens in Private Account	Tokens in Common Account	Deduction Points
A	16	9	<input style="width: 80px;" type="text" value="5"/>
B	10	10	<input style="width: 80px;" type="text" value="0"/>
C	16	9	<input style="width: 80px;" type="text" value="5"/>
D	15	10	

Total cost of deduction points given to others -10

Figure B4. Page 4: Feedback on cost of deduction points and subject's payoffs after stage 2

Period

1 out of 15

Remaining Time [sec]: 16

Your Total Earnings from Stage 1	220
Total cost of deduction points given to others	0
Total cost of deduction points received	15
Your Final Earnings from Stage 2	205

Continue...

Appendix C. Tables

Table C1. Experimental parameters in relation to CPR literature

Features	OGW 1994	AMR 2006*	KL 2014*	CG 2015	Experiment
Endowment	25	100	50	12	25
a	23	6	6	18	25
b	0.25	0.0125	0.25	0.4	0.25
w	5	1	1	2	5
Group size (n)	8	4	4	4	4
Fee-to-Fine Ratio	0.25 to 0.50	-	-	0.33	0.33
x_n -tokens	8	80	40	8	16
x_n -payoff	70	180	112.5	37.6	189
x_p -tokens	4.5	50	25	5	10
x_p -payoff	83	225	90	52	225
Nash (N)/Pareto (P) tokens	1.8	1.6	1.6	1.6	1.6
N%P payoff	84	80	80	72	84

OGW 1994: Ostrom, Gardner, and Walker (1994); CG2015: Cason and Gangadharan (2015); AMR2006: Apesteguia and Maier-Rigaud (2006); KL 2014: Kingsley and Liu (2014); Experiment refers to our study. *No punishment.

Table C2. Individual attributes by treatment (%)

Individual control variables		All	CN	UDN	DCN
Sex = 2	Female	59.38	55	55.56	67.5
Economics = 1	Yes	16.15	15	16.67	17.5
Experience = 1	0	26.04	15	36.11	32.5
Experience = 2	1-5	46.35	45	50	37.5
Experience = 3	6-10	17.19	25	8.33	20
Experience = 4	>10	10.42	15	5.56	10
Number of Sessions		10	3	2	2
Number of Groups		720	225	135	150
Number of Subjects		192	60	36	40

Notes: The p-values give the significance level of the Pearson χ^2 test for independence.

Table C3. Summary statistics by network treatment (session & group-level)

Outcomes	Appropriation	Punishment			Net payoffs	Beliefs	# Groups
		Amount	Severity	Incidence			
Complete Network (CN)							225
Session 1	15.84 (2.97)	7.74 (10.37)	2.58 (3.46)	0.32 (0.32)	171.84 (41.37)	14.15 (2.27)	
Session 2	14.99 (2.87)	6.52 (15.14)	2.17 (5.05)	0.34 (0.36)	183.33 (40.09)	12.74 (2.62)	
Session 3	15.28 (2.75)	20.81 (23.77)	6.94 (7.92)	0.71 (0.31)	161.91 (48.07)	12.86 (2.73)	
CN-All	15.37 (2.87)	11.69 (18.44)	3.9 (6.15)	0.46 (0.37)	172.36 (44.01)	13.25 (2.62)	
Undirected Circle Network (UCN)							135
Session 1	14.9 (2.63)	4.24 (4.70)	2.12 (2.35)	0.4 (0.28)	188.56 (28.19)	12.84 (2.08)	
Session 2	14.02 (2.58)	9.93 (8.86)	4.96 (4.43)	0.49 (0.24)	189.03 (26.78)	12.49 (1.62)	
UCN-All	14.51 (2.64)	6.77 (7.40)	3.38 (3.70)	0.44 (0.27)	188.77 (27.47)	12.69 (1.89)	
Directed Circle Network (DCN)							150
Session 1	15.1 (2.51)	2.17 (4.39)	2.17 (4.39)	0.14 (0.20)	189.91 (25.79)	13.07 (1.82)	
Session 2	14.51 (3.53)	3.04 (6.19)	3.04 (6.19)	0.14 (0.17)	188.61 (31.69)	11.45 (2.38)	
DCN-All	14.8 (3.07)	2.61 (5.36)	2.61 (5.36)	0.14 (0.19)	189.26 (28.80)	12.26 (2.26)	
All							510
All networks & sessions	14.98 (2.89)	7.71 (13.69)	3.38 (5.38)	0.36 (0.33)	181.67 (36.91)	12.81 (2.37)	

Table C4. Difference in appropriation between rounds 1-7 and rounds 8-15 within networks

Random-effects regression models	(1)	(2)	(3)
Variables	CN	UCN	DCN
Rounds 8-15 =1, Yes	0.586 (0.405)	0.898* (0.459)	1.371*** (0.424)
Other's (mean) appropriation	0.092** (0.047)	0.095 (0.084)	0.237*** (0.064)
Constant	14.078*** (1.248)	13.007*** (1.364)	
# Observations	900	540	600
# Subjects	60	36	40
Session dummies	Yes	Yes	Yes

Notes: Robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1. Omitted category = Rounds 1-7.

Table C5. Difference in punishment amount between rounds 1-7 and rounds 8-15 within networks

Regression models:	(1)	(2)	(3)	(5)	(6)	(7)	(9)	(10)	(11)
Networks:		CN			UCN			DCN	
Variables:	Amount	Severity	Incidence	Amount	Severity	Incidence	Amount	Severity	Incidence
Rounds 8-15 = 1, Yes	0.725 (1.124)	0.242 (0.375)	-0.360** (0.141)	1.027 (0.705)	0.514 (0.352)	-0.414*** (0.152)	0.212 (0.952)	0.212 (0.952)	-0.585*** (0.223)
Appropriation	1.007*** (0.157)	0.336*** (0.052)	0.076*** (0.014)	1.021*** (0.224)	0.510*** (0.112)	0.117*** (0.027)	0.219*** (0.084)	0.219*** (0.084)	0.064** (0.032)
Constant	-8.607*** (2.619)	-2.869*** (0.873)	-1.798*** (0.265)	-11.520*** (3.537)	-5.760*** (1.768)	-1.988*** (0.433)	-1.243 (1.390)	-1.243 (1.390)	-2.599*** (0.611)
# Observations	900	900	900	540	540	540	600	600	600
# Subjects	60	60	60	36	36	36	40	40	40
Session dummies	Yes	Yes	Yes		Yes	Yes	Yes	Yes	Yes
Session & round dummies				Yes					

Notes: Robust standard errors in parentheses; *** p<0.01, ** p<0.05. Omitted category = Rounds 1-7.

Table C6. Punishment received by free riders (appropriation > 10 tokens)

Random-effects models: Dependent variables: Punishment received	(1)	(2)	(3)
	Amount	Severity	Incidence
Treat = 1, UCN	4.978** (2.247)	4.101*** (1.072)	1.093*** (0.247)
Treat = 2, DCN	-5.532*** (1.935)	0.616 (1.424)	-1.269*** (0.258)
Appropriation	1.219*** (0.161)	0.556*** (0.074)	0.166*** (0.019)
Sex = 1, 1	1.532 (1.023)	1.025** (0.481)	-0.037 (0.139)
Economics = 1	-1.713* (1.006)	-0.484 (0.516)	-0.253 (0.169)
Experience	-0.315 (0.562)	0.014 (0.331)	-0.068 (0.068)
Constant	-14.837*** (3.212)	-8.460*** (1.722)	-3.454*** (0.534)
# Observations	1,603	1,603	1,603
# Subjects	135	135	135
Session & round dummies	Yes	Yes	Yes

Notes: Robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1. Omitted category = CN. Logistic regression models are used for Incidence, and the corresponding odds ratios for UDC and DC are 2.98 and 0.30.

Table C7. Difference in net earnings between rounds 1-7 and rounds 8-15 within networks

VARIABLES	(1) CN	(2) UCN	(3) DCN
Rounds 8-15 = 1, Yes	-6.403** (3.186)	-10.024*** (2.825)	-13.105*** (3.350)
Constant	175.254*** (4.671)	193.901*** (2.700)	195.598*** (4.103)
# Observations	900	540	600
# Subjects	60	36	40
Session dummies	Yes	Yes	Yes

Notes: Robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1. Omitted category = Rounds 1-7.

Table C8. Difference in beliefs between rounds 1-7 and rounds 8-15 within networks

Regression models:	(1)	(2)	(3)
Networks:	CN	UCN	DCN
Rounds 8-15 = 1, Yes	1.572*** (0.283)	1.587*** (0.376)	1.395*** (0.430)
Constant	13.308*** (0.471)	11.648*** (0.593)	10.704*** (0.670)
# Observations	900	540	600
# Subjects	60	36	40
Session dummies	Yes	Yes	Yes

Notes: Robust standard errors in parentheses; *** p<0.01. Omitted category = Rounds 1-7.

Table C9. Outcomes across networks: Lagged variables

Random effects models:	(1)	(2)	(3)	(4)	(5)	(6)
Dependent variables	Appropriation	Punishment		Incidence	Beliefs	Net payoffs
		Amount	Severity			
Treat = 1, UCN	-0.964 (0.709)	0.747*** (0.270)	2.821 (2.260)	2.696*** (1.027)	-0.893** (0.353)	18.304*** (5.950)
Treat = 2, DCN	-0.477 (0.664)	-1.170*** (0.263)	-4.965*** (1.813)	0.431 (1.208)	-1.221*** (0.422)	18.094*** (5.624)
Appropriation (t-1)	0.405*** (0.041)	0.028** (0.011)	0.291*** (0.102)	0.130*** (0.045)	0.018 (0.020)	0.007 (0.234)
Beliefs (t-1)	-0.001 (0.034)	-0.002 (0.014)	-0.015 (0.117)	-0.053 (0.056)	0.516*** (0.042)	0.339 (0.258)
Received punishment (t-1)	-0.018*** (0.006)	-0.003 (0.003)	-0.018 (0.031)	0.005 (0.015)	-0.002 (0.005)	0.049 (0.073)
Sex = 1, 1	-0.346 (0.342)	-0.013 (0.136)	1.279 (0.911)	0.712* (0.412)	-0.260 (0.245)	-0.199 (2.763)
Economics = 1	-0.169 (0.422)	-0.247 (0.209)	-1.820** (0.914)	-0.557 (0.471)	0.618*** (0.218)	2.880 (3.282)
Experience	0.156 (0.197)	-0.075 (0.084)	-0.226 (0.561)	-0.035 (0.308)	-0.104 (0.155)	0.927 (1.528)
Constant	9.686*** (0.925)	-0.527* (0.307)	3.158 (2.361)	0.720 (1.052)	6.708*** (0.660)	177.041*** (7.820)
# Observations	1,904	1,904	1,904	1,904	1,904	1,904
# Subjects	136	136	136	136	136	136
Session & round dummies	Yes	Yes	Yes	Yes	Yes	Yes

Notes: Robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1. Omitted category = CN.

Table C10. Outcomes across networks: Mixed multilevel model

Multilevel mixed-effects models:	(1)	(2)	(3)	(4)	(5)	(6)
Dependent variables:	Appropriation	Punishment		Incidence	Beliefs	Net payoffs
		Amount	Severity			
Treat = 1, UCN	-0.799* (0.432)	-4.826 (4.504)	-0.476 (1.695)	-0.120 (0.511)	-0.646* (0.390)	16.566*** (5.207)
Treat = 2, DCN	-0.551** (0.241)	-9.199** (4.144)	-1.346 (1.424)	-1.763*** (0.498)	-1.067* (0.636)	16.781*** (5.181)
Sex = 1, 1	-0.497 (0.526)	0.887 (0.566)	0.538* (0.318)	0.014 (0.112)	-0.434 (0.330)	0.482 (3.143)
Economics = 1	0.073 (0.600)	-1.757 (1.135)	-0.614 (0.429)	-0.189 (0.220)	1.501*** (0.374)	4.288 (4.186)
Experience = 1, 1-5	-0.894 (0.549)	0.165 (1.146)	0.214 (0.750)	-0.146 (0.166)	-0.757 (0.519)	-1.389 (3.021)
Experience = 2, 6-10	-0.400 (0.670)	-1.245 (1.304)	-0.747 (0.592)	-0.310 (0.273)	-0.345 (0.554)	-2.526 (4.137)
Experience = 3, >10	0.874** (0.366)	0.061 (1.581)	0.384 (0.878)	-0.209 (0.191)	-0.426 (1.178)	5.632 (5.282)
Constant	12.433*** (0.825)	9.295*** (2.737)	2.819** (1.180)	0.175 (0.475)	10.719*** (0.608)	197.740*** (6.789)
# Observations	2,040	2,040	2,040	2,040	2,040	2,040
# Subjects	136	136	136	136	136	136
# Sessions	7	7	7	7	7	7
Round dummies	Yes	Yes	Yes	Yes	Yes	Yes

Notes: Robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1. Omitted category = CN.

Table C11. Types of punishment across networks: frequency

Poisson regression models: Variables: Counts of types of punishment given	(1) Prosocial punishment	(2) Antisocial punishment
Treat = 1, UCN	0.670*** (0.164)	0.335 (0.381)
Treat = 2, DCN	-1.046*** (0.218)	-0.661 (0.458)
Stage 1 payoff	-0.008*** (0.001)	0.020*** (0.002)
Sex = 1, 1	-0.093 (0.084)	0.137 (0.171)
Economics = 1	-0.004 (0.111)	-0.377 (0.249)
Experience	0.015 (0.048)	-0.099 (0.104)
Constant	0.130 (0.322)	-6.178*** (0.608)
Observations	2,040	2,040
Session & round fixed effects	Yes	Yes

Notes: Standard errors in parentheses obtained using bootstrap methods; *** p<0.01.

OC = Omitted category. In model 1 and 2, Wald tests reveal that UCN levies more prosocial and antisocial punishment than DCN (p-value < 0.01 and p-value = 0.01 respectively).

Table C12. Punishment received severity by deviation from the Pareto equilibrium allocation

Random effects models:	(1)	(2)
Dependent variable:	Punishment received - severity	
(Appropriation > 10) x CN indicator	0.413*** (0.070)	0.418*** (0.068)
(Appropriation > 10) x UCN indicator	0.663*** (0.180)	0.662*** (0.181)
(Appropriation > 10) x DCN indicator	0.295*** (0.093)	0.306*** (0.093)
(Appropriation < 10) x CN indicator	-0.106 (0.092)	-0.094 (0.091)
(Appropriation < 10) x UCN indicator	-0.321*** (0.117)	-0.318*** (0.114)
(Appropriation < 10) x DCN indicator	-0.391** (0.182)	-0.399** (0.183)
(Appropriation = 10) x CN indicator	0.179 (0.142)	0.169 (0.144)
(Appropriation = 10) x UCN indicator	0.214 (0.149)	0.206 (0.150)
(Appropriation = 10) x DCN indicator	0.239 (0.281)	0.232 (0.279)
Sex = 1, 1		0.796** (0.383)
Economics = 1		-0.293 (0.468)
Experience		-0.076 (0.280)
Constant	-0.277 (0.645)	-0.570 (0.837)
# Observations	2,040	2,040
# Subjects	136	136
Session & round dummies	Yes	Yes

Notes: Robust standard errors in parentheses; *** p<0.01, ** p<0.05.

References

- Apesteguia J and Maier-Rigaud FP** (2006) The role of rivalry: public goods versus common-pool resources. *Journal of Conflict Resolution* **50**, 646–663.
- Cason TN and Gangadharan L** (2015) Promoting cooperation in nonlinear social dilemmas through peer punishment. *Experimental Economics* **18**, 66–88.
- Kingsley DC and Liu B** (2014) Cooperation across payoff equivalent public good and common pool resource experiments. *Journal of Behavioral and Experimental Economics* **51**, 79–84.
- Ostrom E, Gardner R and Walker JM** (1994) *Rules, Games, and Common-Pool Resources*. Ann Arbor, MI: University of Michigan Press.