Emergence of Cooperation: Is Spitefulness a Source of Cooperation?

In Honor of John Maynard Smith

By

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1. The Universal Principle

Economic activities can be approximately explained by the consequence of a model consisting of selfish agents, regardless of time and place.

David Hume, 1739:

"Now as we seldom judge of objects from their intrinsic value, but form our notions of them from a comparison with other objects; it follows, that according as we observe a greater or less share of happiness or misery in others, we must make an estimate of our own, and feel a consequent pain or pleasure. The misery of another gives us a more lively idea of our happiness, and his happiness of our misery. The former, therefore, produces delight; and the latter uneasiness."

....

(in *A Treatise of Human Nature: Being an Attempt to Introduce the Experimental Method of Reasoning into Moral Subjects, Book II Of the Passions*)

Hume: People care about how they are doing relative to others.

⇓

Take SPITEFUL actions to decrease the happiness of others.

⇓

Might result in outcomes that are socially inferior to outcomes arising from the interaction of purely self-interested individuals.

However,

- Spitefulness leads to greater cooperation in a new public good provision experiment.
- Casts doubt on fundamental assumptions of human nature underlying the universal principle.

2. The Free Rider Problem

• Public good: Everybody can use the good or service simulteneously – TV programs, Police, Global warming etc.

• The Free Rider Problem:
It is impossible to achieve socially desirable allocation in public goods economies (Samuelson (1964) etc).

1964

• Can we overcome the Free Rider Problem?

Design a institution to achieve a desirable allocation with public goods

The Groves and Ledyard mechanism (1977)
The Walker Mechanism (1981)
The Hurwicz Mechanism (1979) and others

constructed mechanisms to achieve a socially desirable allocation.

<<The Free-Rider Problem is solved!?>>

3. Fundamental difficulties in mechanism design in economies with public goods

• Previous mechanism design including Groves-Ledyard, Walker, Hurwicz and almost all mechanisms assume that everyone MUST participate in a mechanism

⇓

• Ignore NON-EXCLUDABILITY of a public good: non-participants can enjoy the public good provided by participants

<What would happen if we consider voluntary participation?>

• Examples:

<International Treaties >

- The Kyoto Protocol on climate change (1997) to reduce green house gas emissions: the U.S. signed the protocol, but decided not to ratify it

<Public Fee to public goods >

- NHK's Public Broadcasting Fee in Japan
  no penalty without paying the fee

• Saijo-Yamato (1999):
Participation is a choice variable for agents

.

An impossibility theorem :

It is impossible to design a mechanism in which everyone has an incentive to participate

.

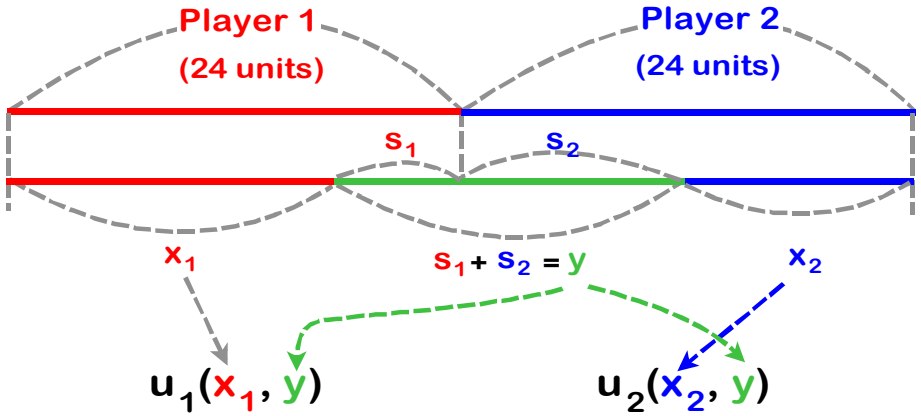
<A new free-rider problem again?>

⇓

<Experiments with human subjects!>

4. The Voluntary Contribution Mechanism

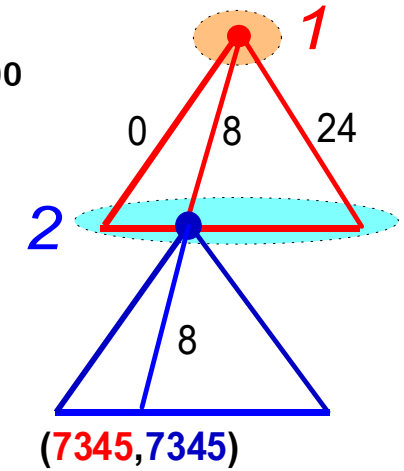
: A two agent game where each agent decides to contribute her money for constructing a public good



• Represent the VCM by a Game Tree

$$u_i(x_i, y) = \frac{(x_i^{0.47} y^{0.53})^{4.45}}{50} + 500$$

Nash Equlibrium:
$(s_1, s_2) = (8,8)$



s_1

s_2 / Your Payoff	0	1	2	3	4	5	6	7	8	9	10	11	12
0	706	871	1072	1297	1536	1775	2003	2210	2386	2523	2615	2658	2648
1	905	1127	1379	1647	1919	2183	2427	2641	2816	2944	3019	3039	3001
2	1186	1465	1764	2072	2374	2658	2913	3129	3297	3411	3465	3456	3385
3	1554	1888	2232	2575	2902	3202	3463	3675	3831	3925	3952	3911	3801
4	2017	2401	2787	3160	3508	3817	4078	4281	4420	4488	4483	4403	4250
5	2578	3010	3432	3831	4193	4507	4762	4950	5064	5101	5057	4934	4733
6	3244	3718	4171	4590	4960	5272	5515	5681	5766	5765	5677	5504	5249
7	4018	4529	5008	5440	5812	6115	6339	6478	6526	6481	6343	6114	5800
8	4904	5447	5944	6383	6751	7038	7237	7340	7345	7250	7056	6765	6385
9	5907	6475	6984	7422	7779	8043	8209	8271	8225	8073	7816	7458	7007
10	7031	7616	8130	8561	8897	9132	9257	9270	9168	8951	8624	8193	7664
11	8278	8873	9384	9800	10109	10306	10384	10339	10173	9886	9482	8970	8359
12	9653	10250	10750	11142	11416	11567	11589	11480	11242	10877	10390	9791	9090

Best Responses

s_1

Your Payoff	0	1	2	3	4	5	6	7	8	9	10	11	12
0	706	871	1072	1297	1536	1775	2003	2210	2386	2523	2615	2658	2648
1	905	1127	1379	1647	1919	2183	2427	2641	2816	2944	3019	3039	3001
2	1186	1465	1764	2072	2374	2658	2913	3129	3297	3411	3465	3456	3385
3	1554	1888	2232	2575	2902	3202	3463	3675	3831	3925	3952	3911	3801
4	2017	2401	2787	3160	3508	3817	4078	4281	4420	4488	4483	4403	4250
5	2578	3010	3432	3831	4193	4507	4762	4950	5064	5101	5057	4934	4733
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7	4018	4529	5008	5440	5812	6115	6339	6478	6526	6481	6343	6114	5800
8	4904	5447	5944	6383	6751	7038	7237	7340	7345	7250	7056	6765	6385
9	5907	6475	6984	7422	7779	8043	8209	8271	8225	8073	7816	7458	7007
10	7031	7616	8130	8561	8897	9132	9257	9270	9168	8951	8624	8193	7664
11	8278	8873	9384	9800	10109	10306	10384	10339	10173	9886	9482	8970	8359
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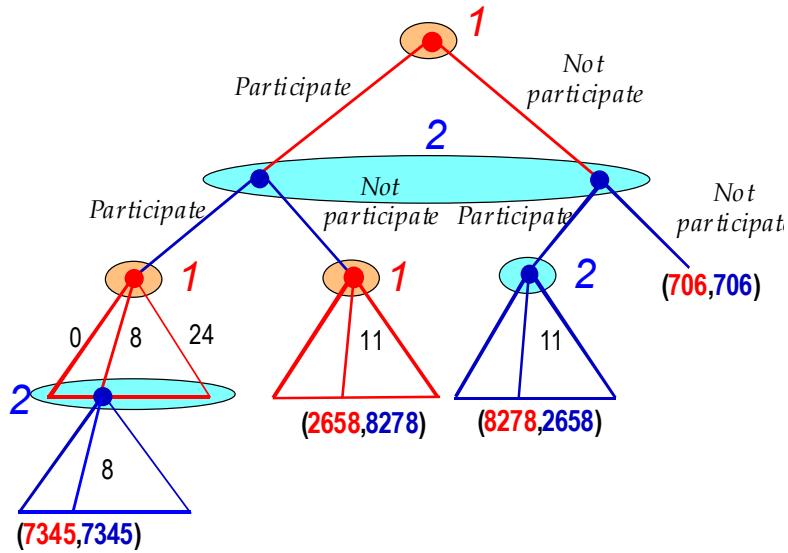
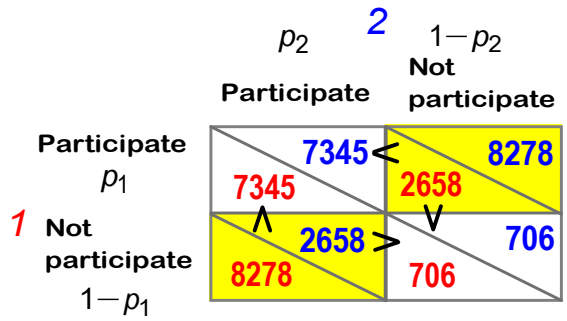
s_2

• Adding a Participation Stage



• Looking at the Participation Decision

⇒ A Hawk-Dove Game ⇐ Not a prisoner's dilemma game



The set of Nash equilibria $\{(p_1,p_2):(1,0),(0,1),(0.68,0.68)\}$

Evolutionarily stable strategy $p_i = 0.68$

• Evolutionarily Stable Strategy Equilibrium (or John Maynard Smith Equilibrium) -

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Consider a game with identical players and pairwise interactions .

$\pi_i(p_i,p_j)$: agent i's expected payoff when i uses strategy p_i and $j \neq i$ uses strategy p_j i p_i j p_j i .

A strategy p_i^* is an ESS if for every strategy p_i',

a) $\pi_i(p_i^*,p_i^*) \geq \pi_i(p_i',p_i^*)$ and

b) $\pi_i(p_i^*,p_i^*) = \pi_i(p_i',p_i^*) \Rightarrow \pi_i(p_i^*,p_i') > \pi_i(p_i',p_i')$

5. Experimental Design

Tsukuba and Tokyo Metro in Japan | USC and Purdue in the US

Treatment A: Every subject must participate in investment

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- 20 subjects
- 2 subjects make a pair (10 pairs)
- No communication
- Each subject does not know who is your opponent

- 15 periods
- No subject faces the same subject twice or more

- Every subject knows that every subject has the same payoff table

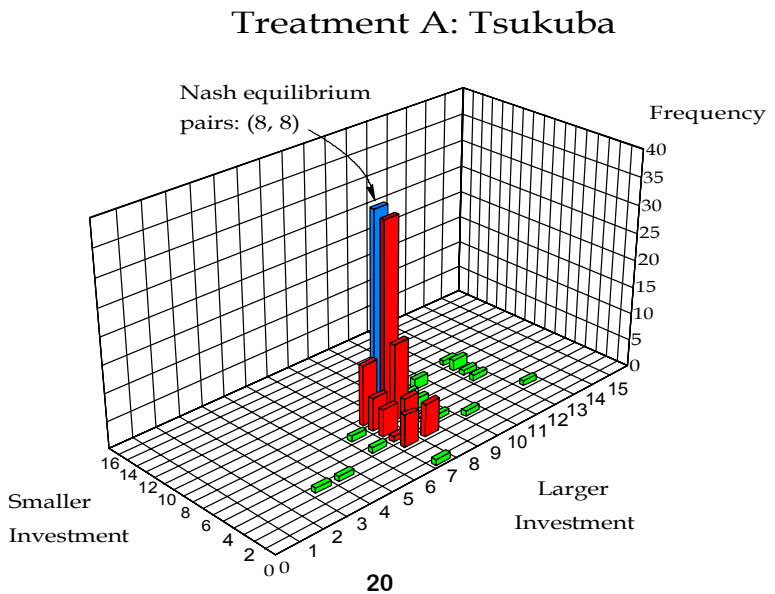
Treatment B: each subject can choose whether she participates in investment or not .

Your Investment Number

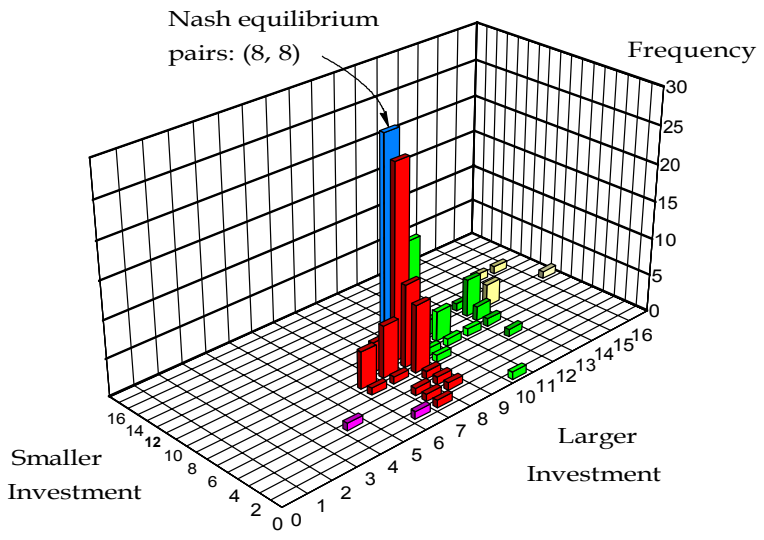
Your Payoff / Your Opponent's Investment Number	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
0	706	871	1072	1297	1536	1775	2003	2210	2386	2523	2615	2658	2648	2585	2470	2309	2106	1871	1614	1349	1091	858	669	543	500
1	903	1127	1379	1647	1919	2183	2427	2641	2816	2944	3019	3039	3001	2905	2755	2553	2313	2038	1743	1443	1154	894	685	548	500
2	1186	1465	1764	2072	2374	2658	2913	3129	3297	3411	3465	3456	3385	3252	3061	2819	2534	2217	1881	1543	1220	933	703	552	500
3	1554	1888	2232	2575	2902	3202	3463	3673	3831	3923	3952	3911	3801	3626	3391	3102	2770	2406	2027	1648	1290	973	721	556	500
4	2017	2401	2787	3160	3508	3817	4078	4281	4420	4488	4483	4403	4250	4028	3743	3404	3020	2608	2181	1759	1363	1015	740	561	500
5	2578	3010	3432	3831	4193	4507	4762	4950	5064	5101	5057	4934	4733	4459	4119	3723	3287	2821	2344	1877	1441	1060	760	566	500
6	3244	3718	4171	4590	4960	5272	5515	5681	5766	5765	5677	5504	5249	4918	4519	4065	3568	3045	2516	2000	1522	1106	781	571	500
7	4018	4529	5008	5440	5812	6115	6339	6478	6526	6481	6343	6114	5800	5406	4944	4425	3866	3282	2696	2129	1607	1153	802	576	500
8	4904	5447	5944	6383	6751	7038	7237	7340	7345	7250	7056	6765	6385	5924	5393	4806	4179	3532	2886	2265	1696	1206	825	582	500
9	5907	6473	6984	7422	7779	8043	8209	8271	8225	8073	7816	7458	7007	6472	5867	5207	4508	3793	3084	2407	1789	1259	849	588	500
10	7031	7616	8130	8561	8897	9132	9257	9270	9168	8951	8624	8193	7664	7051	6367	5628	4854	4067	3292	2555	1886	1315	874	594	500
11	8278	8873	9384	9800	10109	10306	10384	10339	10173	9886	9482	8970	8359	7661	6892	6070	5217	4354	3509	2710	1987	1372	899	600	500
12	9653	10250	10750	11142	11416	11567	11589	11480	11242	10877	10390	9791	9090	8302	7444	6534	5596	4654	3736	2871	2092	1432	926	606	500
13	11158	11749	12229	12589	12820	12916	12875	12694	12376	11925	11349	10656	9860	8976	8022	7019	5992	4967	3972	3039	2201	1494	953	613	500
14	12796	13372	13824	14144	14323	14356	14243	13982	13576	13033	12358	11565	10667	9681	8627	7526	6406	5292	4217	3213	2315	1559	982	620	500
15	14570	15123	15538	15808	15925	15888	15694	15344	14844	14199	13420	12520	11514	10419	9258	8055	6836	5631	4473	3394	2433	1626	1012	627	500
16	16484	17003	17372	17583	17630	17513	17229	16783	16179	15426	14535	13521	12399	11191	9918	8606	7285	5984	4738	3582	2555	1695	1042	635	500
17	18539	19016	19328	19471	19439	19232	18850	18299	17583	16714	15704	14568	13324	11995	10605	9180	7751	6350	5013	3777	2681	1767	1074	642	500
18	20739	21163	21409	21474	21353	21047	20559	19893	19057	18064	16926	15661	14290	12834	11320	9776	8235	6730	5298	3978	2812	1841	1107	650	500
19	23086	23447	23617	23594	23374	22960	22355	21566	20602	19476	18203	16803	15296	13706	12063	10395	8737	7123	5593	4187	2947	1917	1141	659	500
20	25583	25870	25954	25832	25504	24972	24241	23319	22218	20951	19536	17992	16342	14614	12835	11038	9257	7531	5899	4403	3087	1996	1176	667	500
21	28231	28493	28420	28190	27743	27083	26217	25154	23907	22491	20924	19230	17431	15556	13636	11704	9796	7953	6214	4625	3231	2078	1212	676	500
22	31034	31141	31020	30670	30094	29296	28285	27071	25669	24095	22370	20516	18561	16533	14465	12393	10354	8388	6540	4855	3380	2162	1249	685	500
23	33993	33993	33753	33273	32557	31611	30445	29071	27505	25764	23872	21852	19733	17546	15325	13106	10930	8838	6877	5092	3533	2248	1287	694	500
24	37111	36993	36622	36001	35135	34030	32699	31155	29416	27500	25432	23239	20949	18595	16214	13843	11525	9303	7224	5337	3691	2357	1326	703	500

Table 2. Detailed Payoff Table

6. Results



Treatment A: USC



- **Spiteful Behavior**

s_1

Your Payoff	0	1	2	3	4	5	6	7	8	9	10	11	12
0	706	871	1072	1297	1536	1775	2003	2210	2386	2523	2615	2658	2648
1	905	1127	1379	1647	1919	2183	2427	2641	2816	2944	3019	3039	3001
2	1186	1465	1764	2072	2374	2658	2913	3129	3297	3411	3465	3456	3385
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7	4018	4529	5008	5440	5812	6115	6339	6478	6526	6481	6343	6114	5800
8	4904	5447	5944	6383	6751	7038	7237	7340	7345	7250	7056	6765	6385
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11	8278	8873	9384	9800	10109	10306	10384	10339	10173	9886	9482	8970	8359
12	9653	10250	10750	11142	11416	11567	11589	11480	11242	10877	10390	9791	9090

s_2

Your Payoff	7	8
7	6478 <	6526
8	7340 <	7345

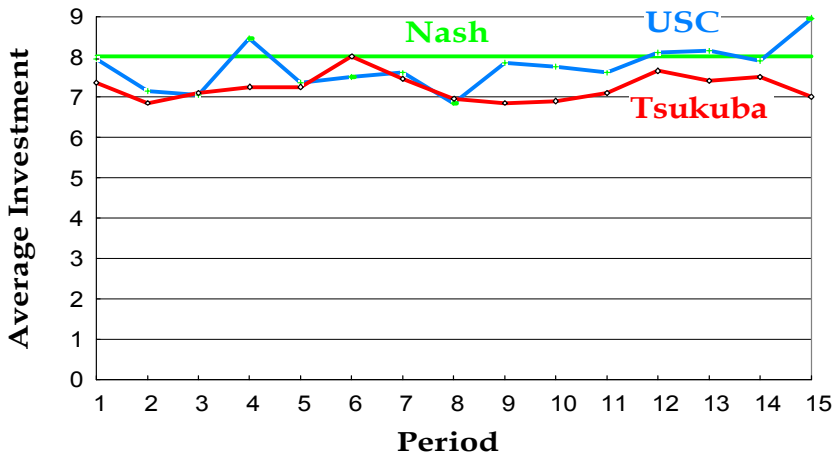
Assume that the other player chooses 8

.

Choose 7 rather than 8
Reduce own payoff from 7345 to 7340 (5 units) 7345 7340 5

The other player reduces from 7345 to 6526 7345 6526

Treatment A: No participation decision



Observation 1 (Treatment A):

(a) Regarding the mean investment per subject, the Nash equilibrium prediction is supported in the USC data, but not the Tsukuba data

.

(b) For the Tsukuba data, the mean investment in all rounds is less than the Nash equilibrium investment and cannot be identified as the Nash equilibrium investment

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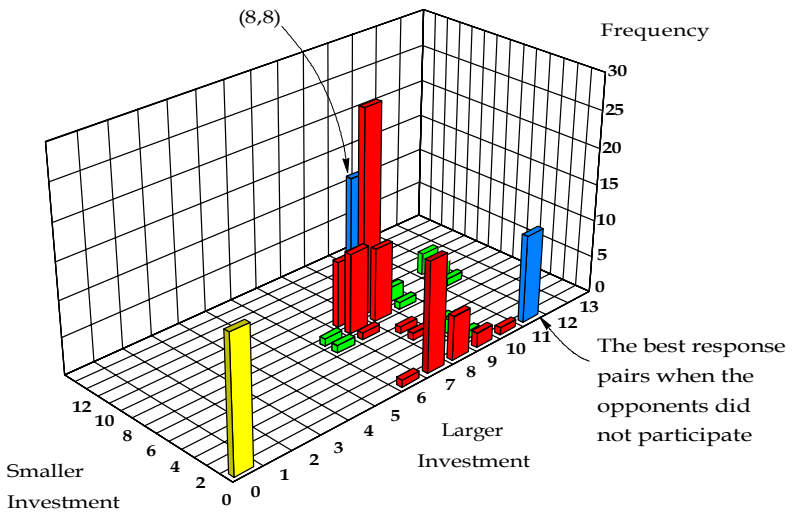
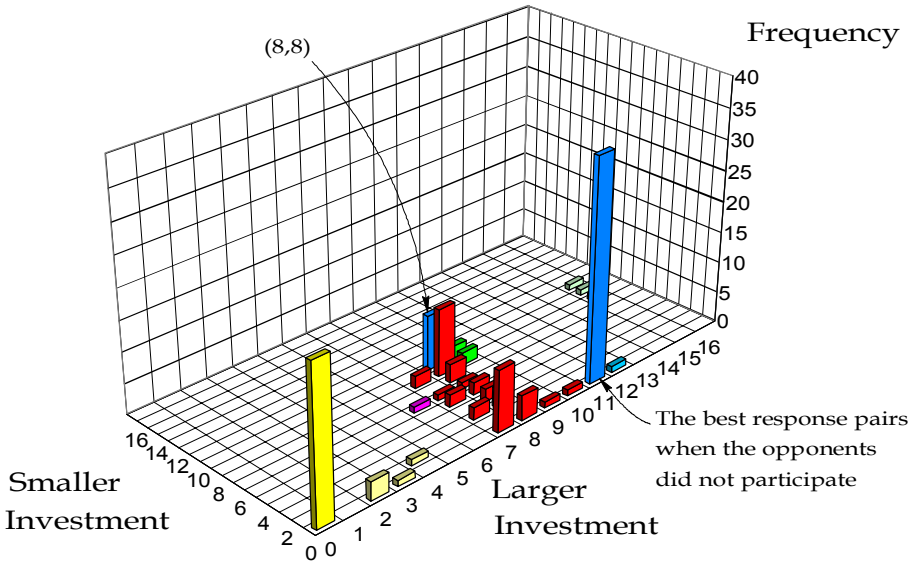
Treatment B:Tsukuba



Treatment B: USC



- **Spiteful Behavior**

s_1

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The best response when the other player does not participate = 11

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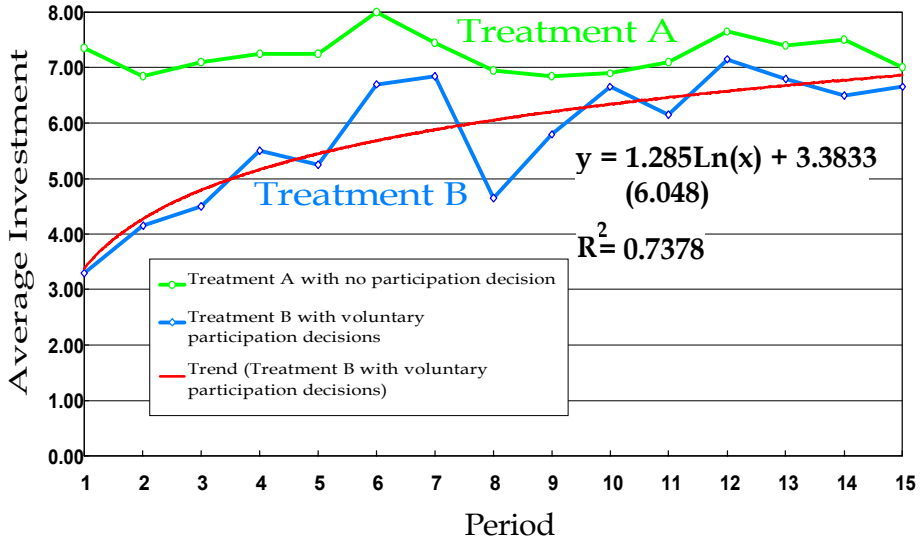
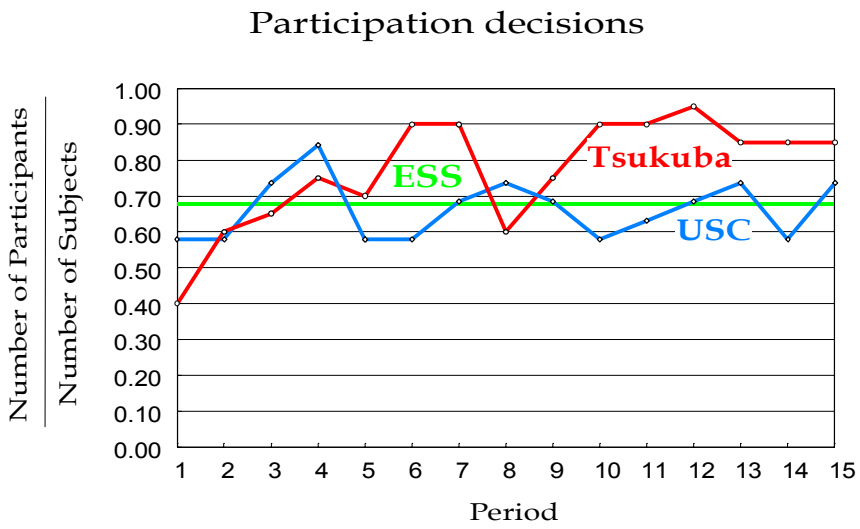
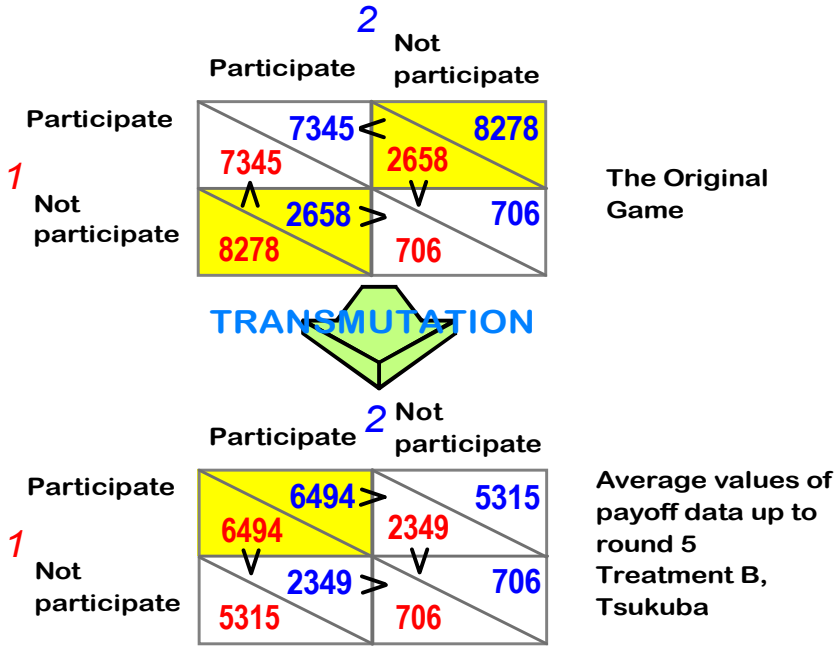
Choose 7 rather than 11
Reduce own payoff from 2658 to 2210 (448 units) 2658 から 2210 448
The other player reduces from 8278 to 2210 7345 to 6526
8278 4018



Comparison of Average Investment Patterns: Tsukuba





Observation 2 (Treatment B):

(a) Regarding the participation ratio, the ESS prediction is supported in the USC data, but not the Tsukuba data

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(b) For the Tsukuba data, the participation ratio rises as round advances and the average investment in the final round in Treatment B is very close to that in Treatment A

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(c) It seems that the source of cooperation is not altruism or kindness but is spiteful behavior of subjects

.

(d) This spiteful behavior eventually leads to more efficient public goods contributions for Tsukuba subjects than for USC subjects

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T. Saijo, and T. Yamato, "A Voluntary Participation Game with a Non-Excludable Public Good," *Journal of Economic Theory*, Vol.84, pp.227-242, 1999.

Tim N. Cason, T. Saijo, and T. Yamato, "Voluntary Participation and Spite in Public Good Provision Experiments: An International Comparison," Working Paper No.29, CREST of Japan Science and Technology Corporation, December, 1998/revised, 2001
http://www.iser.osaka-u.ac.jp/~saijo/researches-e.html

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http://www.iser.iser.osaka-u.ac.jp/~saijo/keisemi/keizaiseminar.html

http://www.iser.osaka-u.ac.jp/~saijo/new.html