Intergroup Conflict versus the Collective Action Problem

Modeling and simulating the relationship between intergroup conflict and intragroup coordination on COBWEB simulation program.

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Abstract

Within every society, humans appear to have the tendency to divide themselves into groups. Groups form when a people identify with each other over common interests, beliefs or goals. Often, the efforts of a group of people can result in some kind of action being taken; however, two threats can exist to a group-- intergroup conflict and intragroup conflict. In his writings, Russell Hardin analyzes the relationship between intragroup preference and intergroup/intragroup conflict, and its effect on society's success; he hypothesizes that as individual groups become more withdrawn and intergroup conflict increases, it results in a failed system where all groups are restricted from thriving. In order to provide Hardin's hypothesis with quantitative data, this study uses COBWEB (Complexity and Organized Behaviour within Environmental Bounds) simulation program in an attempt to recreate scenarios involving various levels of similarity preference and neutral similarity; these variables indicate preference for and bias against ingroup and outgroup members, respectively The success of the system is determined by the success of the population; greater populations yield greater success. The results show that an increase in similarity preference yields greater success, while an increase in neutral similarity shows a decline in success. This conflicts with Hardin's original theory was entirely true; as increased rigidity and decreased cooperation should prevented all agent groups from thriving. It appears that when agents prefer to work with their own kind and groups can peacefully coexist with each other due to lack of intergroup conflict, the agents thrive best. Future findings from this project could potentially be linked to "real world" scenarios involving closed societies; some of this data may be used to explain the relationship between intragroup success and intergroup interactions.

Introduction

People, as defined by the concept of *homo economicus*, are rational, self-interested, and short-sighted. The term is used in several economic theories that explore how decisions are made when it is based entirely around an individual's main goal of maximizing utility, at minimal cost[1]. As humans exist together in the world and are forced to interact with each other, often individuals with the same goal, are placed together in a group. The situation that can arise is one where despite having a common goal among group members, individuals have no personal incentive to act on behalf of the group-- instead, opting to rely on the actions of other members. Thus no action is taken by the group, which is to the detriment of each individual member[2]. This is known as the collective action problem.

The effect of the collective action problem is explored in the works of Russell Hardin, who analyzes the harmful repercussions of group coordination. However in his book, *One For All*, he observes that while this intra-group conflict poses a threat to the group's objectives; there exists a threat beyond this problem. As individuals band together in the name of a common cause; their shared beliefs and common interests are reinforced by other group members, leading to increasing rigidity within the group. This also results in a bias against outgroup members, who may not share the same beliefs. Hardin hypothesizes that as a group becomes more rigid and closes itself off to other groups, there is less cooperation and increased intergroup conflict; which results in a system that restricts any group from thriving, thus leading to the downfall of each individual group[3].

As Hardin's conclusion relies mostly on conceptualizing and examining case studies, this project seeks to test his hypothesis in order to support his theory with quantitative data[4]. COBWEB (Complexity and Organized Behaviour within Environmental Bounds) is a program that simulates the actions of agents within a population after parameters are set on their behaviors. The simulations are run on a two dimensional grid; and later, the results are outputted onto a spreadsheet for further analysis. The simulation settings allow for modifications such as the "Genetics" option, which can be used to establish distinct agent groups; and the "Prisoner's Dilemma" option, which has an effect on how these agent groups cooperate. This makes COBWEB a suitable program to test Hardin's theory.

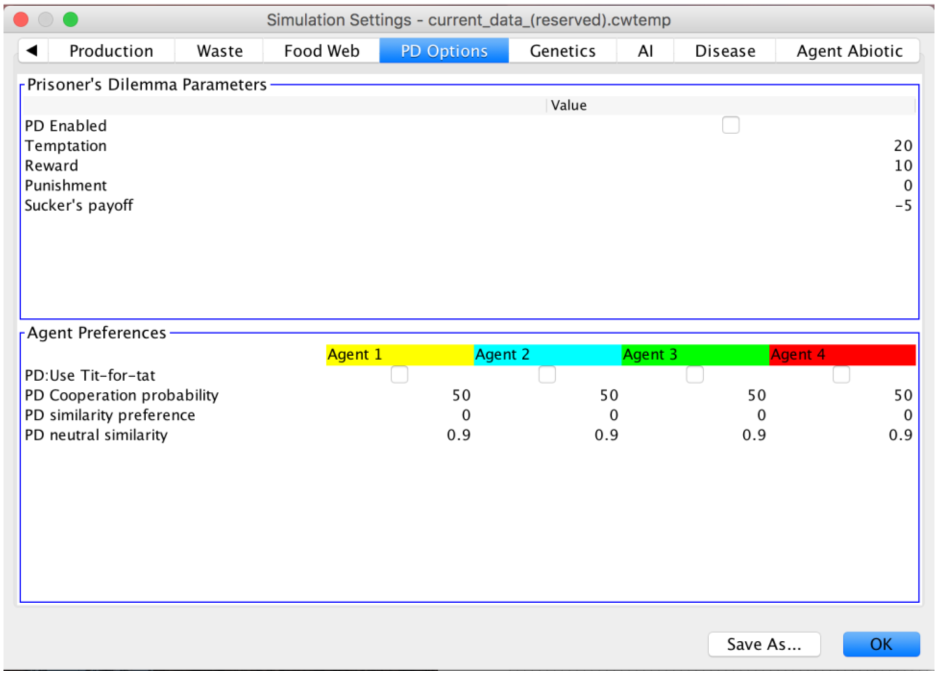
The model for this project is built to test how varying levels of preference towards ingroup members and bias against outgroup members affect intragroup coordination[4]. The total number of surviving agents, as well as the number of surviving agents for each group, will act as indicators for the success of the population. In turn, the effects of preference on cooperation and the system as a whole can assessed. Based off of Hardin's theory, it is hypothesized that increased intra-group preference and increased bias against outgroup members will result in fewer total surviving agents.

Materials and Methods

The tests were run on the February 2015 version of COBWEB. Initially, the genetics of different agents groups are separated by modifying settings in the "Genetics" tabs. Every test for each of the settings were run with randomly generated "AI" (Artificial Intelligence), which are meant to represent different populations of agents. This is done by selecting "Random Seed" for each agent group when modifying the "AI" tab in simulation settings.

“PD Options”

Modifications in the “PD (Prisoner’s Dilemma) Options” settings were made to “Agent Preferences.” These changes influence how agents interact with other agents based on genetic similarity. These settings include cooperation probability, similarity preference and neutral similarity. How two agents interact depends on the similarity of “Genetics.” When there is increased genetic similarity between two agents, cooperation probability is increased. Separating groups by genetics ensures that when two agents of the same agent group interact, they have more cooperation probability than two agents of different groups interact.



Prisoner's Dilemma Parameters

	Value
PD Enabled	☐
Temptation	20
Reward	10
Punishment	0
Sucker's payoff	-5

Agent Preferences

	Agent 1	Agent 2	Agent 3	Agent 4
PD:Use Tit-for-tat	☐	☐	☐	☐
PD Cooperation probability	50	50	50	50
PD similarity preference	0	0	0	0
PD neutral similarity	0.9	0.9	0.9	0.9

Figure 1: Default simulation setting in “PD Options” window.

“PD Similarity Preference”

In these experiments, “PD similarity preference” is set at values between 0 and 1. “PD similarity preference” directly influences the strength of cooperation based on genetic similarity.

With “PD similarity preference” set at higher values, an agent’s willingness to cooperate with like agents will be increased. An agent will be more willing to cooperate with another agent with the same genetics than with a genetically different agent. This setting increases intra-group coordination.

“PD Neutral Similarity”

In these experiments, “PD Neutral Similarity” is set at values between 0 and 1. Based on the genetic similarities between agents, changing the “PD neutral similarity” affects how cooperative agents are. In intra-group settings with interactions between genetically similar agents, increasing neutral similarity from 0 to 1 causes cooperation to fall from increased cooperation to no effect on cooperation. In inter-group settings with interactions between genetically different agents, increasing neutral similarity from 0 to 1 causes cooperation to fall from no effect on cooperation to decreased cooperation. Therefore it can be said that with the increase of neutral similarity, it leads to decreased cooperation between all other agents.

The Tests

20 different settings with various combinations of “PD similarity preference” and “PD neutral similarity” were tested on COBWEB. Each of these settings were tested twenty times, each with modified “AI” in order to test the model’s robustness. Each test was run for 25 000 ticks, and was subsequently logged into a Microsoft Excel file.

Agent groups 1-4 were divided into two groups by genetics; individuals in agent group 1 were given different genetic composition from individuals in agent groups 2-4, who all shared the same genetic composition with each other. This simulates an environment where agent group 1 exists as the minority group, thus making agent groups 2-4 the dominant group.

The agents' genetic composition was adjusted in simulation settings by selecting "Modify Simulation File," and "Genetics." Under this tab are many different parameters that can be selected and added to a list of "Phenotypes"-- or observable characteristics that can be applied to the agents. In this model, "Turn Left Energy" was added and modified so that the genetic codes of Agent 1 was "01111010" and Agents 2-4 were "01110010".

For all of the settings, "PD Cooperation probability" was left at 0; while different combinations of values for the "PD similarity preference" and "PD neutral similarity" parameters were tested. The values for "PD similarity preference" that were tested were 0.25, 0.5, 0.75 and 1. Each of these settings, were tested with each of the different values for "PD neutral similarity," which included: 0, 0.25, 0.5, 0.75, and 1.

With the completion of each test, the results were logged into a Microsoft Excel spreadsheet. Of the information that was presented in the document about the what the agents did, this experiment seeks to observe changes in population count over time. So all of the information under the "AgentCount 1", "AgentCount 2", "AgentCount 3" and "AgentCount 4" columns were selected and graphed by selecting "Insert" and "Line," in order to create a line chart. This offers a visual representation of the total population counts of each agent group over a period of time. Furthermore, observed information included: dominant agent group and whether it belonged to a majority or minority, and the range of population that the dominant agent count fluctuates between.

This information was later compiled into a document which contained a series of twenty charts-- one chart for each simulation setting, with the test number listed as the beginning column and the data collected from each of the twenty tests listed under each subsequent column.

Results

It was found that for the majority of the tests for each setting, the agent group that dominates the simulation belongs to the majority group-- agent groups 2, 3 or 4. The minority agent group, agent group 1, dominates sometimes but not often. These results are considered outliers.

Approximately half of the settings yielded results that show major fluctuations in populations. However, several population patterns exist, including: populations with major fluctuations, constant or relatively constant populations, dying off/declining populations, and steadily inclining populations.

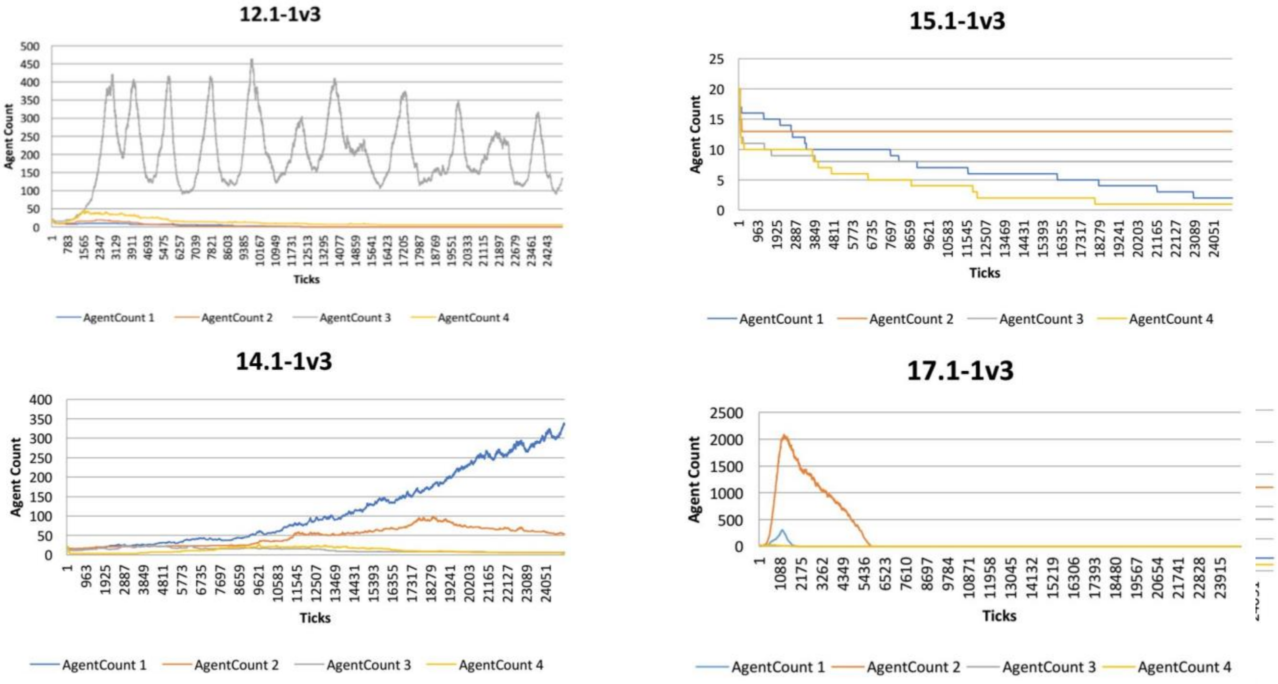


Figure 2: From top left corner counterclockwise to bottom left corner, examples of populations with major fluctuations, constant/relatively constant populations, dying off/declining populations, and steadily inclining populations.

The population range of dominant agents change as similarity preference and neutral similarity values are adjusted. Populations can range from large populations to miniscule populations; and at some points the agent count can be as low as 0. Generally as similarity preference increases, the population of the dominant agent group increases while the other agents counts remain at populations of about 20 agents. As neutral similarity increases, the population of the dominant group decreases while the other agent counts remain at population of about 20 agents.

Population Range

	SP 0.25	**SP 0.5**	**SP 0.75**	**SP 1**
NP 0	(6) High 100s	(11) High 100s	(16) Low 1000s	(21) Mid 1000s
NP 0.25	(7) Mid 100s	(12) Mid 100s	(17) Low 1000s	(22) Low 1000s
NP 0.5	(8) Low 100s	(13) Low 100s	(18) Mid 100s	(23) Mid 100s
NP 0.75	(9) 0-25	(14) Low 100s	(19) Low 100s	(24) Mid 100s
NP 1	(10) 0-25	(15) 0-25	(20) 0-25	(25) 0-25

Figure 3: As similarity preference increases, the population of the dominant agent group increases; as neutral similarity increases, the population of the dominant group decreases.

With each simulation setting, twenty tests were conducted with randomly generated "AI" every time, in order to ensure that the results were generated by the changing variables rather than any other factor. This is because changes in AI do not affect the simulation itself, but it simulates a new population being tested. Usually this did not result in much change in the range or the shape of the graph as a whole, however most tests yielded some kinds of outliers. This occurred as changes in graph shape and/or the population range for each of the agents.

Summary of Tests (Observations)

Test No.	What happened most of the time	Outliers that occurred
6-1v3	Populations fluctuate at around 0-1000; single dominant group thrives all the way; dominant agent group belongs to majority.	Dominating agent group switches but then switches back (5/20); thriving agent group belongs to minority (3/20); fluctuations in populations around 400-200 (5/20)[1]; dominant population fluctuates then dies off (4/20).
7-1v3	Populations fluctuates at around 350-150; single dominant group thrives all the way; dominant agent group belongs to majority.	Dominant population fluctuates before dying off (6/20); dominant agent group switches (5/20); fluctuations in populations around 900-0 (9/20)[2]; thriving agent groups belongs to minority (6/20).
8-1v3	Populations fluctuates at around 400-200; single dominant agent group thrives all the way; dominant agent group belongs to majority; there is a slow incline to population growth.	More than one agent group visibly thrives (5/20); inclines without fluctuating (2/20); population is nearly constant and it ranges around 25-0 (1/20); minority group dominantes simulation (4/20).
9-1v3	Single dominant agent group thrives the entire way; dominant agent group belongs to majority; inclining population with less fluctuations; population ranges around 25-0 (6/20).	Population does not fluctuate, remains flat for many ticks at a time (6/20); Population arounds around 50-5 (3/20); population ranges around 150-0 (4/20); population ranges around 250-0 (2/20); population ranges around 350-0 (5/20); more than one agent group inclines population (2/20); minority group dominates simulation (3/20).
10-1v3	Agent count range between 25-0; dominant agent group belongs to majority; dominant agent group does not thrive significantly more than other groups.	An agent group dies off completely (2/20); minority group dominates simulation (3/20).

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[1] It should be noted that tests 15-20 for 6-1v3 were run on a different day from others with the same parameters.

[2] It should be noted that tests 1-9 for 7-1v3 were run on a different day from others with the same parameters.

11-1v3	Populations fluctuate at around 0-1000; single dominant group thrives all the way; dominant agent group belongs to majority.	Dominating agent group switches (9/20); thriving agent group belongs to minority (5/20); more than one agent group visibly thrives at a time (2/20); dominant population fluctuates then dies off (10/20).
12-1v3	Populations fluctuates at around 500-100; single dominant group thrives all the way; dominant agent group belongs to majority.	Thriving agent groups belongs to minority (4/20); more than one agent group thrives significantly at some point during simulation (9/20).
13-1v3	Populations fluctuates at around 400-100; single dominant agent group thrives all the way; dominant agent group belongs to majority.	More than one agent group thrives significantly, then dies off again (9/20); minority group dominantes simulation (2/20).
14-1v3	Single dominant agent group thrives the entire way; dominant agent group belongs to majority; inclining population with less fluctuations; population fluctuates between 350-200.	Population inclines without fluctuating much (4/20); more than one agent group inclines population (7/20); minority group dominates simulation (5/20); dominant agent group switches (2/20).
15-1v3	Agent count range between 25-0; dominant agent group belongs to majority; dominant agent group does not thrive significantly more than other groups.	An agent group dies off completely (4/20); minority group dominates simulation (1/20).
16-1v3	Populations stays at around 0-6000; more than one agent group visibly thrives at a time; however, the most dominant agent group belongs to majority.	Dominating agent group switches (5/20); thriving agent group belongs to minority (4/20); secondary dominant group die off (4/20); single dominant agent group (3/20).
17-1v3	Populations peak at around 2000; population does not fluctuate much; single dominant group peaks then dies off; dominant agent group belongs to majority.	Thriving agent groups belongs to minority (4/20); agent count fluctuates a couple times at around 1000-0 then inclines and stays at a relatively constant population of 5000 (5/20).
18-1v3	Populations fluctuates at around 700-100; single dominant agent group thrives all the way; dominant agent group belongs to	Minority group dominantes simulation (5/20); dominant group switches (3/20).

	majority; a secondary agent group thrives a little bit before dying off again (12/20).	
19-1v3	Single dominant agent group thrives the entire way; dominant agent group belongs to majority; inclining population with less fluctuations; population fluctuates between 400-200.	More than one agent group inclines population (9/20); minority group dominates simulation (6/20); dominant agent group switches (2/20).
20-1v3	Agent count range between 25-0; dominant agent group belongs to majority; dominant agent group does not thrive significantly more than other groups.	An agent group dies off completely (6/20); minority group dominates simulation (6/20).
21-1v3	Populations are constant at a population of 3000-6000; several agent groups thrive all the way; the most dominant agent group belongs to majority.	Most dominant agent group is minority (6/20); only one agent group visibly thrives at a time (1/20).
22-1v3	Populations are relatively constant at a population of 3500-6000; several agent groups thrive all the way; the most dominant agent group belongs to majority.	Most dominant agent group is minority (3/20); only one agent group visibly thrives at a time (5/20); dominant group switches (7/20).
23-1v3	Populations fluctuates at around 800-100; single dominant agent group thrives all the way; dominant agent group belongs to majority; dominant agent population dies off (13/20).	Dominant agent survives the whole way through (7/20); minority group dominantes simulation (2/20); dominant group switches (4/20).
24-1v3	Populations fluctuates at around 400-150; single dominant agent group thrives all the way; dominant agent group belongs to majority.	More than one agent group thrives significantly, then dies off again (7/20); minority group dominantes simulation (6/20); dominant group switches (5/20).
25-1v3	Agent count range between 25-0; dominant agent group belongs to majority; dominant agent group does not thrive significantly more	An agent group dies off completely (4/20); minority group dominates simulation (5/20).

	than other groups.	

Discussion

Overall, these tests show that increased similarity preference yields more surviving agents, while increased neutral similarity yields fewer surviving agents. These results do not entirely match with the original hypothesis-- that increased similarity preference and neutral similarity results an overall decrease in total agent count. According to the original hypothesis, the system should have fared best with lower neutral similarity and similarity preference; as this would simulate a system that encourages more cooperation between all agents, regardless of what group they belong to. However, agents were most successful when there was lower neutral similarity and an increased preference for one’s own group.

Explanation of the Effects of “Similarity Preference” and “Neutral Similarity”

In these tests, it seems as though changing the “similarity preference” values had a greater effect over agent count than any other variable. This makes sense because increased similarity preference results in a direct preference for one’s own agent group, which also causes agents to discriminate against outgroup members. As a result, agents interact more with their own agent group, which wills them to breed more with each other; thus, increasing their population. Since these settings remained in positive and increasing values, understandably, the increasing population counts would correspond to the increasing preference for like-agents.

Generally, the increasing values in “neutral similarity” leads to a decrease in the total agent count. When agents have extra-cooperation with like-agents and no preference for unlike-agents, they are more cooperative and interact more with other agents, in general. As neutral similarity increases, this extra-cooperation between like-agents starts to disappear and bias against unlike-agents appears. As a result, agents are less sociable in general; which leads to decreased interactions with other agents. Thus, increasing neutral similarity yields fewer total surviving agents.

Analysis of Gridlock Scenario Where Multiple Agent Groups Thrive

Agent count is highest when “similarity preference” values high (at “0.75” and “1.0”) while “neutral similarity” values are low (“0.0” and “0.25”). These parameters, when combined, yield the expected results; the agent population take over nearly the entire grid-- the system becomes gridlocked. The increased preference for genetically similar agents combined with the extra cooperation drives like-agents to interact with each other. This increased interaction leads to more births and an increase in population. This is occurs consistently in tests 16, 21, and 22.

Furthermore, when the gridlock scenario is exhibited, there also tends to exist the situation where multiple agent groups thrive. The lack of intergroup conflict likely allows for group members to ignore outside conflict and focus building relationships with other ingroup members. This leads to greater success for the dominant group, but it also leads to greater success for all groups. Agents directly prefer to work with their own kind, but the lack of conflict between groups allow for them to peacefully coexist with each other.

Analysis of Scenario Where Population Remains Miniscule

It has been observed that for all the tests with neutral similarity set at “1”, all populations counts are within the same range-- at 0-25-- regardless of similarity preference value. When neutral similarity is set at 0, there is no extra cooperation between like-agents, but more conflict between unlike-agents. Due to this, it can be inferred that these tests display a situation where the collective action problem takes place: agents are forced to work with agents who share their genetic composition due to their bias against outgroup members. However, they do not have the willingness to cooperate with their group members, as they are also much more self interested. No agent takes action on behalf of the group, and this lack of willingness to cooperate with others comes at the group's own detriment. Nothing is accomplished, so agent populations never thrive and remain miniscule.

Conclusion

Relating back to Hardin's theory, rigid groups do not restrict agent groups from thriving; however, the decreased cooperation and increased group conflict does restricts groups from thriving. Thus, these tests do not entirely prove the original hypothesis; as an increase in similarity preference and neutral similarity did not lead to an overall decrease in population. If his theory was entirely true, increased rigidity and decreased cooperation should have led to the failure of the system.

Overall, similarity preference has a greater effect over the simulations; these tests appear to prove that agents are more successful when agent groups are closed off from one another, and there is a lack of intergroup conflict. The results of these tests could be linked back to scenarios involving societies that want to withdraw themselves from the world and predicting the potential repercussions of taking this form of action. It seems to suggest that distinct groups could potentially thrive best if they peacefully co-existed independently of each other. Of course, it should be noted that COBWEB is not meant to simulate "real life," as it cannot truly express the complexities of individuals and social interactions. The program itself simply analyzes overarching trends that a population expresses when certain parameters are set.

To conclude, the next steps for this project would be to test different values of cooperation probability. Since all of these tests were run with cooperation probability left at zero; this third variable should be tested at different values with different combinations of similarity preference and neutral similarity in order to analyze the effect it has over the system. Furthermore, these tests should additionally be run on updated versions of COBWEB in order to test the robustness of the model.

Abbreviations

Abbreviation	**Full Form**
"COBWEB"	(Complexity and Organized Behaviour within Environmental Bound)
"AI"	(Artificial Intelligence)
"PD"	(Prisoner's Dilemma)
"SP"	(Similarity Preference)
"NP"	(Neutral Similarity)

Key Words

Cooperation; intergroup; intragroup; conflict; society.

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