ROLE OF OPTIMIST ON EMERGENCE OF COOPERATION IN DEMOGRAPHIC MULTI-ATTRIBUTE DONOR-RECIPIENT GAME

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ABSTRACT

We consider an interaction between a donor and a recipient where the actions of a donor produce multiple results to the recipient. There are Optimists and Pessimists who focus on the best and worst outcomes among them as a recipient of the interaction, respectively, and they try to reflect on their experience in their next action as a donor. What is the effect on the emergence of cooperation? This paper formulates the situation as a Demographic Multi-attribute Donor-Recipient game and introduces also Average, who focuses on the average outcome and considers the effect of the initial distribution of them on the emergence of cooperation by Agent-Based Simulation. If the initial population includes only one type from Pessimist, Optimist, or Average, then the emergence rate of cooperation increases in this order. In particular it is very low with only the Pessimist. The emergence rate of cooperation in case of initial populations including both Optimist and Pessimist is larger than that of the initial population including only the Optimist. Thus the Optimist is crucial for a high emergence rate of cooperation in realistic initial populations including the Pessimist.

INTRODUCTION

We introduce personal characters of players (agents), the Optimist, the Pessimist, and the Average, and investigate the role of the Optimist against the Pessimist on the emergence of cooperation in a Demographic Multi-attribute Donor-Recipient (DR) game.

Epstein (2006) introduces his demographic model. He shows the emergence of cooperation where AllC and AllD are initially randomly distributed in a square lattice of cells. In each period, players move locally (that is, to a random cell within the neighboring 4 cells, that is, the north, west, south, and east cells; or von Neumann neighbors, if unoccupied) and play the Prisoner's Dilemma (PD) game against local (neighboring) player(s). Here AllC always Cooperates and AllD always Defects. If wealth (accumulated payoff) of a player becomes negative or his age becomes greater than his lifetime, he dies. If his wealth becomes greater than some amount and there is an unoccupied cell in a von Neumann neighbor, he has offspring and gives the offspring some amount from his wealth. Thus the local interaction in the spatial structure is an important element in the emergence of cooperation. Namekata and Namekata (2011 and 2012) extend Epstein's original model discussed above by introducing a global move, a global play, and a Reluctant player into a demographic PD or DR game. Reluctant players delay replying to changes and use extended forms of tit-for-tat (TFT). Here, TFT Cooperates in the first game and in later games uses the same move as his opponent did in the previous game. They show cases where the reluctance to respond the opponent's change promotes the emergence of cooperation. Thus, this reluctance, which is a personal character of players, is an important element to promote cooperation. They also show that cooperative strategies evolutionarily tend to move and play locally, defective do not. Szabó and Hauert (2002) consider the effect of voluntary participation on the emergence of cooperation in PD games on square lattice or random regular graphs. Besides usual AllC and AllD in the PD game, they introduce the third player called the Loner in their model. Loners do not participate in the PD game. When every player plays a game against a Loner, he and the Loner always obtain the fixed payoff that is better than the payoff between two AllD's and worse than the payoff between two AllC's. In their voluntary participation model, two players actually play a different game other than the PD game if at least one of them is Loner. Namekata and Namekata (2014) investigate the effect of stochastic participation in a game on the emergence of cooperation in a Demographic Donor-Recipient Game. They show that the emergence rate of cooperation is fairly small if the initial population contains players who have Low participation probability if he is a Donor and a probability of one if he is a Recipient, but introducing variableness of these probabilities in terms of his recent experience as a Recipient promotes cooperation.

Szabó and Szolnoki (2012) deal with two-strategy (C or D) games including a PD game in a spatial structure (a square lattice) and introduce a Fraternal player. A player on the lattice plays the games against his nearest

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neighbors and calculates his utility that depends on his and co-players' payoff. A player chosen at random changes from his current move to an opposite move, that is, from C to D, or from D to C, in order to maximize stochastically his utility. The Fraternal player calculates his utility by averaging his own and a co-players' payoff. They show that the stationary pattern of C or D does not fall into a state of the "strategy of the commons" and gives the maximum total payoff if the system starts initially with the fraternal players. Zagorsky, Reiter, Chatterjee, and Nowak (2013) consider all strategies that can be implemented by one and two-state automata in a strictly alternating DR game and observe a convergence to some equilibria, one of which represents a cooperative alliance of several strategies, dominated by a Forgiver. In each period, two strategies in the population play strictly alternating DR games some fixed number of times. Frequencies of strategies in the population over continuous periods are determined by a usual replicator dynamics. The Forgiver cooperates whenever the opponent has cooperated; it defects once when the opponent has defected, but subsequently the Forgiver attempts to re-establish cooperation even if the opponent has defected again. The Fraternal player and the Forgiver represent human behavioral features that relate to cooperation.

In general, interaction structures for the evolution of cooperation in dilemma situations are classified into five mechanisms, some of which are (reduced to) spatial structure, direct reciprocity, and indirect reciprocity (Nowak 2012; Nowak and Sigmund 2005). Here an interaction structure specifies how players interact to accumulate payoff and to compete for reproduction. Spatial structure means that players are embedded on a square lattice of cells, they stay at their original position or may dynamically move around the lattice, and they basically play games against their nearest neighbors. Direct reciprocity assumes that a player plays games with the same opponent repeatedly and he determines his move depending on the moves of the same opponent. If a player plays games repeatedly and the opponents may not be the same, indirect (downstream) reciprocity assumes that the player determines his move against the current opponent depending on the previous moves of this current opponent, or indirect upstream reciprocity, or generalized reciprocity, assumes that the player determines his move against the current opponent depending on the previous experience of his own. Epstein (2006) uses spatial structure. Namekata and Namekata (2011, 2012, and 2014) use spatial structure and generalized reciprocity. Szabó and Hauert (2002) use spatial structure. Szabó and Szolnoki (2012) and Zagorsky, Reiter, Chatterjee, and Nowak (2013) use direct reciprocity.

We are interested in human behavioral features that relate to cooperation. Let us imagine a situation where a person (as a donor) invites another person (as a recipient) to dinner. They are interested in, for example, the following aspects (attributes): (1) Is the quality of the dinner good or not? (2) Is the dinner ready on schedule or not? (3) Is the room for the dinner neat and clean or not? It requires some effort of (cost to) the donor in order for the recipient to get benefit by, for example, experiencing a good quality dinner. By the benefit of only one attribute, an optimistic recipient may have the impression that the donor is cooperative. However, it may require all benefits of three attributes for a pessimistic recipient to have the impression that the donor is cooperative. This impression as a recipient may adjust his next action as a donor. This paper considers the role of Optimist against Pessimist on the emergence of cooperation.

MODEL

We start with extending the TFT as follows in order to introduce a reluctant strategy: Let m+1 represent the number of states, $t\in\{0,...,m+1\}$, and $s\in\{0,...,m\}$. The inner states of a strategy (m,t;s) are numbered 0,1,...,m. The state i is labeled D_i if $i<t$ or C_i if not. If the current state is labeled C or D, then the strategy prescribes using C or D, respectively. In other words, the strategy prescribes using D if the current state $i<t$ but using C if not; thus the value t is the threshold which determines the move of the player. The initial state is state s; its label is D_s if $s<t$ or C_s if not. If the current state is i, then the next state is basically $\min\{i+1,m\}$ or $\max\{i-1,0\}$ given that the opponent uses C or D, respectively, in this game. If $m>1$, then the strategy may delay replying to its opponent’s change. Note that TFT is expressed as (1,1;1) in this notation. Thus a strategy (m,t;s) is an extended form of TFT. To sum up, our strategies are expressed as (m,t;s); m is the largest state number, t is the threshold, and s is the initial state number. The initial state is denoted as (m,t;*) if it is determined randomly. We also omit the initial state like (m,t) if we have no need to specify it. We also call the inner state, “Cooperation Indicator” (abbreviated as CI). Note that a reluctant strategy (m,t;s) by itself decides its move against the current opponent depending on its own previous experience, meaning indirect upstream reciprocity, that is, generalized reciprocity. We set m=2 in this paper. AllC is denoted by (2,0) and AllD by (2,3).

We deal with a Multi-attribute DR game as a stage game. A Multi-attribute DR game has K (=3) attributes and is a two-person game where one player is selected as a Donor and the other as a Recipient randomly. A Donor has two moves for each attribute, Cooperate (C) and Defect (D). For each attribute, C means Donor pays cost c of the attribute in order for Recipient to receive benefit b of the attribute ($b>c>0$). Defect means the Donor does nothing. Note that the Recipient has no move. The payoff of the Multi-attribute DR game is the sum of all payoffs among the K attributes. For the sake of simplicity, players are supposed to think that all K attributes are basically independent and to have K reluctant strategies an i-th of which is used for the i-th attribute (i=1,...,K). Thus the CI of the reluctant strategy for an attribute j changes basically by the move for the attribute j. We assume that each player plays 8 games against (possibly different) players at each period. Since it is common in demographic dilemma games that the sum of payoffs of a player, in two successive games - once as a Donor and once as a Recipient, to be positive if the opponent uses C and negative if D; and the worst sum of a player is equal to the best sum in absolute value, we therefore transform the original payoffs to new ones by subtracting the constant x. Constant x is given by $(b-c)/4$. We set b=6 and c=1 in this paper. Table 1 shows the transformed payoff matrix for each attribute of the Multi-attribute DR game.

Table 1: Payoff Matrix for each attribute of the Multi-attribute DR Game

		Recipient
Donor	C	$-c-x, b-x$
	D	$-x, -x$

In this paper, we introduce three human personal characters, Optimist, Pessimist, and Average, into our model. Optimist, Pessimist, and Average focus the best, the worst, and the average outcome of a Multi-attribute DR game as a recipient, respectively, and try to reflect on their experience for the next move as a donor. After a Multi-attribute DR game, for example, with one C move and two D moves for all three attributes, an Optimist focuses on the best outcome C, feels that he is treated cooperatively on the whole in the game, and adjusts the CI's of his three reluctant strategies in the following way: He increases the CI of his reluctant strategy for the attribute with move C, whereas he does not decrease the CI's of his reluctant strategies for the attributes with move D and keeps them the original states because he was treated cooperatively on the whole during the game. A full description of the adjustment of CI is given in Table 2. The first column indicates the moves for attributes of Donor, the second to the fourth shows the adjusted changes for the corresponding attributes of CI's by Optimist, Pessimist, and Average as a Recipient, respectively, where "+" and "–" mean basic changes (increase and decrease) of CI's and "0" means that the basic change is actually canceled by the Recipient's character. Thus Optimist tends to be more cooperative than Average, and Average more than Pessimist.

Table 2: Adjusted change of CI by Optimist, Pessimist, and Average

	O	P	A
CCC	+++	+++	+++
CCD	++0	00–	++0
CDD	+00	0––	0––
DDD	–––	–––	–––

A player has the following properties that are inherited from parents to offspring; character, three-tuple of strategies, rateOfGlobalMove (*rGM*), and rateOfGlobalPlay (*rGP*); whose initial distributions are summarized in Table 3.

In period 0, N (=100) players (agents) are randomly located in a 30-by-30 lattice of cells. The left and right borders of the lattice are connected. If a player moves

Table 3: Initial Distributions of Inheriting Properties

property	initial distribution
character	We deal with 7 distributions, P, O, A, O+P, O+A, P+A, and O+P+A, where P, O, and A represent Pessimist, Optimist, and Average, respectively, and O+P+A, for example, means the character is selected randomly from Optimist, Pessimist, and Average.
strategies	Three elements in three-tuple of strategies are independent and each element is identically distributed with Rlct-2:={(1/4)(2,0), (1/4)(2,1;*), (1/4)(2,2;*), (1/4)(2,3)}. Rlct-2 means Reluctant strategies with m=2. Rlct-2 implies that with a probability of 1/4 strategy (2,0) (AllC) is selected, with a probability of 1/4 strategy (2,1;*) is selected, and so on, where * indicates that initial state is selected randomly. Note that initially 50% of players use C on the average since both AllC and AllD are included with the same probability and so are both $(m,t;*)$ and $(m,m-t+1;*)$.
(*rGM*,*rGP*)	We deal with distribution, {(1/4)ll, (1/4)lg, (1/4)gl, (1/4)gg}. For example, gl means *rGM* is distributed in interval g and *rGP* in interval l, where l:=(0.05,0.2) and g:=(0.8,0.95), indicating to move globally and play locally. {(1/4)ll, (1/4)lg, (1/4)gl, (1/4)gg} means *rGM* and *rGP* are selected randomly among ll, lg, gl, and gg.

Table 4: Detailed Description of Move and Play

(1)	With probability *rGM*, a player moves to a random unoccupied cell in the whole lattice. If there is no such cell, he stays in the current cell. Or with probability $1-rGM$, a player moves to a random cell in von Neumann neighbors if it is unoccupied. If there is no such cell, he stays in the current cell.
(2)	With probability *rGP*, the opponent against whom a player plays the dilemma game is selected at random from all players (except himself) in the whole lattice. Or with probability $1-rGP$, the opponent is selected at random from von Neumann neighbors (no interaction if there are no neighbors). This process is repeated 8 times. (Opponents are possibly different.)

(1) describes move and (2) describes play in detail.

outside, for example, from the right border, then he comes inside from the left border. The upper and lower borders are connected similarly. Players use three-tuple of strategies, each of which is (*m*,*t*;*s*) form. The initial wealth of every player is 6. Their initial (integer valued) age is randomly distributed between 0 and deathAge (=50).

In each period, each player (1^{st}) moves and (2^{nd}) plays Multi-attribute DR games against other players. Positive payoff needs opponent's C. (The detailed description of (1^{st}) move and (2^{nd}) play is given in Table 4.) The payoff of the game is added to his wealth. If the resultant wealth is greater than fissionWealth (=10) and there is an unoccupied cell in von Neumann neighbors, the player has an offspring and gives the offspring 6 units from his wealth. His age is increased by one. If the resultant wealth becomes negative or his age is greater than deathAge (=50), then he dies. Then the next period starts.

In our simulation we use synchronous updating, that is, in each period, all players move, then all players play, then all players have offspring if possible. We remark that the initial state of the offspring's strategy for attribute *i* is set to the current state of the parent's strategy of the same attribute *i*. There is a small mutationRate (=0.05) with which inheriting properties are not inherited. The initial distributions of inheriting properties given in Table 3 are also used when the mutation occurs. We assume that with errorRate (=0.05) a player makes mistake when he makes his move. Thus AllC may defect sometimes.

Note that the initial distribution of a strategy is Rlct-2 (including AllC, (2,1), (2,2), and AllD). Also note that a player moves and plays locally or globally with high probability, thus there are 4 move-play patterns such as ll, lg, gl, and gg.

Especially note that there are three characters, O, P, and A, and the initial distribution of characters is one of 7 distributions, P, O, A, O+P, O+A, P+A, and O+P+A. They are all possible combinations where the number of characters in the population is 1, 2, or 3 and the character(s) is (are) selected at random in the population.

SIMULATION AND RESULT

Our purpose to simulate our model is to examine the role of Optimist against Pessimist on the emergence of cooperation and the distribution of average strategies. We use Repast Simphony 2.2 to simulate our model.

We execute 300 runs of simulations in each different setting. We judge that cooperation emerges in a run if there are more than 100 players and the average C rate is greater than 0.2 at period 500, where the average C rate at a period is the average of the player's average C rate at that period over all players, and the player's average C rate at the period is defined as the number of C moves used by the player, divided by the number of games played as a Donor at that period. (We interpret 0/0 as 0.) This average C rate is the rate at which we see cooperative move C as an outside observer. We call a run in which the cooperation emerges as a successful run. Since the negative wealth of a player means his death in our model and he has a lifetime, it is necessary for many players to use C so that the population does not become extinct. We are interested in the emergence rate of cooperation (Ce), that is, the rate at which the cooperation emerges.

Emergence Rate of Cooperation, Ce

What is the effect of introducing human personal character, Optimist, Pessimist, and Average, on the emergence of cooperation? We summarize the emergence rate of cooperation, Ce, in Table 5. The first column indicates the initial distribution of character and the second Ce. Its graph is depicted in Fig 1. Ce for P is 0.067 and is very small (the minimum) compared with other values. Ce's for P, O, and A increase in this order. Note that Ce for Optimist is not larger than Ce for Average. Although the maximum of Ce's is attained for O+A, the initial distribution only with Optimist and Average (excluding Pessimist) is unrealistic Utopia. Among the other initial distributions, P+A, O+P, and O+P+A, Ce for P+A is small but Ce's for O+P and O+P+A are as large as Ce for A. Especially Ce for O+P is larger than both Ce's for P and O. We conclude the following observation:

1. Emergence rates of cooperation, Ce's for the initial distribution consisting of only one character, Pessimist, Optimist, and Average, increase in this order. Thus Ce for Optimist is not the maximum of these three. If the initial distributions consist of more than one character and include Pessimist, Optimist is crucial for a high Ce. Optimist promotes cooperation better with other character(s) than with only itself.

Table 5: Emergence Rate of Cooperation, Ce

	Ce
P	0.067
O	0.557
A	0.733
P+A	0.283
O+P	0.680
O+A	0.840
O+P+A	0.700

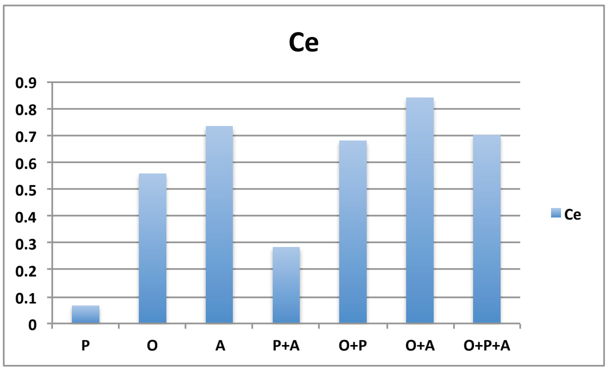

Fig 1: Emergence Rate of Cooperation, Ce for Various Initial Distributions of Characters

Distributions of Characters, Move-play Patterns, and Strategies at Period 500 for The Initial Distribution O+P+A

We concentrate on the most realistic initial distribution of characters, that is, O+P+A and investigate distributions of characters, move-play patterns, and strategies over the successful runs at period 500. First we examine average C rates of characters in average strategies. An average strategy of 3-tuple of reluctant strategies ((2,t_0), (2,t_1), (2,t_2)) is defined as (2,t_{Ave}), where t_{Ave} is the nearest integer to (t_0+ t_1+ t_2)/3. Table 6 shows the correspondence between the reduced form of 3-tuple of reluctant strategies (in the first and the third columns) and its average strategy (in the second and the fourth columns). A reduced form of 3-tuple of reluctant strategies, for example, C1D, represents all permutations of AllC, (2,1), and AllD. Hereafter we use the reduced forms of strategies instead of 3-tuple of the reluctant strategies themselves and call them simply strategies. Shaded CCC, CCD, CDD, and DDD have NO difference between their types of characters because their actions are constant regardless of their CI's. Fig 2 depicts average C rates of characters in average strategies. Av.AllC has similar average C rates among all characters, P, O, A, and NO. Thus introducing characters P, O, and A has little influence on Av.AllC. Av.(2,1) has larger average C rate for O and A than for P and NO. Thus we regard Av.AllC and Av.(2,1)(O+A) as cooperative in the sense that they have large average C rate, where Av.(2,1)(O+A) indicates the portion of Av.(2,1) with character O or A.

Table 6: Average Strategy

	Av.Strategy		Av.Strategy
CCC	Av.AllC	C2D	Av.(2,2)
CC1		11D	
C11	Av.(2,1)	122	
CC2		CDD	
111		12D	
C12		222	
CCD		1DD	
112		22D	
C22		2DD	Av.AllD
C1D		DDD	

C, 1, 2, and D in the first and third column mean AllC, (2,1), (2,2), and AllD, respectively. Three letters from them are arranged in the order of C, 1, 2, and D.

Let x and y be the frequency of Av.AllC and that of Av.(2,1)(O+A) over the successful runs at period 500. A scatter graph (x,y) is shown in Fig 3. We divide the whole plane into 5 regions, Case A, Case B, Case C, Case D, and the rest. Case A represents x>0.3 and y<=0.4. Case B indicates x<=0.3 and y>0.4. Case D represents x<0.05 and y<0.25. Case C is given by x<=0.3 and y<=0.4 excluding Case D. The rates of Case A, B, C and D over all successful runs are 55.7%, 29.5%, 13.8%, and 1.0%, respectively. We ignore Case D because the rate 1.0% is very small. Thus Av.AllC dominates Av.(2,1)(O+A) in Case A (55.7%). Av.(2,1)(O+A) dominates Av.AllC in Case B (29.5%). Av.AllC and Av.(2,1)(O+A) coexist in Case C (13.8%). Fig 4 shows the corresponding scatter graph between AllC and (2,1) over the successful runs at period 500 when the characters, Optimist, Pessimist, and Average are not introduced. (Emergence rate of cooperation of this no character situation is 64.7%.) The rates of Case A, B, and C over all successful runs are 71.1%, 14.4%, and 14.4% in Fig 4. The important difference between Figs 3 and 4 is that the quantity of about 15% moves from Case A in Fig 4 to Case B in Fig 3. That is, the rate that (2,1) (Av.(2,1)(O+P)) dominates AllC (Av.AllC) is decreased (increased) by about 15% because of introducing the characters, Optimist, Pessimist, and Average.

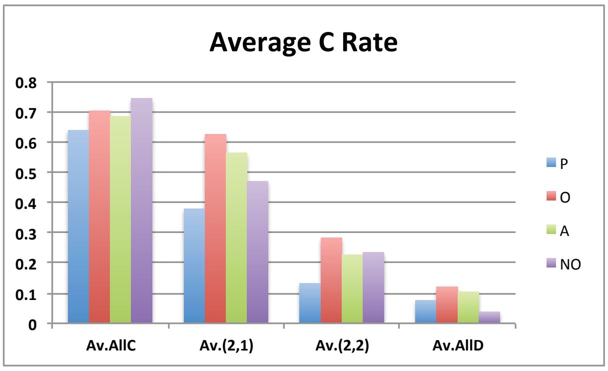

Fig 2: Average C Rate of Characters in Av.Strategies

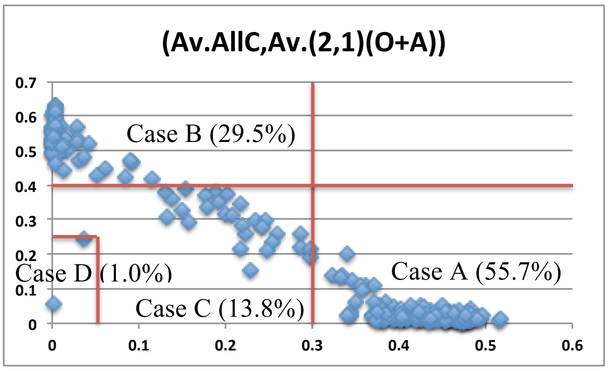

Fig 3: Scatter Graph (x,y), where x and y are the frequency of Av.AllC and that of Av.(2,1)(O+A)

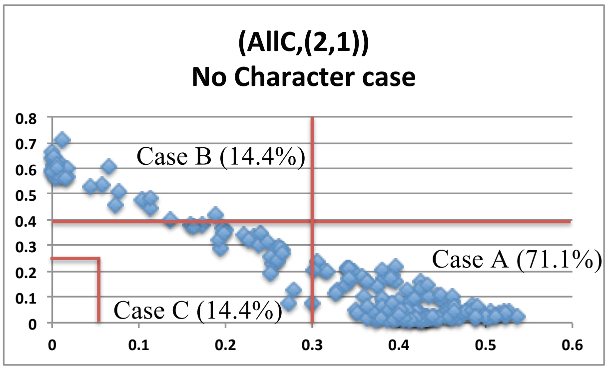

Fig 4: Scatter Graph (x,y) of No Character Case, where x and y are the frequency of AllC and that of (2,1)

Let us examine distribution of characters over the successful runs at period 500 in each case. Fig 5, Fig 6, and Fig 7 show the distribution of characters in Case A, Case B, and Case C, respectively. First we examine common features in Case A, B, and C. Av.AllD consists almost of NO and Pessimist. Here NO means DDD. Although the share of Av.(2,2) is small, Av.(2,2) consists of many Pessimists. Thus there are many Pessimists in Av.(2,2) and Av.AllD (that is, 2DD).

Case A consists of more than 55% of the successful runs. In Case A Av.AllC and Av.AllD have a large share. Optimist exists in Av.AllC, more specifically, CC1, but the rate of Optimist over all population is very small. Thus it is expected that Optimist plays a limited role in the emergence of cooperation in Case A.

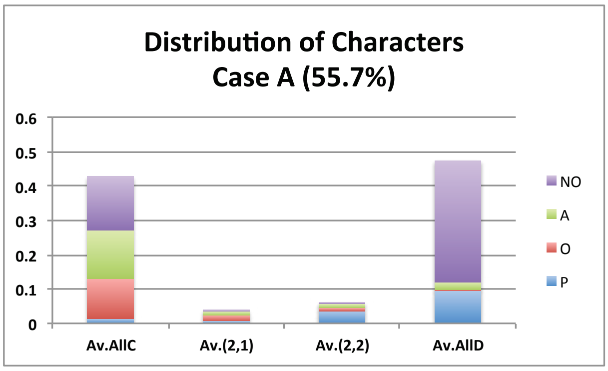

Fig 5: Distribution of Characters, Case A (55.7%)

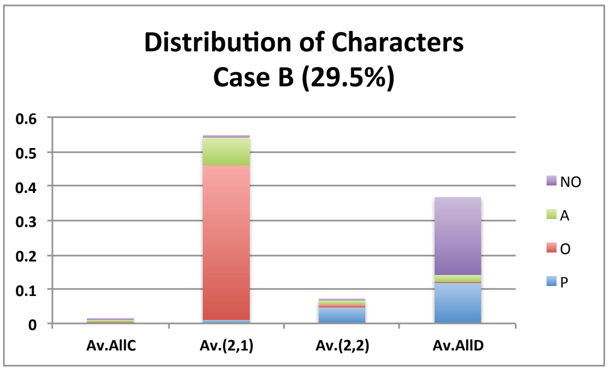

Fig 6: Distribution of Characters, Case B (29.5%)

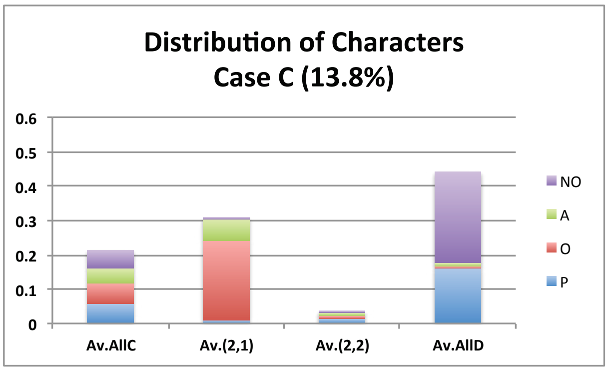

Fig 7: Distribution of Characters, Case C (13.8%)

Case B has about 30% of all successful runs. In Case B Av.(2,1) consists of quite a few Optimists. There exists almost no Av.AllC. Thus we expect that Optimist in Av.(2,1) is crucial for the emergence of cooperation. Because of introducing the characters, Optimist, Pessimist, and Average, Av.(2,1) increases, Optimists become the great majority of Av.(2,1), and therefore they promote cooperation. We observe typically the role of Optimist among all characters (specifically against Pessimist) on the emergence of cooperation in Case B.

Case C consists of about 14% of all successful runs. In Case C both Av.AllC and Av.(2,1) coexist. Av.(2,1) is made up of quite a few Optimists. Thus Optimist plays some but limited role in the emergence of cooperation in Case C. We summarize the following observation about distribution of characters:

2. Average AllC promotes cooperation at about 55% of the successful runs, whereas average (2,1) strategy consists of quite a few Optimists and thus promotes cooperation at about 43%.

Next we examine distribution of move-play patterns over all successful runs at period 500. The distribution is given in Fig 8. Av.AllC and Av.(2,1) move locally and play locally, whereas Av.(2,2) and Av.AllD play globally. This result is consistent with that in Namekata and Namekata (2012). Since Pessimist and NO become extinct in Av.(2,1) and average C rates of Av.(2,2) and Av.AllD is small, we summarize the following observation about distribution of move-play patterns:

3. Cooperative strategies move locally and play locally evolutionarily, whereas non-cooperative strategies play globally evolutionarily.

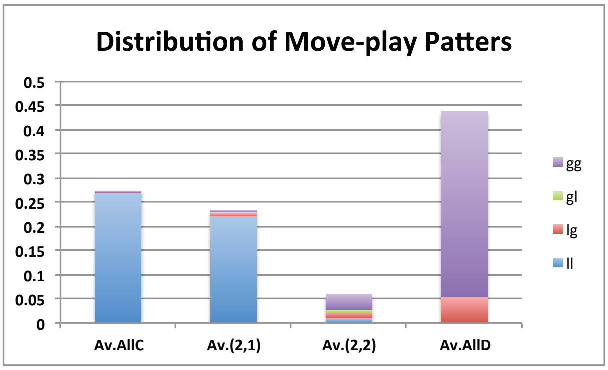

Fig 8: Distribution of Move-play Patterns

Finally we consider distribution of strategies themselves rather than the average strategies. Fig 9, 10, and 11 depict the distribution of strategies in Case A, B, and C, respectively. Av.AllC consists of CCC and CC1. The rate of CC1 is larger than that of CCC in Case A and C. Av.AllD consists of DDD and 2DD. The rate of DDD is larger than that of 2DD in Case A, B, and C. C11, C12, and CC2 are members of Av.(2,1). They include at least one C and their average threshold are not larger than 1. The rate of C11 is larger than that of C12, which is larger than that of CC2 in Case B and C. We summarize the following observation about the distribution of strategies:

4. Strategies other than 7 strategies, CCC, CC1, C11, CC2, C12, 2DD, and DDD, become extinct evolutionarily. DDD is most popular among

strategies including D. CC1 or C11 is most popular among strategies including at least one C.

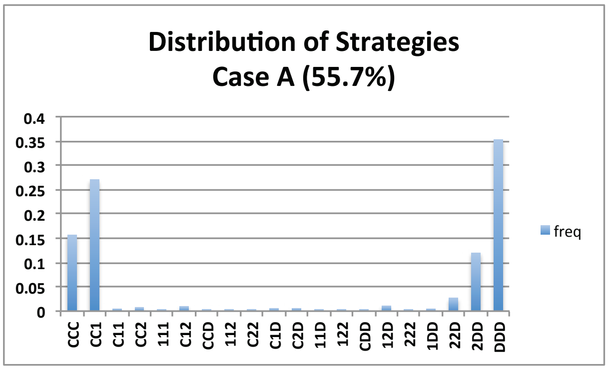

Fig 9: Distribution of Strategies, Case A

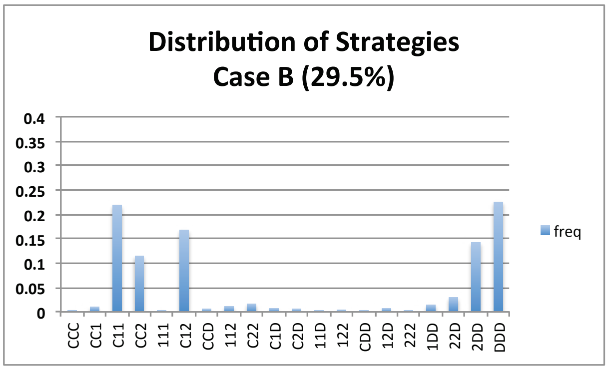

Fig 10: Distribution of Strategies, Case B

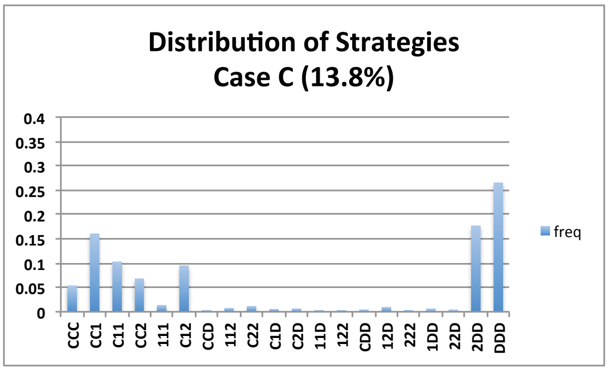

Fig 11: Distribution of Strategies, Case C

CONCLUSION

We investigate the role of Optimist against Pessimist on the emergence of cooperation in Demographic Multi-attribute Donor-Recipient game. We show, by Agent-Based Simulation, that Optimist promotes the emergence of cooperation in the initial population even with Pessimist, in comparison to the initial population of only Optimist. We also show that Av.(2,1) strategy consists of many Optimists.

Let us return to our example of inviting a person to dinner given in the Introduction. Suppose plausibly that there are Pessimists who focus on the worst attribute of the outcomes and adjust their next actions accordingly. Our result suggests that Optimists play a crucial role to promote cooperation.

Our future research is to find some feature of a player other than optimist, which is oriented toward cooperation, and to investigate its effect on the emergence of cooperation.

REFERENCES

Epstein, J. M. 2006. “Zones of Cooperation in Demographic Prisoner's Dilemma.” In: *Generative Social Science*. Princeton University Press, 199-221.

Namekata, T. and Y. Namekata. 2011. “Effect of Reluctant Players in Demographic Prisoner's Dilemma Game.” In: R. Bartak (ed.): *Proceedings of the 14th Czech-Japan Seminar on Data Analysis and Decision Making under Uncertainty* (held in September 18-21, 2011, Hejnice, Czech Republic), 102-109.

Namekata, T. and Y. Namekata. 2012. “Emergence of cooperation and patterns of move-play in Demographic Donor-Recipient Game.” In: Masahiro Inuiguchi, Yoshifumi Kusunoki and Hirosaki Seki (eds.): *Proceedings of the 15th Czech-Japan Seminar on Data Analysis and Decision Making under Uncertainty* (held in September 24-27, 2012 Osaka, Japan), 51-58.

Namekata, T and Y. Namekata. 2014. “Effect of Stochastic Participation in Demographic Donor-Recipient Game.” In Junzo Watada and Haiyu Yu eds., *Proceedings of the 17th Czech-Japan Seminar on Data Analysis and Decision Making* (held in September 16-19, 2014, Kitakyushu, Japan).

Nowak, M. A. 2012. "Evolving cooperation." *Journal of Theoretical Biology* 299, 1-8.

Nowak, M. A. and K. Sigmund. 2005. “Evolution of indirect reciprocity.” *Nature*, No. 437, 1291-1298.

Szabó, G. and A. Szolnoki. 2012. "Selfishness, fraternity, and other-regarding preference in spatial evolutionary games." *Journal of Theoretical Biology* 299, 81-87.

Szabó, G. and C. Hauert. 2002. "Evolutionary prisoner’s dilemma games with voluntary participation." *Physical Review* E 66, 06293.

Zagorsy, B. M., J. G. Reiter, K. Chatterjee, and M. A. Novak. 2013. "Forgiver Triumphs in Alternating Prisoner's Dilemma." *PLoS ONE* 8(12): e80814. doi:10.1371/journal.pone.0080814.

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