The Effect of Indifference and Compassion on the Emergence of Cooperation in a Demographic Donor-Recipient Game

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Abstract A player in a game sometimes does not fully understand the situation of the game. We regard him in this state as being indifferent to the game. He needs to experience the games some times in order to escape being indifferent to the game and to fully understand the situation of the game. It is also an important factor in his experience how other players deal with him when he is indifferent to the game. We model this situation into a Demographic Donor-Recipient game. We investigate their effect on the emergence of cooperation by Agent-Based Simulation.
We observe the following main results under some reasonable assumptions by Agent-Based Simulation: (1) If indifferent players are supposed not to escape from being indifferent to the game, then the cooperation almost does not emerge. (2) If indifferent players are supposed to escape from being indifferent to the game by experiencing some number of games as a recipient and imitating their experience in a certain inner way, then the cooperation emerges more often. (3) Further, if compassionate recipients, faced with an indifferent donor, pay the cost of Cooperative move in order for the indifferent player to experience the Cooperative outcome, then the cooperation emerges more often. Thus we observe that the indifferent player's imitation of his experience in the games and the compassionate player's self-sacrificing move promote the cooperation.

Keywords: Emergence of Cooperation, Donor-Recipient Game, Demographic Model, Agent-Based Simulation, Indifference, Compassion

1 Introduction

We introduce two states of a player, indifferent and compassionate. A player in the indifferent state in a game does not fully understand the situation of the game and therefore he is indifferent to the game. A player in the compassionate state is compassionate toward the indifferent player to the game. We investigate their effect on the emergence of cooperation in a Demographic Donor-Recipient (DR) game.

Epstein [1] 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 [2, 3] 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 the cooperation. They also show that cooperative strategies evolutionarily tend to move and play locally, defective do not.

Szabó and Szolnoki [7] 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 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 coplayers' payoff. They show that the stationary pattern of C or D does not fall into a state of the "trategy of the commons" and gives the maximum total payoff if the system starts initially with the fraternal players. Zagorsky, Reiter, Chatterjee, and Nowak [8] 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 reestablish cooperation even if the opponent has defected again. The Fraternal player and the Forgiver represent human behavioral features that relate to cooperation. Namekata and Namekata [4] introduce a set of human personal characters, Optimist, Pessimist, and Average in a Demographic Multi-Attribute DR game and investigate the role of the Optimist against the Pessimist on the emergence of cooperation. The Optimists focus on the best attribute of the

outcomes and adjust their next actions accordingly, whereas the Pessimists focus on the worst attribute. They show that the Optimists are crucial for a high emergence of cooperation if the initial distribution consists of more than one character and includes the Pessimists.

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 [5]; Nowak and Sigmund [6]). 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 [1] uses spatial structure. Namekata and Namekata [2–4] use spatial structure and generalized reciprocity. Szabó and Szolnoki [7] and Zagorsky, Reiter, Chatterjee, and Nowak [8] use direct reciprocity.

We are interested in human behavioral features that relate to cooperation. Let us imagine that a player in a game do not fully understand the situation of the game. We interpret this state of the player as indifferent. An indifferent player cannot take a suitable action for the game. He needs to experience the games some times in order to fully understand the situation of the game and his experience in his indifferent state adjusts his future actions in the game. There is also a compassionate player who is compassionate toward the indifferent player to the game. The compassionate player takes self-sacrificing actions to the indifferent player. We investigate the effect of indifference and compassion on the emergence of cooperation in a Demographic DR game.

2   Model

A DR game in the original form is a two-person game between a donor and a recipient. The donor has two moves, Cooperate and Defect. Cooperate means the donor pays a cost c for the recipient to receive a benefit b ($b > c > 0$), whereas Defect means the donor does nothing. The recipient has no move. We introduce two states (personal characters) of a player, indifferent and compassionate. A player in the indifferent state does not fully understand the situation of the game and therefore he is indifferent to the DR game, and a player in the compassionate state is compassionate toward the indifferent player to the game. We add a third move, Indifference (I) to the original DR game. The indifferent move of the donor means both of the donor and the recipient receive a small positive payoff d. We

assume that each player plays 6 games against (possibly different) players at each period. Since it is common in a 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 $b = 6$, $c = 1$, and $d = 0.5$ in this paper. Table 1 shows the transformed payoff matrix of the DR game with Indifference. If an

Table 1. Payoff Matrix of the DR game with Indifference

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

indifferent donor makes his indifferent move to a compassionate recipient, then the compassionate recipient pays the cost c of Cooperative move in order for the indifferent player to experience the Cooperative outcome, that is, to receive the benefit b. This compassionate move of the recipient is not included in the original DR game.

We extend the TFT as follows in order to introduce a reluctant strategy: Let $m + 1$ represent the number of states, $t \in \{0, \ldots, m + 1\}$, and $s \in \{0, \ldots, m\}$. The inner states of a strategy $(m, t; s)$ are numbered $0, 1, \ldots, m$. The current state determines the move of the strategy. The current state changes according to the move of the opponent player. 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 $\min\{i + 1, m\}$ or $\max\{i - 1, 0\}$ given that the opponent uses C or D, respectively. 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 current value of the inner state, "Cooperation Indicator" (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 explain how the indifference and the compassion relate to each other in detail: A player has his properties, *indifferent* (true or false), *compassionate* (true or false), strategy, *lengthOfImitation*, and *onlyForLocalPlay* (true or false). Every player can be indifferent (his *indifferent* property is true). The *indifferent* property is not an inheriting one. A player in the first generation or at age 0 is set to be indifferent with a probability of *rateOfIndifferent* (= 0.2). An indifferent player makes only Indifferent move as a donor in the DR game. Both (2,1) and (2,2) player can be compassionate (his *compassionate* property is true). If the compassionate player as a recipient is faced with the Indifferent move of the indifferent donor in the DR game, then the compassionate player feels compassion for the indifference of the indifferent player and pays the cost *c* in order for the indifferent player to receive the benefit *b*, that is, makes the Cooperative move to the indifferent player, as an example of good move and result of the DR game. If *onlyForLocalPlay* of the compassionate player is true, then the compassionate move is restricted only to a local play (explained later). If the indifferent player experiences C or D moves *lengthOfImitation* times, where these experiences modify CI of his strategy as described in the last paragraph (i.e. the indifferent player imitates in a certain inner way), then the indifferent player escapes from being indifferent to the game and starts to use his strategy (AllC, (2,1), (2,2), or AllD).

A player has the following properties that are inherited from parents to offspring; *compassionate*, *lengthOfImitation*, *onlyForLocalPlay*, strategy, rateOf-GlobalMove (*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 outside, for example, from the right border, then he comes inside from the left border. The upper and lower borders are connected similarly. Players have their own properties such as *indifferent*, *compassionate*, strategy, and so on. The initial distributions of inherited properties are given in Table 3. With a probability of *rateOfIndifferent* (= 0.2) the *indifferent* property of every player is set to be true. 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 (1st) moves and (2nd) plays the DR games against other players. Positive payoff needs opponent's C. (The detailed description of (1st) move and (2nd) play is given in Table 5.) 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 offspring and gives the offspring 6 units from his wealth. The *indifferent* property of the offspring is not inherited from the parent. The *indifferent* property of the offsping is set to be true with a probability of *rateOfIndifferent* (= 0.2). The age of parent 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.

Table 3. Initial Distributions of Inheriting Properties

property	initial distribution
compassionate	With a probability of *Co*, *compassionate* is true. We assume *Co* is one of 0.0, 0.5, 0.8, and 1.0.
onlyForLocalPlay	With a probability of *L*, *onlyForLocalPlay* is true. We assume *L* is one of 0.0, 0.5, 0.8, 0.99, and 1.0.
lengthOfImitation	We deal with 2 distributions, $(5, 10)$ and $(5, 20)$. (x, y) $(x < y)$ means length of Imitation is selected randomly between x (*Lower* value) and y (*Upper* value). We vary *Upper* value of length of imitation in these 2 distributions. We also deals with the case of *lengthOfImitation* $= \infty$, which means that an indifferent player never escape from being indifferent, as a reference point.
strategy	We deal with the population, 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 the 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 the distribution, $\{(1/4)ll, (1/4)lg, (1/4)gl, (1/4)gg\}$. For example, *gl* means *rGM* is uniformly 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 5. Detailed Description of (1) Move and (2) Play

(1)	With a probability of *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 a probability of $1-rGM$, 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 a probability of *rGP*, the opponent against whom a player plays the DR game is selected at random from all players (except himself) in the whole lattice. Or with a probability of $1-rGP$, the opponent is selected at random from von Neumann neighbors (no interaction if there are no neighbors). This process is repeated 6 times. (Opponents are possibly different.)

We remark that the initial state of the offspring's strategy is set to the current state of the parent's strategy. 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 a probability of *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 the following:

1. An indifferent donor makes only an Indifferent move in the DR game. After the indifferent player experiences C or D and modifies CI of his strategy accordingly, that is, imitates *lengthOfImitation* times, he escapes from being indifferent and starts to use his strategy (one of AllC, (2,1), (2,2), or AllD).
2. An *indifferent* property of a player is not an inheriting one. It is set to be true with a probability of *rateOfIndifferent* (= 0.2) when the player is born.
3. Faced with the indifferent move of an indifferent donor, a compassionate recipient makes the Cooperative move to the indifferent player in order for the indifferent player to experience an example of good move and result of the DR game. If the *onlyForLocalPlay* of the compassionate player is true, the Cooperative move is restricted to a local play.

3 Simulation and Results

Our purpose to simulate our model is to examine the effect of indifference and compassion on the emergence of cooperation and the distribution of strategies. We use Repast Simphony 2.3.1 to simulate our model.

We execute 300 runs of simulations in each different setting. We judge that the cooperation emerges in a run if there are more than 100 players and the average C rate over non-indifferent players is greater than 0.2 at period 500, where the average C rate over non-indifferent players at a period is the average of the player's average C rate at that period over all non-indifferent 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 over non-indifferent players is the rate at which we see cooperative move C within non-indifferent players 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.

3.1 Emergence Rate of Cooperation, *Ce*

What is the effect of introducing human personal characters, indifference and compassion, on the emergence of cooperation? We first consider two reference

points, (1) NoIndiff ($rateOfIndifferent = 0.0$) case and (2) Indiff-∞ ($rateOfIndifferent = 0.2$ and $lengthOfImitation = \infty$) case. (1) NoIndiff is the case where there are no indifferent players, whereas (2) Indiff-∞ is the case where there exist some indifferent players and they cannot escape from being indifferent. We see that the emergence rates of cooperation, Ce's for NoIndiff and Indiff-∞ are 80.7% and 1.3%, respectively. Thus we observe that the indifference reduces the cooperation quite a lot. What is the effect of $lengthOfImitation$ and introducing compassionate players on the emergence of cooperation if $rateOfIndifferent = 0.2$ and $Upper$ value of $lengthOfImitation$ is 10 or 20? We summarize the emergence rates of cooperation, Ce's, for the distributions of $lengthOfImitation$, (5,10) and (5,20) in Table 7 and Table 9, respectively. The first column indicates the value of Co and the first row L. The rest entities are Ce's for the corresponding Co and L. Their corresponding graphs are depicted in Figure 1 and Figure 2, respectively.

Table 7. Emergence Rate of Cooperation, Ce, for $lengthOfImitation$=(5,10)

Ce(5,10)	L=0.0	L=0.5	L=0.8	L=0.99	L=1.0
Co=0.0	0.423	0.423	0.423	0.423	0.423
Co=0.5	0.526	0.500	0.510	0.527	0.593
Co=0.8	0.653	0.607	0.627	0.603	0.637
Co=1.0	0.680	0.603	0.633	0.723	0.703

Table 9. Emergence Rate of Cooperation, Ce, for $lengthOfImitation$=(5,20)

Ce(5,20)	L=0.0	L=0.5	L=0.8	L=0.99	L=1.0
Co=0.0	0.253	0.253	0.253	0.253	0.253
Co=0.5	0.183	0.197	0.173	0.470	0.513
Co=0.8	0.153	0.153	0.187	0.533	0.603
Co=1.0	0.137	0.187	0.237	0.567	0.613

Since Ce's for Co=0.0 in Table 7 and Table 9 (see also coressponding Figure 1 and Figure 2) are larger than 1.3% but quite smaller than 80.7%, we observe that the imitation of an indifferent player promotes the cooperation to some degree.

In Table 7 (see also Figure 1), Ce's for Co=0.5, 0.8, and 1.0 are larger than that for Co=0.0 and do not vary so widely with values of L. We observe that the compassionate players further promote the cooperation if $Upper$ value of $lengthOfImitation$ is 10. The larger Co (the initial rate of compassionate player), the larger Ce. Co=0.8 is almost sufficient for a large Ce. Ce does not depend

on the value of *L*, that is, whether the compassionate players restrict their compassionate move to local plays or not.

The situation in Figure 2 is quite different from that in Figure 1 (see also Table 7 and Table 9). *Ce*'s for *Co*>0.0 is smaller than that for *Co*=0.0 if *L*<0.99. *L*=0.8 is not enough for a high *Ce*. Thus if *Upper* value of *lengthOfImitation* is 20, then it is necessary for almost all compassionate players to initially restrict their compassionate move to local plays in order to promote the cooperation. We summarize the following observation about the emergence rate of cooperation:

1. The indifference reduces the cooperation quite a lot.
2. The imitation of an indifferent player promotes the cooperation to some degree.
3. If *Upper* value of *lengthOfImitation* is small (10), then the compassionate players further promote the cooperation. The emergence rate of cooperation does not depend on whether the compassionate players restrict their compassionate move to local plays or not. 80% rate of the initial compassionate player is almost sufficient for a high emergence rate of cooperation.
4. If *Upper* value of *lengthOfImitation* is large (20), then almost all compassionate players (99%) need to initially restrict their compassionate moves to local plays for a high emergence rate of cooperation.
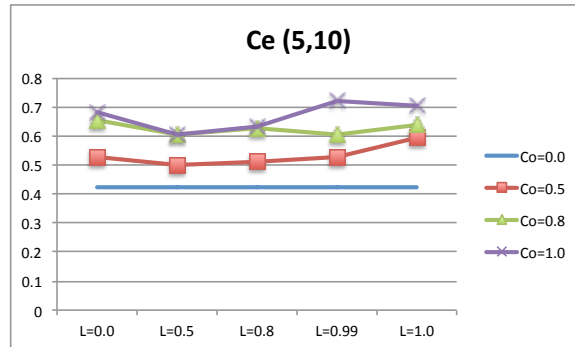

Figure 1. *Ce* for (5,10)

3.2 Average Distribution of Strategies, Indifferent and Compassionate Player

Let us pick up two typical cases. Case 1 is (5,10), *Co*=0.8, and *L*=0.0. The other, Case 2, is (5,20), *Co*=0.8, and *L*=0.99. We concentrate on them and investigate average distribution of strategies, indifferent and compassionate player over the successful runs at period 500.
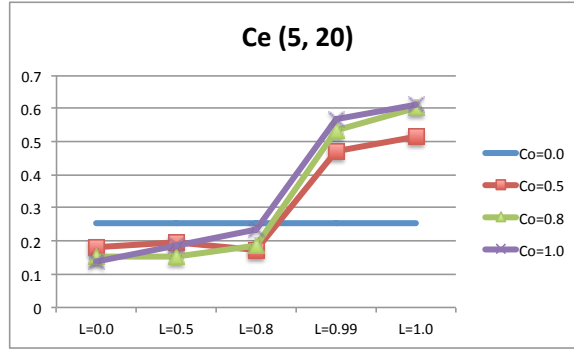
Figure 2. *Ce* for (5,20)

Average distribution of strategies over the successful runs at period 500 for NoIndiff case is shown in Figure 3 as a reference point. AllD and AllC have large share, whereas (2,1) and (2,2) are very small.
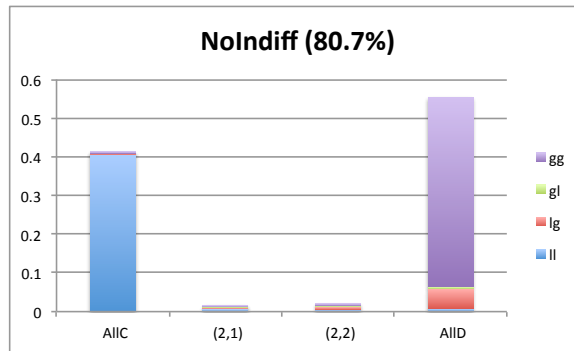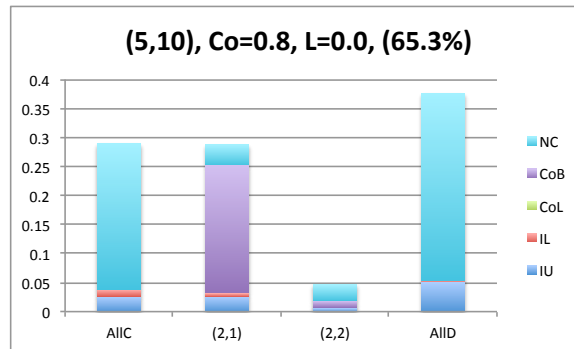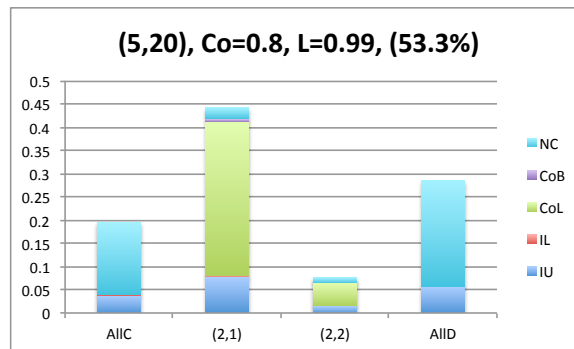

Figure 3. Distribution of strategies for NoIndiff

Average distribution of strategies over the successful runs at period 500 for Case 1 is shown in Figure 4 and that for Case 2 in Figure 5. Share of (2,1) is large and increases as *Upper* value of *lengthOfImitation* increases from 10 to 20. In Figure 4 and Figure 5 NC means non-compassionate players, CoB does compassionate players with *onlyForLocalPlay*=false, CoL does compassionate players with *onlyForLocalPlay*=true, IL does indifferent players with *Lower* value of *lengthOfImitation*, and IU does indifferent players with *Upper* value of *lengthOfImitation*.

Table 11 shows the average value of *Co*, that is, the average rate of compassionate player (2,1) and (2,2), and the average value of *L*, that is, the average rate of compassionate player (2,1) and (2,2) with onlyForLocalPlay=true, over

Figure 4. Distribution of strategies for Case 1

Figure 5. Distribution of strategies for Case 2

the successful runs at period 500. We observe that the average *Co*'s of (2,1) are 86.3% and 93.3% for Case 1 and Case 2, respectively. Thus the average rates of compassionate players within (2,1) are larger than the initial value 80.0%. Average *L* of (2,1) is 98.1%, which is almost the same as the initial value 99.0%.

Table 13 shows the average rate of indifferent player and other related average rates over the successful runs at period 500. The second column (I) indicates the average rate of indifferent player. The third and the fourth column (U and L) indicates the rates of the indifferent player with the *Upper* value and with the *Lower* value of *lengthOfImitation*, respectively, within the indifferent players. The average rates of indifferent player are 13.2% and 19.4% for *Upper* value of *lengthOfImitation* 10 and 20, respectively. These rates are less than their initial value 20.0%. The longer *Upper* value of *lengthOfImitation*, the larger the rate of the indifferent player. The average rates of the indifferent player with the *Upper* value within the indifferent players are 83.6% and 97.0% for *Upper* value of *lengthOfImitation* 10 and 20, respectively. These rates are quite larger than their initial rate 50%.

Table 11. Average *Co* and *L*

Co, L	(2,1)	(2,2)
Case 1: (5,10), *Co*=0.8, and *L*=0.0: *Co*	0.863	0.293
Case 2: (5,20), *Co*=0.8, and *L*=0.99: *Co*	0.933	0.794
Case 2: (5,20), *Co*=0.8, and *L*=0.99: *L*	0.981	0.997

Table 13. Average rate of I(ndifference), and U(pper) and L(ower) of *lengthOfImitation*

	I	U	L
Case 1: (5,10), *Co*=0.8, and *L*=0.0	0.132	0.836	0.164
Case 2: (5,20), *Co*=0.8, and *L*=0.99	0.194	0.970	0.030

We summarize the following observation about the average distributions of strategies, indifferent and compassionate player over the successful runs at period 500:

1. If there is no indifferent player, then AllC and AllD have large share but (2,1) and (2,2) almost vanish.
2. (2,1) has large share if there are both indifferent and compassionate players. The larger *Upper* value of *lengthOfImitation*, the larger the share of (2,1).

3. The average rates of compassionate players over the successful runs at period 500 are larger than their initial value 80%.
4. The average rates of the indifferent players with the *Upper* value of *lengthOfImitation* within the indifferent players over the successful runs at period 500 are quite larger than their initial value 50%.

4 Conclusion

We investigate the effect of Indifference and Compassion on the emergence of cooperation in a Demographic Donor-Recipient game. We show, by Agent-Based Simulation, that the indifference reduces the cooperation, the imitation of indifferent players promotes the cooperation, and the compassionate moves to the indifferent players further promote the cooperation, although the compassionate moves need to be restricted to a local play if *Upper* value of *lenghtOfImitation* is large. And also that the share of strategy (2,1) is large if there are compassionate players and it increases as the *upper* value increases.

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