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The Effect of a Decisive and Pure Altruist using Agent-based Simulation

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Abstract: *The aim of this study demonstrates that one decisive and pure altruist (DPA) can change the world if he owns the ability to assimilate others. The research is based on the evolutionary model of Hammond and Axelrod (2006a) which describes the operation of a community in the world. This study shows that we can simulate an decisive pure altruist agent who always performs both in-group and out-group altruistic behaviors including the dissemination of his altruism and giving of material objects in the interaction and whose agent type of DPA, while ordinary human beings are modeled as four-type agents based on the model of Hammond and Axelrod (2006a) that evolve according to the genetic potential to reproduce. The results show that such an influential pure altruist can make more pure altruists in the community through the dissemination of his altruism and giving of material objects.*

Keywords: *altruism, agent-based modeling, agent-based simulation, dissemination of culture.*

1. Introduction

The term "altruism" in the West is defined by Auguste Comte (1798-1857), the founder of sociology [1], as a moral principle emphasizing the importance of placing the welfare and happiness of others before that of oneself, or of sacrificing oneself for the benefit of others. It is the purist form of prosocial behavior that occurs when someone acts to help selflessly another person. It is also a traditional virtue in many cultures and a core aspect of various religions such as Buddhism, Islam, Christianity and so on. However, the existence of altruism represents a key problem in Darwin's theory of evolution. Survival of the fittest fails to provide a biological explanation of selfless altruism from an evolutionary perspective, or "examine the biology of selfishness and altruism" (Dawkins 2006, page 1). Early scholars sought to discover how and why selflessness could have evolved. For instance, the biological explanation was expanded to the genetic kinship theory [2], reciprocal altruism [3], and group selection of sociobiology [4].

Since the beginning of the late 1970's, political scientist Robert Axelrod at the University of Michigan had held in three computer tournaments of iterated prisoners' dilemma to study the issues such as cooperation and altruism. He created a new era applying computer simulation to the study of altruism and cooperation [5, 6]. Using an agent-based evolutionary model, Hammond and Axelrod [7] show that the contingent altruistic behavior which favors in-group cooperation and repels out-group cooperation, can become widespread under a broad range of conditions and can support very high levels of cooperation, even when cooperation is especially costly to individuals. In their model, the behaviors of four-type agents[1] are un-constant over generations, as they rely on the growth and decline of PTR (potential to reproduce) which follow predefined rules to rise and fall. Hereafter, H & A model refer to the agent-based evolutionary model of Hammond and Axelrod [7].

But the previous works lacks to emphasize the cultural dissemination that Dawkins coin it as ***meme***, or ***cultural gene*** [5]. This study further simulates one decisive and pure altruist (DPA)

[1] The selfish that repels both in-group and out-group cooperation; the contingent altruistic that performs in-group cooperation but repels out-group cooperation; the cosmopolitan that performs out-group cooperation but repels in-group cooperation; and the pure altruistic that performs both in-group and out-group cooperation.

agent that always performs both in-group and out-group altruistic behaviors with either the preaching of altruism or the giving of material objects in the interaction, while ordinary human beings are modeled as four-type agents in H & A model that evolve according to the genetic fitness. The impact of altruistic behaviors of a DPA agent to the community that is represented by H & A model could be traced via the computer simulation.

This paper is structured as follows. Section 2 makes the related works. Section 3 presents the assumptions and the proposed model. Section 4 shows the simulation results and discussions.

2. Related Works

2.1 Altruism in Modern Science and Social Science

The ubiquity of altruism suggests that discovering ever more minimal conditions for the evolution of altruism has been a major research program for the last 50 years [7]. Within the evolutionary paradigm, three basic different theories are raised to explain to the existence of altruism: (1) the theory of kin selection [2, 8], (2) the theory of reciprocal altruism [9], and (3) group selection theory [4].

The explanation of kin selection altruism is based on directly estimated relatedness when benefactors uses strategies biased in favor of altruism with those who appear to be close relatives—a bias which is assumed to have already evolved [2, 8]. Richard Dawkins argues that what appears in kinship selection as altruism is an egoism of the genes which related individuals share (Dawkins, 1976, p. 278.). The assumption of reciprocal altruism is that such altruism may serve the donor himself (or herself) if there exists some way to ensure that the benefits are returned [9]. According to the theory of group selection, altruism may evolve in populations that are divided into relatively isolated subpopulations (called “demes”) because it enhances the fitness of a subpopulation [4, 10].

Besides evolutionary biology, altruism has been a central topic in developmental psychology or educational psychology since Monroe studied juvenile altruism [11]. In contrast to the hard side of altruism from evolutionary perspective, psychology focuses on the soft side emotion such as gratitude, empathy, sympathy or compassion [12, 13]. Since these works were applied to many other disciplines like economics or sociology, altruism has become an interdisciplinary issue.

2.2 Contingent Altruism Model

Hammond and Axelrod [7] demonstrate a new mechanism that combines tags and viscosity to show how even a weak and possibly deceptive indicator of relatedness can account for (rather than assume) the evolution of bias toward apparently similar others, known as the armpit effect” (Dawkins, 1976; Lacy and Sherman, 1983). They show that this joint mechanism vastly increases the range of environments in which contingent altruism or ethnocentric behaviors can evolve in viscous populations. The contingent altruism or ethnocentric behavior is surprisingly dominant even though the parameters and structure of the model changes in a wide range [7, 14]. They also demonstrate the contingent altruistic form of in-group favoritism without requiring mechanisms such as reciprocity based on continuing interaction [3, 5, 15, 16], reputation [17], inclusive fitness based on kinship [2, 5, 8], or group selection [4, 5]. H & A model is distinctive among models of in-group behavior in treating discrimination as one of a range of possible outcomes and in requiring only minimal cognitive ability in individuals. Moreover, H & A model proven useful for studying adaptation in designing the evolutionary framework is an abstract model without intention to portray realistically specific social behaviors [14].

In order to discriminate group differences among them, they assign each agent three traits as followed [7, 14].

(1) A tag specifying its group membership as one of four predefined colors.

(2) Each agent is specified a strategy as either cooperation or defection when meeting someone of its own color.

(3) Each agent is specified a strategy as either cooperation or defection when meeting an agent of a different color.

Thus, there exist four-type agents, named selfish, contingent altruistic, cosmopolitan and pure altruistic agent, respectively. (1) the selfish agent, which repel both in-group and out-group cooperation, (2) the contingent altruistic agent, which perform in-group cooperation but repels out-group cooperation, (3) the cosmopolitan agent, which perform out-group cooperation but repels in-group cooperation, (4) the pure altruistic agent, which performs both in-group and out-group cooperation. Therefore, the contingent altruistic strategy is only one of the four possible strategies.

The simulation starts with an empty space of 50 x 50 sites. The space is toroidal, meaning that it has wraparound borders so that every site has exactly four neighboring sites as showed in Figure 2-1.

S	**S**	**S**	**S**	**S**
CA	**CA**	**S**	**PA**	**CA**
PA	**S**	**CA**	**CA**	**S**
PA	**S**	**CA**	**S**	**PA**
S	**C**	**S**	**S**	**S**

Figure 2-1. *An example of 5 X 5 sites. S: selfish agent, CA: conditional altruistic agent, PA: pure altruistic agent, and C: cosmopolitan agent.*

2.3 The Dissemination of Culture

Using an agent-based adaptive model, Axelrod [18] illustrates the effects of a mechanism of convergent social influence. After taking into account the interaction between different features, his model reveals how local convergence can generate global polarization under the assumption of that an individual's culture can be described in terms of his or her attributes, such as language, religion, technology, style of dress, and so forth. Nemeth and Takacs [19] suggest that teaching could be modeled as a knowledge transfer improving the survival chances of the recipient although it lowers the reproductive efficiency of the provider.

The idea that agents who are similar to each other are likely to interact and then become even more similar can be implemented by assuming that the chance of interaction is proportional to the cultural similarity two neighbors already have.

The formal statement of the entire dynamics of his model as followed:

Repeat the following steps for as many events as desired.

Step 1. At random, pick a site to be active, and pick one of its neighbors.

Step 2. With probability equal to their cultural similarity, these two sites interact. An interaction consists of selecting at random a feature on which the active site and its neighbor differ (if there is one) and changing the active site's trait on this feature to the neighbor's trait on this feature.

The social influence model finally illustrates three fundamental points: First, local convergence can lead to global polarization. Second, the process of social influence can be shaped by the interplay between different features of culture. Third, the model shows that even simple mechanisms of change can give counterintuitive results in which large territories generate surprisingly little polarization [18].

2.4 Agent-based Modeling

Agent-Based Modeling (ABM), or Agent-Based Simulation, refers to the computer simulation of agents (representing individual roles) in a dynamic social system. Here, agents refer to different "representatives" who interact with each other or the environment based on pre-set rules. The so-called "agent" that is able to produce a series of environmental awareness (percept sequence) and actions. Rational agents can be expected to achieve optimal performances, and are all built on a series of perception and their internal knowledge.

ABM has been applied in multidiscipline such as economics, physics, biology or ecology, to explore the phenomenon of Complex Adaptive Systems (CAS), and has gradually been more widely used in almost every field of study for a deeper understanding of its particular phenomena.

For instance, an economic system in agent-based economics can be composed of heterogeneous agents and that those summation variables are the results of these heterogeneous agents' interactions. Unlike the "top-down" mode of thinking in traditional macroeconomics, ABM has introduced a "bottom-up" style of thinking to macroeconomics under a new paradigm, which presents a challenge to most economists [20, 21]. Thus, ABM serves as an ideal tool for us to advance our thinking from the micro to the macro perspective, and to observe the links and relationships between these two levels [22].

There is also a growing trend toward the application of ABM in political studies, for it does not focus on the causal relations between variables, as statistics and econometrics do. Instead, it is mainly concerned with addressing "how" or "what-if" questions—observing how the complicated social/political phenomena in question have been formulated through the interaction between the simulated agents [23-25]. In addition, the patterns being discovered through such observations may be used either to test existing theories or to explore new ones [26]. Axelrod [26] also argues that ABM can be used to describe certain fundamental questions in many fields, thereby promoting inter-disciplinary cooperation. Moreover, when existing mathematical methods fall short, ABM presents itself as a useful tool to reveal the underlying unity behind various academic fields.

3. Experiment Design

To trace the evidence or reasonable explanation on how a DPA makes differences to the world through the community through H & A model with one DPA. That is, the following five agents are adopted in the study: (1) the selfish agent proposed in H & A model, (2) the CA agent proposed in H & A model, (3) the cosmopolitan agent proposed in H & A model, (4) the (ordinary) PA agent proposed in H & A model, and (5) one DPA agent that acts as an altruistic belief disseminator in every generation while the former four agents are solely evolved according to the genetic PTR.

3.1 Assumptions

In this study, an assumption that guides this work is elaborated as follows:

Within the interaction, the neighbors of the DPA will always be benefited by the giving of material objects or dissemination of his altruism. Since contingent altruists has invade the populations of pure altruists and egoists and then dominate the populations [7, 14], this study will focus more on the fundamental dynamics whose in-group favoritism can be converted into non-discriminative pure altruism. However, the study has no intention to portray any specific social behaviors, and rather be abstracted.

3.1 Experiment Design

In this study, there are four models: (1) H & A model that is identical to the H & A model proposed by Hammond and Axelrod (2006a), (2) DPA-GM model that has the DPA agent with giving of merely material objects like a PA, (3) DPA-DA model that has the DPA agent with dissemination of altruism, and (4) DPA-GMDA model that has the DPA agent with giving of both material objects and dissemination of altruism.

In the DPA-GM model, we assume DPA performs the material giving and brings more benefit than PA because DPA has superior wisdom than sentient beings. That is, the neighbors of DPA will receive the benefit with $b = 0.06$, while the neighbors of PA with $b = 0.03$.

In the DPA-DA model, in which the DPA performs solely on teaching altruism to others and enlightens his/her neighbors to perform altruistic behaviors, we assume that the neighbors of the DPA will learn the altruistic behavior from the DPA for the DPA owns the wisdom and skill up with infinite time of practicing six perfections, four all-embracing virtues and boundless deeds.

In the DPA-GMDA model, the DPA preaches altruism to others while giving material helps. The recent developmental research shows that the cultural learning of altruism have little or no difference on learners' donations if a model (who they are inclined to learn from) just only give the verbal statements ("exhortations" or "preaching") in order to make more valuable charity donations for others. Once the model making valuable donations by himself, such preaching or statements are accompanied by the model powerfully disseminates charitable preferences or altruistic behavior to others [27]. In the DPA-GMDA model, the neighbors of DPA will also receive the benefit with b = 0.06, while the neighbors of PA with b = 0.03; meanwhile the influence of altruism by DPA can transforms the cosmopolitan neighbor into the PA agent, the CA agent into the PA agent, the selfish agent will change to the CA agent.

Behaviors of selfish, CA, cosmopolitan, and (ordinary) PA agents of the four models within four stages (immigration, interaction, reproduction, and death) showed in Figure 2 will follow the experimental designs in H & A model. Behaviors of the DPA agent within these four stages are as follows:

1. Immigration: A DPA with no color enters at a random empty site near a random agent.
2. Interaction: For the case of giving material helps, the neighbors of DPA will also receive the benefit with b = 0.06, while the neighbors of PA with b = 0.03. For the case of, the preaching of altruism transforms the cosmopolitan neighbor into the PA agent; the CA agent into the PA agent, the selfish agent will change to the CA agent.
3. Reproduction: We assume that the DPA will not reproduce any offspring, however, the other 4 agents will follow the original H & A model.
4. Death: The death rate of DPA follows the design of H & A model. That is, the DPA has a 10 percent chance of dying.

The simulations of these models start with an empty space of 50 x 50 sites. the simulation environment is the NetLogo environment referring to Wilensky [28].

4. RESULTS AND DISCUSSIONS

The main results of the simulations suggest that the DPA could make differences on the population of four groups compared to the standard model of H & A. In the final 100 periods of ten 2,000-period runs, 14.78%, 20.35%, and 22.61% of the agents with the giving of DPA have the pure altruistic strategy, compared to 15.57% which lacks the giving of DPA (Table 1, row b, c, d and a). This result shows that the dissemination of altruism of the DPA can raise the population of pure altruism under the standard parameters of the DPA-DA and DPA-MGD models.

Table 1. *Comparison among the four models*

standard model	PA%	CA%	CO%	SA%	populations	populations%
(a) H&A	15.57 ± 3.52	78.72 ± 4.22	1.23 ± 0.68	4.48 ± 2.41	1578 ± 29	63.11 ± 1.15
(b) DPA-GM	14.78 ± 4.32	74.96 ± 4.80	2.26 ± 0.81	8.00 ± 1.78	1566 ± 24	62.63 ± 0.95
(c) DPA-DA	20.35 ± 4.28	69.59 ± 4.88	2.53 ± 0.83	7.53 ± 1.46	1565 ± 23	62.59 ± 0.93
(d) DPA-GMDA	22.61 ± 4.64	67.67 ± 4.80	2.61 ± 0.80	7.11 ± 1.43	1573 ± 26	62.91 ± 1.03
low cost	(c=0.005)					
(e) H&A	20.43 ± 4.75	74.61 ± 5.16	1.21 ± 0.81	3.75 ± 2.06	1691 ± 24	67.66 ± 0.95
(f) DPA-GM	18.96 ± 4.41	73.58 ± 4.59	2.02 ± 0.71	5.44 ± 1.32	1685 ± 23	67.39 ± 0.91
(g) DPA-DA	27.07 ± 5.35	65.47 ± 5.59	2.55 ± 0.73	4.91 ± 1.15	1691 ± 21	67.65 ± 0.83
(h) DPA-GMDA	27.01 ± 4.69	65.54 ± 4.80	2.40 ± 0.73	5.05 ± 1.07	1691 ± 20	67.65 ± 0.79
high cost	(c=0.02)					
(i) H&A	11.42 ± 3.18	77.01 ± 6.08	1.90 ± 1.03	9.67 ± 4.74	1228 ± 51	49.14 ± 2.03
(j) DPA-GM	10.32 ± 2.62	66.26 ± 5.52	4.09 ± 1.54	19.32 ± 4.81	1185 ± 53	47.42 ± 2.12
(k) DPA-DA	15.41 ± 3.62	61.64 ± 5.03	4.56 ± 1.70	18.39 ± 3.88	1190 ± 47	47.58 ± 1.90
(l) DPA-GMDA	16.39 ± 3.69	60.01 ± 5.91	4.68 ± 1.66	18.92 ± 3.96	1183 ± 54	47.33 ± 2.16

Notes: PA%: the percent of pure altruist against the 4 groups, CA%: contingent altruist percent, CO%: cosmopolitan agent percent, and SA%: selfish agent percent. Population: the total agents of four groups. Population%: 4 group's percent against total size (50 x 50). The standard parameters are as follows: 3 percent as the benefit of giving help, 1 percent as the cost of giving help, four colors of tags, 0.5 percent mutation rate per trait, one immigrant per time period, 50 x 50 lattice size, and 2,000 periods per run. Data are averaged over the last 100 periods. The range shown is plus or minus the standard error based on 100 runs. Although none the variants shown in the table affect the basic result (the predominance of contingent altruists), it is interesting to note how each parameter change affects the results. The higher the cost (i, j, k, l vs a, b, c, d), the less pure altruism and the less contingent altruism because of environmental austerity.

The simulation begins with an empty environment with each time period consisting of four stages-immigration, interaction, reproduction, and death. In this first model, the CA can be estimated logically by calculating the sources of his benefit, which is accomplished by the three agents: CA, PA, and Cosmopolitan agents each round and solving for the condition in which proportions of each strategy in the population are stable. CA will dominate the population, because he/she receives the benefits from the same color CA (in-group cooperation) and the different color cosmopolitan agent (out-group cooperation), in addition to free riding of PA's benefits. Thus, this could be the main reason to prevail on CA’s population (around 75%) is outperforming as referring Table 1 row a.

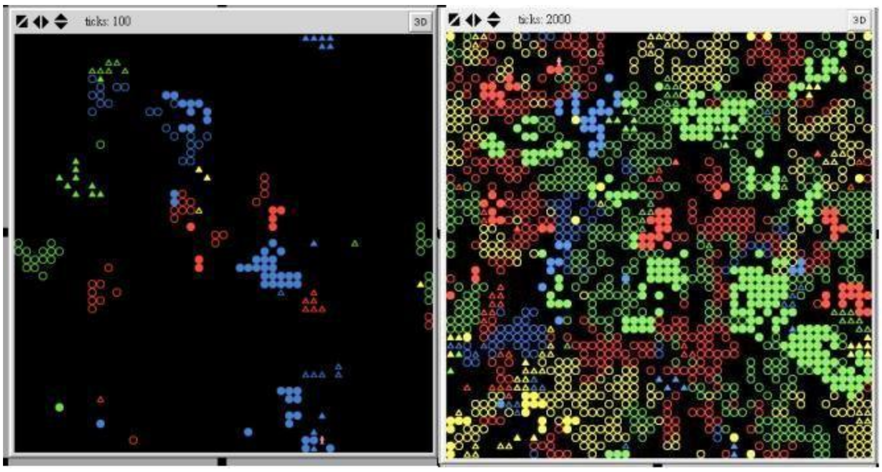
In the second model-the DPA-GM model, the populations of four groups had less differences from the H & A model (Table 1 rows a and b). This result shows the DPA implementing giving of material objects does not performed well, even though the benefit of DPA is two times than PA.

Wanting to show the preaching or teaching of DPA, we create the third model, DPA-DA model, in which the DPA has the capability to convert the trait of an agent with Dharma of altruism. In fact, CA reduces the proportion while PA increases, this also indicates some contingent altruists had been advocated with the pure altruism under the influence of DPA (Table 1 rows a and c). Most importantly, however, the population of the third model increases because of the DPA successfully persuades more PA making more cooperation.

Our final model, DPA-GMDA has achieved a high level of featuring the pure altruism with respect to the mechanism of combining the giving of material objects and Dharma by the DPA. Herewith the standard parameters, 22.61% of the populations are pure altruists (Table 1 row d), the demographic parameter of cost are either halved or doubled, the population of PA in the DPA-DA and DPA-GMDA models have increased significantly, which indicates the teaching or preaching of the DPA does affect the population (Table 1 rows e g h and i k l).

Examining the dynamics of the model reveals how the DPA enlighten more pure altruism by the dissemination of altruism and the giving of material objects. In the early periods of a simulation run, the scattered immigrants have created regions of similar agents (Figure 4a). Colonies of those willing to cooperate with their different color (i.e. PA) will tend to grow faster as those willing to cooperate with their own color (i.e. CA), but over time, PA faces free riding by CA who accepted the benefits from PA. CA who free rides suppresses PA and therefore tends to dominates near the whole regions (Figure 4b).

Future works might take account of the fact that free-will of an agent, considering the effects of cultural influence in the interaction among agents. The results also suggest some other Buddhist implications worth further study. We have demonstrated that dissemination of altruism accompanied with giving of material objects by a DPA could be an effective mechanism to improve the level of pure altruism and benefit of human beings in the smaller community. Herewith, the welfare of a human being refers to the average potential to reproduce (PTR) of an agent according to Becker [29]. However, how a decisive and pure altruist improves the other qualitative measurement of a human being by combining with the more Buddhist literatures or psychological models is another challenge in the future.



(a) (b)

Figure 4. *The typical run of the DPA-GMG model after 100 periods (a) and 2000 periods (b). The five tag types are represented as shades of filled-in circles (PA), empty circles (CA), filled-in triangles (CO), empty triangles (SA), and person type (DPA). In the early periods of the run (a), the scattered immigrants create regions of similar agents. By time (b), contingent altruists (shown here as empty circles) comprise on average about 75%, and pure altruists (filled-in circles) another 21% of the population. Selfish agents (empty triangles), and the cosmopolitan agents (filled-in triangles) comprise only 7% and 2%, respectively. See text for explanation of the dynamics.*

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