Conditions of Depleting Offender Behavior in Volunteering Dilemma: An Agent-Based Simulation Study

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1 Abstract

In this paper, an agent-based model of bystanders effect on volunteering in a crime situation is presented. The model is pivoted on the results of a game-theoretic experimentation of the volunteering dilemma (1), emphasizing the role of guilt in increasing the volunteering tendency. An analytical model of bystanders effect on volunteering (2) is extended so that it incorporates multiple interventions and changes in agents' beliefs to be used in subsequent interactions. However, the main contribution is the model extension including the guilt propagation, subsequently responsible for increases in volunteering tendency. We also introduce a new model of offender behavior, that operates in conjunction with the model of volunteering. The model is simulated asking interesting "what-if" questions with particular focus on decreasing offending tendencies. The results of the simulation reveal that, the model we have proposed, validates the theoretical foundations of bystanders effect on volunteering and importance of guilt in increasing the volunteering tendency.

2 Introduction

Agent-based Modeling (ABM) is a computational method based on autonomous decision-making entities; called agents; interacting with each other locally (3). Exploiting the bottom-up approach (the essence of the modeling approach), ABM is used to perform (pseudo-) experiments, highlighting the interplay of agents' influence on others. This often helps us understand the root cause of the emergence of a global phenomena and the co-evolution of various behavioral streams in sub-populations of an overall population, thus validating and/or refining the theoretical foundations of it.

Exploiting the advantages stated above, ABM is a helpful tool to analyze the emergence of norms and customs in a society (4). More recently, ABM has been used to analyze different aspects influencing the dynamics of crimes in a social setting (2). In criminology, ABM has been used to explore spatio-temporal dynamics of crime, with focus on spatial as well as behavioral aspects. For example, the model presented in (5) explores the dynamics of displacement of crime places based on diffusion of reputation about those places. At the behavioral level, the relationship between the behavior of offenders, targets and guardians is modeled and simulated. Similarly, in (6), the behaviors of offenders, targets and crime places are modeled based on routine activities theories and the results of the simulation are validated against real data.

Using ABM, the criminologist research has investigated various violent crimes, such as, street robbery (7; 8), gang rivalries (9) and civil violence (10; 11; 12). At the same time, research has also been done on society's reaction to a crime situation, which corresponds to the norms prevalent in the society (2). One of these situations is the bystander effect (2), which refrains a person to volunteer her effort against a crime which she observes. Gerristen in his article (2), referenced the work by (13), explaining the possible reasons for such a behavior, namely, *audience inhibition*, *social influence*, and *diffusion of responsibility.*

The mere presence of *audience inhibits* a person to intervene or volunteer due to possibility of her to misinterpret the situation resulting into an embarrassment. In addition to that, people are *socially influenced* by others; when she sees others not intervening, she also does the same. The third factor is also associated with a social dilemma (the Volunteer's dilemma (VD)) indicated by Diekmann (14) as "It is appreciable that *somebody* volunteers, but it is best if that somebody is not me", thus, *shifting the responsibility* from her own shoulders to the others. Looking at these factors in combination, it is often argued that the *audience inhibition* and the *social influence* are consequences of the *diffusion of responsibility.* Hence, in literature, the bystander effect / volunteer's dilemma is seen as a consequence of the *diffusion of responsibility*, in which an increase in the size of the group of bystanders lowers the rate of volunteering (1).

However, in practical situations, the volunteering dilemma does not always guarantee a negative result (a person not volunteering). People cooperate and volunteer so often. It is evidenced (1) that the cooperative behavior in humans is driven by many aspects of social interaction, including the aspects tightly integrated with the cognitive behavior of *guilt*, such as "reciprocal altruism" and "conflict resolution". Guilt is a negative value resulting due to inconsistency between the adopted and the desired behavior. Hence, to get rid of sense of guilt and act *responsibly*, it may lead to an altruistic volunteering from an individual, in conflict situations requiring a cooperative decision making. In fact, responsibility is a function of guilt (15) (both terms thus qualify to be used interchangeably). In other words, volunteering in the volunteer's dilemma can be ensured, if an individual tries to be responsible to get rid of state of guilt.

Results of a careful experimentation of the VD have revealed that 'no-intervention' due to bystanders effect often leads to guilt which, as a consequence, persuades the participants to volunteer (1). However, the study does not provide an analytical model of volunteering. A model of volunteering (whether a person volunteers or not), having an underpinning on three human behavior theories (stated above), is presented by Gerritsen in (2). Although, this model presents a sophisticated, yet simplistic example of application of social theories within an agent's behavior, it is restricted along two dimensions. First, the model supports only one volunteer. Second, the model does not provide any specification of how an offender will behave as a result of a possible intervention, i.e., a model of offender behavior is missing.

Therefore, the contributions of this paper are as under:

1. We extend the "model of volunteering" (2) so that it may handle more than one volunteers against a single event (a crime).
2. We affirm that the central notion of "responsibility" used in the model (2) can be used to introduce the findings related to guilt as a persuasive factor for volunteering (1). This has been incorporated into our model.
3. We introduce a new model of the offender behavior whose motivation is the reciprocity of the original VD.
4. Multi-volunteering and guilt-enabled model is integrated with the model of the offender behavior to analyze the co-evolution of volunteering vs. crimes, asking various interesting "what-if" questions.

3 Related Work

A game-theoretic definition of guilt has been presented in (16). Authors in (16) have defined the guilt as "the size of the gap between the first agent's beliefs about the second agent's expectations of her, and her own behavior." Hence, guilt is a second order measure, i.e. an agent's belief about the belief another agent is having about itself. In game-theoretic terms, the behavior of an agent i results in lower payoff of another agent j against j's expectations. This results in i's guilt dependent on the difference between the i's current behavior and j's expectations of i. Quantifying the feeling of guilt in this way helps in cooperating (volunteering in this case), if agent i is guilt averse, i.e. it acts to live up to j's expectations.

A variation of game theory capable to handle emotions was first introduced in (17). The concept was used to allow beliefs to be included into agents' utility function (16). Authors in (16) modified a trust game originally presented in (18). In the game, both agent A and agent B choose the best response given their perception about each other. The game is played pivoted on the belief of A about B *rolling* the dice and on the belief of B about A choosing to be *in* the game rather then being *out*. An experimental investigation verified that a player will feel guilty if she perform lower than what was expected of her. Also, if she is guilt averse, she would raise her contribution to match the expectations.

Since VD is a collective game, authors in (1) have pointed out a possible extension of the above mentioned two players' settings, i.e. to use average of the beliefs of the bystander group. However, to avoid the complexity of this mechanism, they have proposed to use a special player known as designated volunteer (DV) who will volunteer automatically. This to us is a grave simplification which restricts the game towards a specific situation in which a public good is achieved only if more than one person in a group of bystanders volunteer. This also presets volunteering as the choice of priority thus hindering an inert evaluation (a fairness between volunteering and not volunteering right from the start). Another simplification is about avoidance of diffusion of guilt. This was achieved through a relatively smaller group size (of 5). We in our model not only refrain from introducing a DV (instead we use a behavior-based model of volunteering), but also, the group sizes used are quite flexible. Since guilt is a function of responsibility. Responsibility is the basic ingredient of our model already, would avoid the diffusion of guilt situation.

Although, the logic presented in (1) would be able to avoid the diffusion of responsibility and diffusion of guilt, thus supporting a reasonable number of individual to volunteer. However, at best, this is just one special case of many possibilities that can happen. To analyze all these possibilities, we have opted to use ABM in different settings. Instead of using a designated volunteer, we like the model used in (2), which analytically model a person to volunteer or not based on his own capabilities (beliefs, desires and intentions) and his perceptions (about norms and intensity of violation). However, we introduce a feedback loop in the model transforming it from a one-shot model to a repetitive one. As stated above, we have also extended the model so that it support more than one volunteers. We also introduce a new model of the offender behavior, that operates in conjunction with the model of volunteering. Hence, in our framework, we use a model of "bystanders effect on volunteering" (whether a person will volunteer or not). The model is run in a repeated game manner with a feedback loop, thus able to generate interesting dynamics. Hence, the consequence of volunteering or not volunteering is then integrated with agents' cognition in terms of responsibility to act.

4 Models

4.1 Longuemar's Experimentation of VD

	Enough players Volunteer	**Not enough players Volunteer**
V (Volunteer)	8 points	0 points
D (Defect)	10 points	2 points

Table 1. Game Structure of Volunteering Dilemma.

First, we state an experiment signifying the importance of guilt in VD. In (1), it is assumed that, initially, the game played would increase probability of failure in cooperation (a group not volunteering to an extent to ensure public good). Such a failure would incur guilt in agents, thus infusing a sense of responsibility (15), which is assumed to motivate them to cooperate for public good in subsequent runs of the game. The structure of the game is presented in Table 1. A player can either choose to volunteer (cooperate) or defect (free-riding). The players are informed about required number of volunteers. There is a cost of volunteering equal to 2 points. A player defecting would gain 10 points if, in the group, enough players choose to volunteer. A player volunteering would gain 8 points if, in the group, enough players choose to volunteer, excluding the cost of volunteering. Similarly, if not enough players volunteer, then a player volunteering would gain 0 points, whereas, a player defecting would still gets 2 points.

The game is further enhanced by explaining to the participants that there is one person who will volunteer unconditionally (a designated volunteer (DV)). An experimental analysis was conducted to explore the effect of guilt aversion in the volunteer's dilemma. The following results were found:

1. If the player is guilt averse, then her second order beliefs about the DV's expectations have a positive correlation with her choosing to volunteer.
2. The volunteering rate is proportional to v, where v is the number of volunteers required for public good.
3. There is no significant difference in volunteering rate between situation with DVs and situation without DVs.
4. The players avoid "no-guilt" behavior and "guilt-inducing" situation in the presence of DVs.

4.2 Gerritsen Model of Bystanders Effect on Volunteering

Gerritsen proposed an agent-based model of bystanders' effect on volunteering (2). The model described the decision-making behavior of one individual using the BDI-model (19). The agents are of three types; (i) the bystanders, (ii) the intervener (who will make a decision of intervening or not, and (iii) the offender (who performs an action against a norm). In addition to beliefs ('B' of BDI), desires ('D' of BDI), and intentions ('I' of BDI), an intervener will also "observe" and perceive the surrounding. Observations may change the beliefs of the agents. The model is based on rules executed in an order. The following sequence depicts the application of rules:

1. If the intervener observes that there is no intervention from others, it turns its belief that the "intervention-will-be-evaluated-negatively" from boolean value false to true. This corresponds to *social influence* theory.
2. If the intervener believes that "intervention-will-be-evaluated-negatively", then her belief of "audience-inhibition" will be set to number of bystanders who can observe him. If the number of bystanders who can observe him are zero, then there will be no "audience-inhibition". Contrary to belief of audience inhibition (and related theory of *audience inhibition*) derived from social influence theory, the belief of "intervention-cost" (equal to number of bystanders) is a consequence theory of *diffusion of responsibility.*
3. The value of beliefs of "audience-inhibition" and "intervention-cost" will determine the belief that the intervener has "personal-responsibility" to intervene. The value of "personal-responsibility" will be set to true, if both above beliefs justify the thresholds, corresponding to intervener perception

of seriousness of the event. The more the values of these thresholds, the more serious the crime is.

4. Next the intervener resets its belief about seriousness of the crime. If he observes no intervention from others in the presence of n bystanders, then the belief of "has-seriousness" is set to previously believed value of seriousness divided by n times α, where α determines the influence of the group. This means that more the value of n, more the decrement in belief about seriousness of an event will be.
5. If the updated value of "has-seriousness" is greater than believed value of "normality", then the intervener believes that there is a "emergency".
6. The belief of "emergency" leads to the desire to intervene.
7. If the intervener has a desire and believes in "personal-responsibility", the desire will be converted into the intention to intervene. However, the actual intervention will only happen if the intervener believes that she is "capable", and "resourceful".

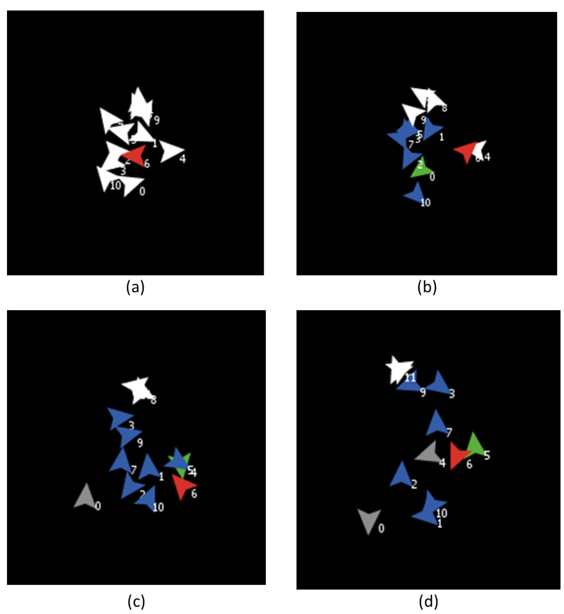

Fig. 1. Simulation Environment and Screen-shots of a selected case.

4.3 The Proposed Extended Model of Bystanders Effect on Volunteering

The extended model is motivated from findings of Longuemar's Experiment of VD. Specifically, first, the finding that "If the player is guilt averse, then her second order beliefs about the DV's expectations have a positive correlation with her choosing to volunteer", corresponds to **decrement in the audience inhibition, equal to the difference between the number of bystanders (who are observing) and the number of bystanders who have already intervened**. More explicitly, this extension is realized in extended rule 1 and rule 2 as stated below. Second, the finding that "The volunteering rate is proportional to v, where v is the number of volunteers required for public good.", corresponds to **introduction of sense of guilt equal to difference between the number of bystanders that were required to intervene and the number of bystanders who have actually intervened**. The more the sense of guilt the more the belief about the seriousness of the event is, which increases the possibility of volunteering in the subsequent interaction with the offender. More explicitly, this extension is realized in extended rule 3 and rule 4 as stated below.

The rule 1 restricts the inclusion of more than one volunteers, that may be necessary to achieve a public good (multiple interventions), and will be first extension of the model we have proposed. In our model the number of volunteers needed to achieve a public good is represented as v. If number of bystanders who are observing an intervener are n, and m is the number of bystanders who have already intervened, then the belief that the "intervention-will-be-evaluated-negatively" may have two opposite values; $true$ if $m = 0$ and $false$ if $m > 0$.

The rule 2 has to deal with two possible values of the belief of "intervention-will-be-evaluated-negatively"; being $true$ or $false$. In the former case (as before), the belief of "audience-inhibition (represented as $N1$)" will be equal to n. In the later case, the belief of "audience-inhibition" will be equal to $n - m$. Similarly, the belief of "intervention-cost (represented as $N2$)" is changed to $n - m$ in the later case, while retaining it (equal to n) in the former case.

The rule 3 also changes accordingly. However, we introduce the notion of "guilt" here. Since, the values of beliefs of "audience-inhibition" and "intervention-cost" will determine the belief that the intervener has "personal-responsibility" to intervene or not, which depends on corresponding thresholds (corresponding to intervener perception of seriousness of the event), we incorporate the sense of guilt to raise these thresholds. The guilt infuses into intervener cognition if he had not intervened recently, and is represented as: $guilt(intervener) = v - m$. Hence, as before, the value of "personal-responsibility" will be set to true, if both above beliefs ($N1$ and $N2$) justify the *updated assignments* of thresholds (with attachment to guilt in this case).

The rule 4 also changes. The basic rule as as follows. The intervener resets its belief about seriousness of the crime. If he observes no intervention from others in the presence of n bystanders, then the belief of "has-seriousness" is set to previously believed value of seriousness divided by n times α, where α determines the influence of the group. The extended rule is as follows. Since, m bystanders may have intervened already, the belief of "has-seriousness" is set to previously believed value of seriousness divided by $n - m$ times α. This change has the following consequence. If value of m is 0, the new value of belief about seriousness of the crime depends on n (the more it is the less serious the crime is), whereas, if the value of m is greater than 0, then, the more the value of m, the more the seriousness of the crime is.

Rules 5 to rule 7 remain the same.

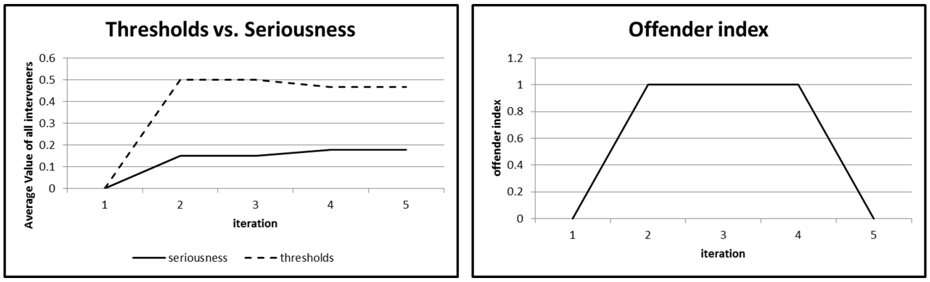

Fig. 2. Quantitative Analysis of Simulation setting presented in Figure. 1

4.4 The Proposed Offender Model

This model represents a reciprocating case of VD presented in Table. 1.

The offender will have an index, say, $OffenderIndex$, initialized with 1. From this value, the index can only decrease based on intensity of intervention against the offense. After each iteration (run of the simulation), the $OffenderIndex$ will be updated as: $1 - (m/v)$. Hence with, continuous interventions, the index will reach to 0, which would be equal to offender not offending anymore.

5 Simulation

The simulation was performed in ABM simulation environment NetLogo (20). A square space equal to the dimension of 32×32 cells was used. A cell is a spatial representation of a place where an agent can reside. Simulation runs in iterations. In each iteration, all agents "perform" what is modeled in a sequential manner, where, an agent can use the updated state (even in the same iteration, if sequentially preceded, or the previous iteration, if sequentially proceeded) of the environment and the other agents.

Initially, the agents are of two types; an *offender* who will commit a crime, and all other *agents* in the population. For example, in Figure. 1 - (a), agent 6 is the offender, whereas, all agents colored white are normal agents. As we can see that all the agents at the start are very close to each other. This gives ample opportunity to the agents for a possible intervention. Although, arguing that such a setting does not depict a realistic situation (of randomly placed agents) seems acceptable, however, this is not the case. We have started with a sample of agents represented by a population. And a population is a set of agents who are within a given radius relative to the offender, at the start. Only the behavior

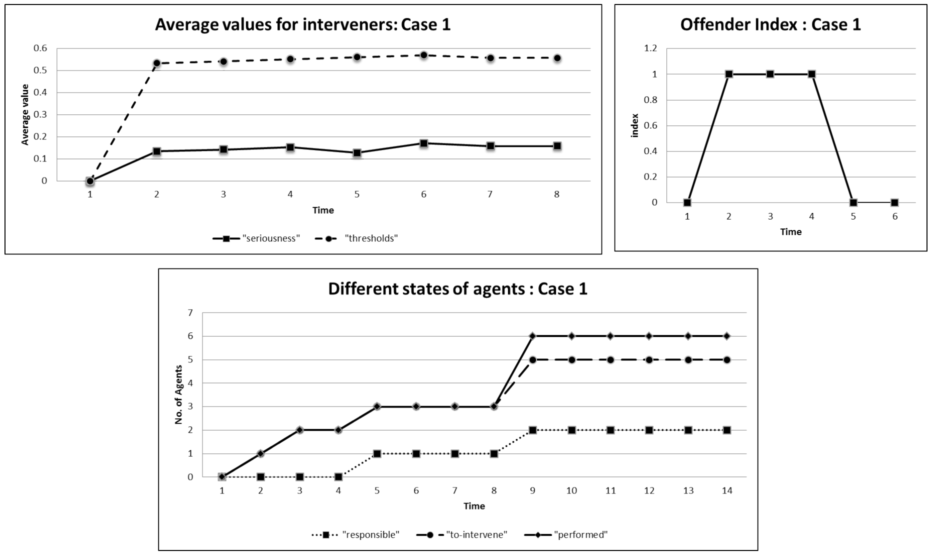

Fig. 3. Simulation results of case 1.

of this sample is relevant for behavioral analysis, even when the neighborhood of the offender would not be same in subsequent iterations. Since, we do not include new agents during the simulation, placing all agents in close proximity at the start of the simulation makes sense.

Three variables, *radius*, *normality*, and α, are not changed between different cases that are simulated, setting these to 4, 0.2 and 0.5, correspondingly. For the scenario presented in Figure. 1 - (a), the *population* is equal to 12 agents. The *thresholds* are set to 4, and the number of agents required to intervene (v) are 1. Agents perform random walk between iterations. During iteration 1 (see Figure. 1 - (b)), agent 0 (the agent in green) had a contention to intervene. The bystanders of agent 0 are represented in blue color (6 in number). A large population of bystanders dropped the perceived value of seriousness of crime from original value of 0.4 (corresponding to the thresholds) to 0.15. However, the value of threshold is increased to 5 due to feeling of guilt as a consequence of non-intervention. Since the intervention-cost and audience-inhibition is greater than thresholds, agent 0 will not feel responsibility to intervene.

A similar behavior during iteration 2 (see Figure. 1 - (c)) was observed (the intervener being agent 4 with similar number of bystanders, while agents in gray represent the interveners in previous iterations). However, during iteration 2 (see Figure. 1 - (d)), the current intervener (agent 5), in fact, performed intervention, as a consequence of less bystanders. This also increases the value of perceived seriousness of the crime from agent 5 perspective. Since the number of interventions required to intervene are sufficient, the simulation stops. The performance of this simulation is quantitatively represented in graphs of Figure. 2.

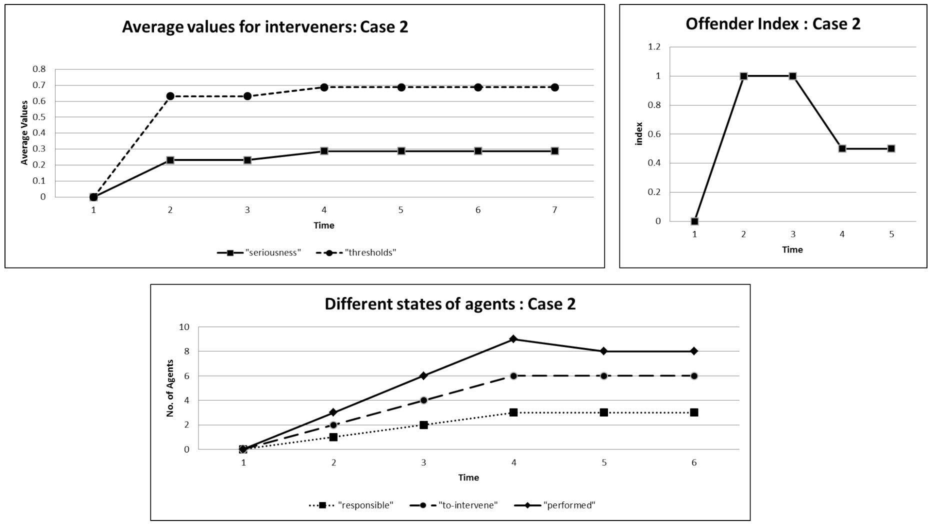

Fig. 4. Simulation results of case 2.

We simulated three representative case of the model. These cases explain the change in agents' behavior due to variation in agent population, thresholds and required number of volunteers. These cases are given in Table. 2.

	Number of Agents	Thresholds	Required number of Volunteers
Case 1:	6	3	1
Case 2:	6	4	2
Case 3:	12	4	2

Table 2. Interesting Simulation Cases.

Overall, the simulation results reveal the following trends.

The threshold plays an important role in volunteering. If it is too low at the start (< 0.3), even the sense of guilt is not capable to raise it to a level where intervention is materialized. This is evident in case 1 of the simulation, described by thresholds equal to 3, population equal to 6 and value of v equal to 1. A represented result of this simulation is shown in Figure 3.

With population equal to 6, the minimum initial threshold required to ensure volunteering is 3. With increase in thresholds to 4, there is a decrease in number of iterations required to lower the offender-index from 1 to 0 (even when the value of v is raised from 1 to 2). This is case 2 that we represent in Figure 4.

With increase in population, the time required to realize a successful intervention increases. This is evident in case 3 (see Figure 5), with thresholds equal to 4, population equal to 12 and the value of v equal to 2.

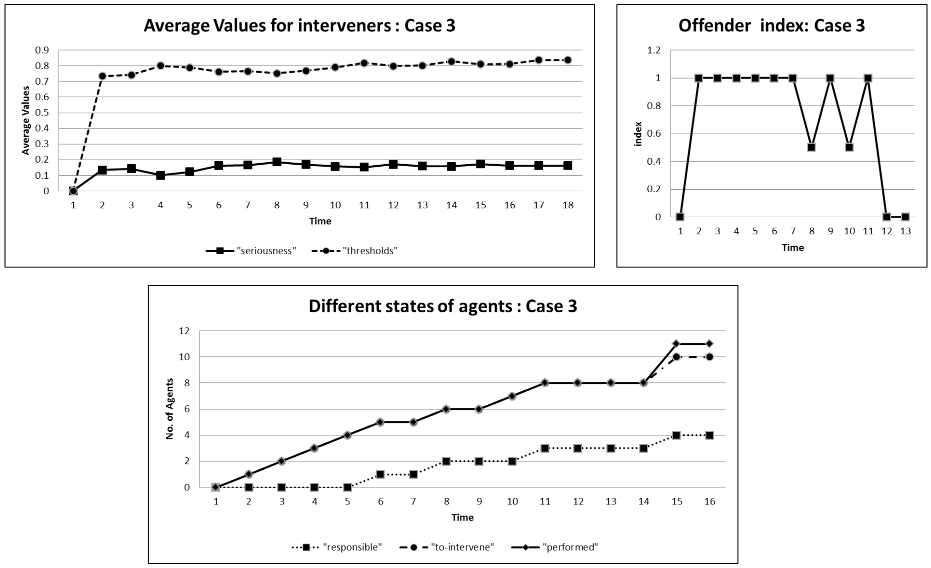

Fig. 5. Simulation results of case 3.

From many simulations we performed, it was revealed that an increase in thresholds increases the the chances of volunteering. Also, an in increase in the neighborhood (with increase in radius) increases the likelihood of intervention. Finally, the more the value of normality, there was less likelihood of intervention.

6 Conclusion

In this paper, an agent-based model of bystanders effect on volunteering in a crime situation is presented. The model is pivoted on the results of a game-theoretic experimentation of the volunteering dilemma (1), emphasizing the role of guilt in increasing the volunteering tendency. An analytical model of bystanders effect on volunteering (2) is extended so that it incorporates multiple intervention and change in agents beliefs to be used in subsequent interactions. However, the main contribution is the model extension including the guilt propagation subsequently responsible for increase in volunteering tendency. We also introduce a new model of offender behavior, that operates in conjunction with the model of volunteering. Through repeated simulation, it was revealed that an increase in thresholds (a value relating the seriousness of a crime with bystander inhibition) increases the chances of volunteering. Also, an in increase in the neighborhood - the bystanders themselves - increases the likelihood of intervention. The sense of guilt enables this unlikely relation, where, the theories not taking guilt as part of people-making loop, just advocate the opposite. Finally, the more the value of normality (a value representing the extent of seriousness of a crime), there was less likelihood of intervention.

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