Model Structure of Agent-Based Artificial System for Reproducing Bullying Phenomenon

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Abstract. The macrophenomenon associated with bullying is characterized by the emergence of bullies, the bullied, and a third party that makes up the majority, as well as persistent and offensive behavior by the perpetrator against the victim as particular agents. To elucidate the mechanism of bullying through agent-based modeling, this paper analyzes the structural aspects of the model that are considered indispensable in reproducing the bullying phenomenon by systematically changing the behavioral rules of the model. One of the necessary conditions for the model structure is found to be that each agent has the characteristic tendency of tuning and excluding behavior, which is modeled using shared values and an agent-specific threshold for the tuning and excluding actions. This model successfully reproduced the emergence of the third party, as well as the victim and perpetrator, during the process of the agents' actions and interactions. However, this model could not reproduce the emergence of the tendency for intensively repeated attacks by specific perpetrators against specific victims. Through the analysis of various factors, it is concluded that people who are less likely to tune with others are more likely to become solo and not belong to any groups, which increases the likelihood of being a victim of bullying. The personality conditions for becoming the perpetrator could not be entirely determined by the simple behavioral rules employed in this study, suggesting that the inclusion of motivation-related viewpoints could be required. Based on these results, the mechanisms and countermeasures for bullying are discussed.

Keywords: Agent-based modeling, Bullying, System structure, Shared value, Tuning and exclusion behavior

1 Introduction

Although bullying is a crucial social phenomenon, no effective countermeasures have yet been established. One reason seems to be that the underlying mechanism for bullying behavior is not well understood. There are many previous studies related to bullying [1]–[12]. According to the literature, bullying refers to negative actions perpetrated by one or more people toward one or more individuals that are conducted repeatedly and regularly over a period of time. The negative actions may include harassing, mobbing, offending, and socially excluding [1]. Many studies have focused on the

cause of bullying. Some argue that the perpetrator is the origin of the bullying, and his or her envy and self-esteem are the factors responsible for bullying [1][3]. In fact, at least from the victims' perspective, the cause of bullying is identified with a particular perpetrator [1]. Others believe that the personality of the victim is the cause of bullying. There is evidence that the simple fact of being significantly different from the rest of the group increases the risk of becoming the victim [1]. Coyne et al. [12] found the victims of bullying to be less extroverted and independent than a control sample of non-victims, as well as more unstable and conscientious. In addition to the perspectives of perpetrators and victims, an organization such as a school or workplace could be responsible for the occurrence of bullying. Zapf [3] classified the causes of bullying into three categories, namely the victim, the perpetrator, and the organization. Zapf [3] also analyzed a wide range of empirical data and found that bullying can be caused by more than one factor simultaneously; therefore, one-sided explanations should be avoided. He also identified that research into the causes of bullying is insufficient, mainly because many reports are based on interviews with victims while the perspectives of perpetrators and potential bystanders are not considered. Because of the limitations of current approaches, there is still much to be clarified regarding the underlying mechanism of bullying. Using conventional approaches, there is clearly a limit to how well the dynamic characteristics of the occurrence of bullying can be elucidated.

However, it should be noted that agent-based modeling (ABM) is an effective approach for studying the mechanisms behind dynamic characteristics of social phenomena. Various features of ABM have been described in the literature [13], such as it being an individual-based modeling approach and its ability to deal with heterogeneity. However, the most essential feature of ABM is that it is a bottom-up modeling method in the sense that the artificial society modeled on a computer works, in principle, under the same mechanisms as in the real world. The social phenomenon in question emerges in the artificial system as a result of the actions and interactions of agents, as in a real system. According to one of the authors' previous works on ABM applied to the macroeconomic system [15][16][17], there exists a specific system structure of the model that is indispensable in reproducing the desired macrophenomenon. In other words, the class of agents and their behavioral rules, including their attribute variables, are responsible for the emergence of the phenomenon. Therefore, the class of agents and behavioral rules are required to be similar to those of the real system for the model to reproduce the desired macrophenomenon. If this requirement is not fulfilled, the ABM cannot reproduce the phenomenon, even at a qualitative level. We believe the system structure that is indispensable in reproducing a phenomenon can be elucidated by a series of computer experiments in which factors are systematically changed one by one while other factors remain constant. Moreover, by elucidating the indispensable model structure, we can obtain a greater understanding of the causal mechanism behind the macrophenomenon.

The macrophenomenon associated with bullying is characterized by two features. First, the emergence of bullies, the bullied, and a third party, which makes up the majority. Second, persistent and repeated attacks are conducted by a specific person or group, as the perpetrator, against a particular person or group as the victim. Some researchers have used ABM to study the bullying phenomenon. For instance, Maeda et

al. [14] developed an ABM that models the tuning and excluding actions of agents and reproduces the emergence of the bullied. However, few studies have attempted to elucidate the indispensable system structure of the model required to reproduce the phenomenon.

Using the ABM approach, this study analyzes the factors within the model structure that are indispensable in reproducing the characteristic features of the bullying phenomenon. This allows for a discussion on effective measures for preventing the bullying phenomenon from occurring. The model in the present study is based on the behavioral rules proposed by Maeda et al. [14]. Additional factors relating to the model structure are introduced as experimental levels to clarify which conditions are indispensable and which are not for reproducing the bullying phenomenon.

2 Method of Study

2.1 Model

The artificial system includes n agents. Each agent has a value vector of size M, each element of which is assigned a value of 1 or 0. This vector represents a set of values with M elements, each of which corresponds to traits in the real world covering preferences, skills, and behavioral patterns, and the value of 1 or 0 signifies whether or not that trait is selected or owned by the agent. The value of the k^{th} element of the i^{th} agent is represented by $v_{i,k}$. The total number of selected values for the i^{th} agent is given by Equation (1), which is assumed to range between the upper limit $m_{\max}$ and the lower limit $m_{\min}$.

$$\begin{aligned} m_i &= \sum_{k=1}^{M} v_{i,k} \\ &\text{where, } v_{i,k} = 1 \ (\textit{when selected}) \\ &\qquad\qquad = 0 \ (\textit{when not selected}) \end{aligned} \tag{1}$$

The agent who performs the action and the agent who is the object of the action are denoted by the subscripts *act* and *obj*. Shared and non-shared values are defined as those in which both $v_{act,k}, v_{obj,k}$ are 1 or one of the values is 0, respectively.

Each agent communicates through tuning actions, excluding actions, or doing nothing depending on the action probability given by Equation (2), in which the numerator represents the shared value given by Equation (3). It is assumed that each agent has characteristic threshold values for tuning and excluding actions, and these are defined as uniform random numbers in the range [0, 1].

$$p(act, obj) = c(act, obj) / m_{act} \tag{2}$$

$$c(act, obj) = \sum_{k=1}^{M} v_{act,k} . v_{obj,k} \tag{3}$$

In the calculation, a pair consisting of an active agent and an objective agent is selected at random, and the active agent performs one of three actions on the objective agent. This will be either a tuning action, excluding action, or doing nothing. Repeating this process for all of the agents makes up one step of the calculation. During the repeated steps, the pattern of the selected values of each agent may change. As a result, the number of selected values may increase in some agents through the tuning action, which increases the number of shared values with respect to others. Thus, a group of agents emerges in which the members have the same set of values. In contrast, excluding actions will decrease the number of selected values in some agents, leading to solo agents who do not share any value with other agents.

In this model, an agent who excludes others most frequently without being excluded often corresponds to the bully or perpetrator, an agent who is frequently excluded without excluding others corresponds to the bullied or victim, and the other agents who exclude others as well as being excluded less frequently correspond to the third parties or bystanders.

In a typical experiment, the tuning and excluding actions are defined as follows.

Tuning Action

The active agent conducts the tuning action defined below when the action probability exceeds the tuning action threshold, as stated by Equation (4). The tuning action threshold is a random number in [0, 1] and is fixed for each agent.

$$p(act, obj) > g_{act} \quad \text{where } g_{act} : agent's\ threshold\ of\ tuning\ action \tag{4}$$

The active agent randomly selects one of the k values characterized as $v_{act,k} = 0, v_{obj,k} = 1$, and changes its own value to $v_{act,k} = 1$. However, when m_{act} exceeds the upper limit $m_{\max}$ under this procedure, the active agent additionally selects another value p at random from the set of values characterized as $v_{act,p} = 1, v_{obj,p} = 0$ and changes the value to $v_{act,p} = 0$. Thus, the tuning action modifies the active agent's set of selected values to make it closer to that of the objective agent.

For comparison, the case in which g_{act} is not inherent to each agent but given by the same uniform random number in the range [0, 1], which is computed at each step, is also calculated (see EC3 and EC2 in Table 1).

Excluding Action

The active agent conducts the excluding action defined below when the conditions given by Equation (5) are fulfilled. The excluding action threshold is assumed to be given by a random number in [0, 1] and is fixed for each agent.

$$p(act,obj) < e_{act} \ \ and \ \ m_{act} > m_{obj}$$
$$where\ e_{act} : agent's\ threshold\ of\ excluding\ action \tag{5}$$

When m_{obj} is greater than the lower limit $m_{\min}$, the active agent selects one of the values p at random from the set of values characterized by $v_{act,k} = 1$, $v_{obj,k} = 1$, and changes the value of the objective agent to $v_{obj,p} = 0$. Thus, the excluding action modifies the set of selected values in the objective agent to make it more different from that of the active agent (see EC6 and EC5 in Table 1).

For comparison, the case in which the excluding action is only conducted when $m_{act} > m_{obj}$ (see Equation (6)) is also calculated (see EC4 and EC3 in Table 1). Additionally, the case in which the exclusion action is only conducted when the difference in the number of shared values between the current and previous steps exceeds some threshold value is considered. In this study, the threshold is assumed to be 1, as stated in Equation (7) (see EC2 in Table 1). Equation (7) is the assumption made by Maeda et al. [11].

$$m_{act} > m_{obj} \tag{6}$$

$$c'(act,obj) - c(act,obj) > 1$$
$$where\ c(act,obj): Number\ of\ shared\ values\ in\ the\ current\ step \tag{7}$$
$$c'(act,obj): Number\ of\ shared\ values\ in\ the\ previous\ step$$

Reaction Against Excluding Action

For comparison with the base model, the effect of the reaction against an excluding action is analyzed in which a characteristic random number in [0, 1] is assigned to each agent. Depending on this number, an agent that has just been subjected to an excluding action performs one of the three choices, namely an excluding action, a tuning action, or doing nothing toward the objective agent. This action is conducted in addition to the abovementioned shared-value-dependent tuning or excluding actions (see EC5 in Table 1).

2.2 Experimental Conditions.

The behavioral rules and parameter values are presented in Table 1. The base model is EC5, which includes agent-specific tuning and excluding actions. The models denoted EC1–EC4 and EC6 represent the modified versions for comparison with the base model

in which the behavioral rules are changed. The aim of the comparison is to elucidate the effect of the model structure on the emergence of the bullying phenomenon and to understand the conditions required to reproduce this phenomenon.

Table 1. Calculation conditions

		Model with agent-specific rules			Model without agent-specific rules		
		Model with agent's threshold of tuning and exclusion, and the reaction against exclusion	Model with agent's threshold of tuining and exclusion, (The base model)	Model with agent's threshold of tuning only	Model with revised rule of exclusion	Model presented by Maeda	Model with tuning only
Name of experimental condition		EC6	EC5	EC4	EC3	EC2	EC1
Behavioral rules of agent	Tuning	$p(act,obj)>g_{act}$	$p(act,obj)>g_{act}$	$p(act,obj)>g_{act}$	$p(act,obj)>\delta$	$p(act,obj)>\delta$	$p(act,obj)>\delta$
	Exclusion	$p(act,obj)<e_{act}$, m(act)m(obj)	$p(act,obj)<e_{act}$, m(act)m(obj)	m(act)>m(obj)	m(act)>m(obj)	$c(act,obj)^{t-1}$-$c(act,obj)^{t}$>1	–
	Reaction against exclusion	Tuning, exclusion, neutral, depending on the agent	–	–	–	–	–
Experimental parameters	Number of agents	30	20				
	Number of values	100	50				
	initial number of selected values	10	10				
	Max. number of selected values	15	15				
	Min. number of selected values	5	5				
	Max. number of steps	1000000	1000000				
	Number of runs	10	10				

Note: g_{act}:The threshold value for tuning action of the agent, defined by a [0-1] random number.
e_{act}: The threshold value for exclusion action of the agent, defined by a [0-1] random number.
δ : A [0-1] random number

3 Simulation results

The simulation results for each of the six experimental conditions are described in this section. In Figs. 2–9, we use the notation ‘solo,’ ‘Mxx,’ ‘Mxx_1,’ and ‘Mxx_2,’ where solo refers to an agent who is not a member of any groups and Mxx refers to an agent who is a member of a group with xx members. The notation Mxx_1 and Mxx_2 is used when more than one group have the same number of members.

3.1 Results without agent-specific rules

Model with tuning only (EC1)

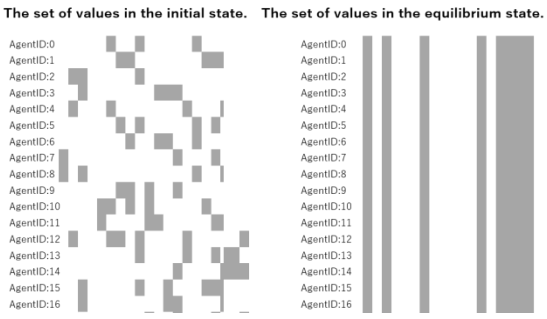

Fig. 1. Example of the set of values in the initial and equilibrium states obtained in the model with tuning only.

Although the initial set of values is randomly assigned to each agent, the set becomes the same for all agents in the equilibrium state, as shown in Fig. 1. This result agrees with the findings reported by Maeda et al. [14], indicating that no conflict between bullies and the bullied emerges with this model.

Model with tuning and excluding actions, where the exclusion rule presented in the literature is employed (EC2)

In this case, the excluding action is only conducted when the number of shared values between the active and objective agents is less than the value in the previous step by at least the constant threshold value, as stated in Equation (7). This rule of exclusion is the same as that employed by Maeda et al. [14].

In this case, two types of agent emerge as a result of the interaction among agents. Those are solo agents, whose set of selected values is not coincident with that of others, and agents in a group, where the set of selected values is coincident inside the group. However, when looking at the relationship between the number of excluding actions performed by an agent and the number of times the same agent is excluded, it appears that agents who exclude other agents more often are more likely to be excluded by other agents. Figure 2 shows an example of this behavior, indicating that victims and perpetrators do not separately emerge.

Thus, it is evident that bullies and the bullied do not emerge under the conditions of this model.

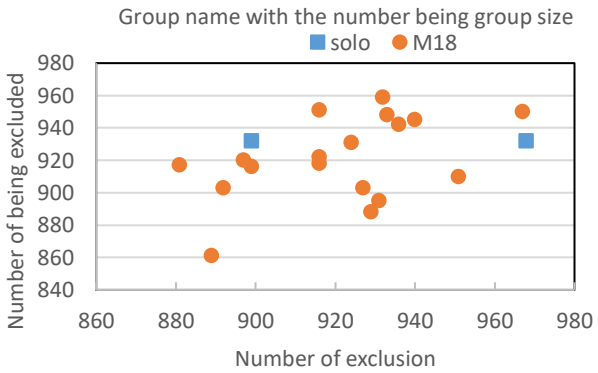

Fig. 2. Example of the relationship between the number of excluding others and the number of times an agent is excluded by others in model EC2.

Model with tuning and excluding actions, where the new exclusion rule is employed (EC3)

When the exclusion rule is changed from that assumed in Equation (7) to that assumed in Equation (6), a negative correlation emerges between the number of exclusions

performed by an agent and the number of times that agent is itself excluded, as shown in Fig. 3. This result indicates the separate emergence of agents who are more likely to exclude others than to be excluded and agents who are more often excluded by others. The former are typical candidates for the perpetrator, whereas the latter are candidates for the victim. Thus, bullies and the bullied emerge under the conditions of this model.

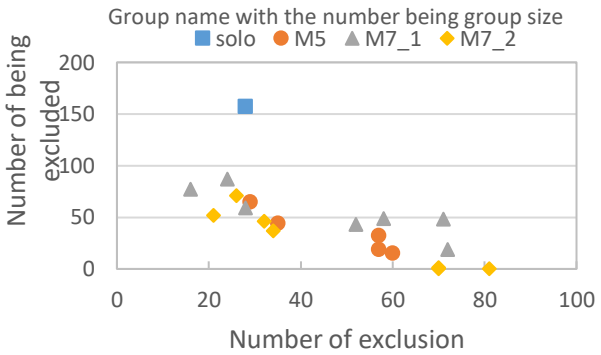

Fig. 3. Example of the relationship between the number of exclusions and the number of times an agent is excluded in model EC3.

However, it should be noted that we cannot observe any agents who rarely exclude others and are rarely excluded by others, indicating that third-party agents who are not directly involved in the conflict between the perpetrator and the victim do not emerge with this model.

3.2 Result with agent-specific rules

Model with agent's tuning threshold only (EC4)

When the threshold value for the tuning action is defined as being specific to each agent, the negative relationship between the number of exclusions and the number of times

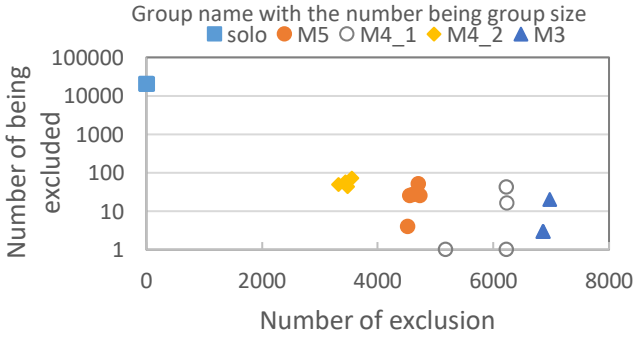

Fig. 4. Example of the relationship between the number of exclusions and the number of times an agent is excluded in model EC4.

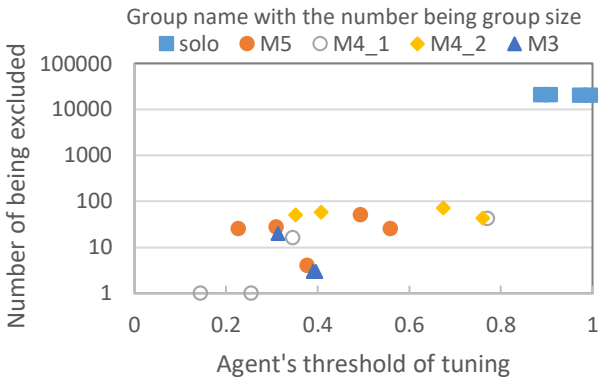

Fig. 5. Effect of the agent's tuning threshold on the number of cases of being excluded in model EC4.

the same agent is excluded emerges, as shown in Fig. 4, even though the criteria for the excluding action is randomly defined. Moreover, agents in the same group exhibit a similar number of exclusions as other agents, as seen in Fig. 4, indicating that they behave similarly. In addition, agents whose threshold **v**alue for tuning is very large are more often excluded by others, as shown in Fig. 5, suggesting that agents who are less likely to tune with others are more likely to become victims. However, as is evident from Fig. 4, the third-party behavior does not emerge with this model.

Model with agent's threshold of tuning and exclusion (EC5, the base model in the present study)

An example of the relationship between the number of exclusions and the number of times an agent is excluded is shown in Fig. 6. Note that the agents in Fig. 6 are categorized into three types. The first type consists of agents who are very often excluded but rarely exclude others: these are the victims and the candidates for victims. The second type includes agents who are likely to exclude others while rarely being excluded themselves: these are the perpetrators and the surrounding agents. The remaining group of agents, for which the number of exclusions and the cases of being excluded are relatively low, corresponds to the third party. The typical victim in Fig. 6 is the agent who is most often subjected to excluding actions. In this case, this is agent 16, who was excluded 38 times (see the vertical axis in Fig. 6). The perpetrators of these excluding actions and the number of times they applied this action to agent 16 is shown in Fig. 7. Note that the agent who excluded others the most often, agent 5 in this case, applied the most excluding actions to agent 16. This indicates that agent 5 is the main perpetrator toward the victim agent. Thus, we can conclude that one of the features of the bullying phenomenon, namely the existence of the third party as well as the victim and the perpetrator, is successfully reproduced with this model.

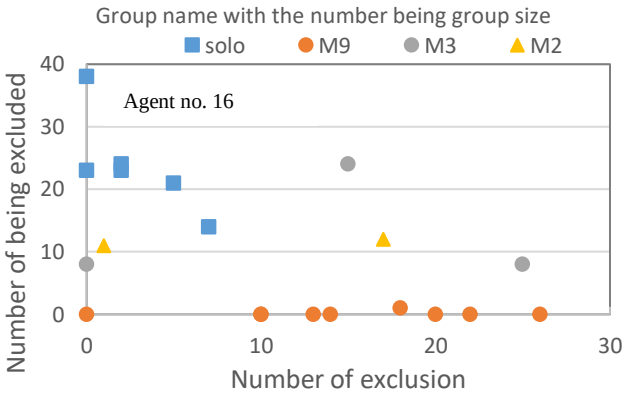

Fig. 6. Example of the relationship between the number of exclusions and the number of times an agent is excluded in model EC5.

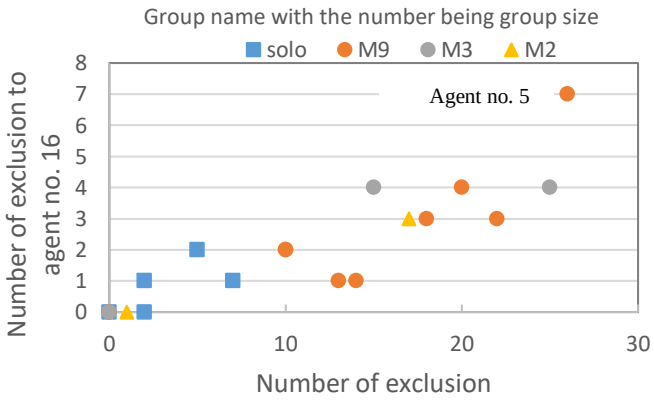

Fig. 7. Number of excluding actions applied to agent 16 in relation to the total number of exclusions.

However, it should also be noted that this model does not reproduce another feature of the bullying phenomenon, namely the tendency for the perpetrator as a specific agent or group to attack the victim as a particular agent persistently and repeatedly. In the real world, this tendency is thought to be caused by the personality or characteristic features of the perpetrators and the victims, which are modeled by the set of values in the present model. However, the main perpetrator stated above is a member of a group with nine members, having the same set of shared values as seen in Fig. 6 and Fig. 7. There are agents in this group who only exclude the victim agent once, which is much less frequently than the main perpetrator. This result indicates that the behavior of agents relating to the actions of excluding and being excluded is not well determined by the shared values in this model, despite the presence of agent-specific threshold values for tuning and exclusion.

The effects of the threshold values for tuning and excluding actions on the number of times agents are excluded are shown in Figs. 8 and 9. These figures indicate that the number of times an agent is excluded by other agents is mainly dependent on the agent's tuning threshold, with the effect of that agent's exclusion threshold being relatively small. Moreover, as can be seen in Fig. 8, agents with lower tuning thresholds are more likely to share values with others, and therefore tend to become members of a large group and are rarely excluded. Agents with larger tuning thresholds are less likely to tune with others and tend to become solo agents, making them more likely to be excluded by others.

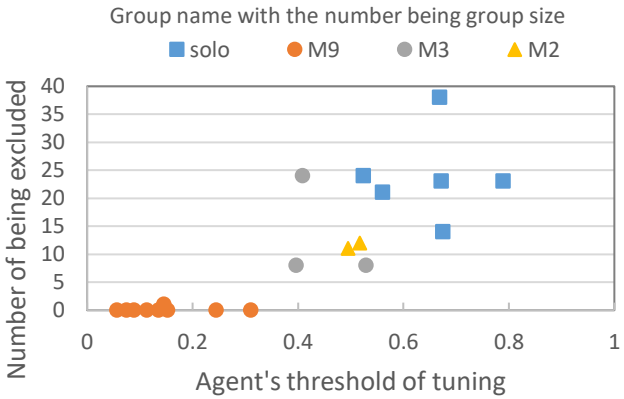

Fig. 8. Effect of the agent's tuning threshold on the number of times they are excluded by other agents.

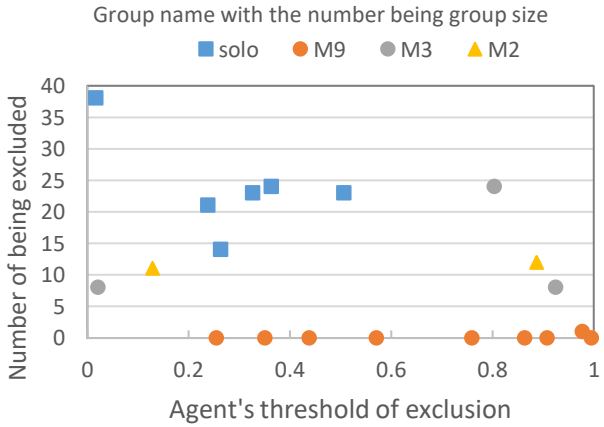

Fig. 9. Effect of the agent's excluding threshold on the number of times they are excluded by other agents.

Model with agent's retaliation against exclusion as well as tuning and excluding actions (EC6)

The effect of including some reaction by the excluded agent against the excluding action is now analyzed. A characteristic random value in [0, 1] was used to express the type of retaliation performed by each agent. As a retaliation action, the agent selects one of three choices,

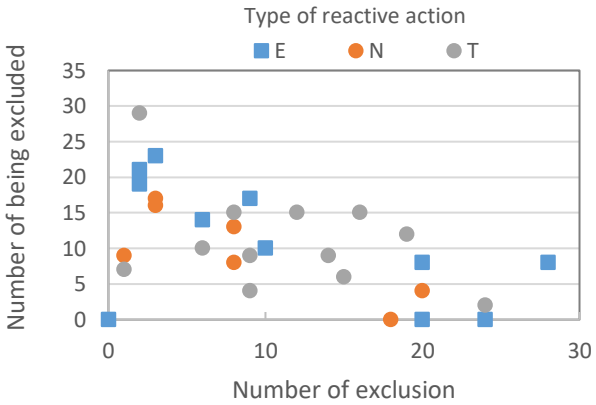

Fig. 10. Effect of reactive actions seen in the relationship between the numbers of exclusions and cases of being excluded in model EC6. Reaction types are denoted as E for exclusion, N for neutral (doing nothing), and T for tuning.

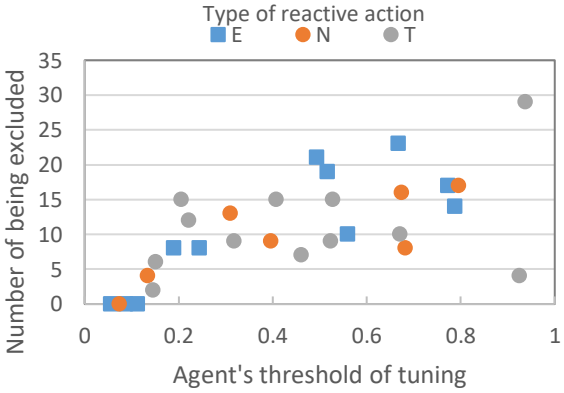

Fig. 11. Effect of the agent's tuning threshold and the reactive actions on the number of cases of being excluded in model EC6. Reaction types are denoted as E for exclusion, N for neutral (doing nothing), and T for tuning.

namely, an excluding action, tuning action, or doing nothing, when the assigned random number is less than 0.34, greater than 0.67, or between these two values,

respectively. The number of times each agent was excluded is shown in Fig. 10 as a function of the number of excluding actions and in Fig. 11 as a function of the agent's tuning threshold.

As evident in Figs. 10 and 11, the influence of the reactive actions is negligible. This indicates that persistent and intensive attacks by the perpetrator toward the victim cannot be explained by simple rules using the tuning and exclusion thresholds assumed in the present model. Other factors should be considered to model the agents' personality, which could be essential in determining the cause of bullying.

3.3 Summary of the simulated results

Findings regarding the system structure required to reproduce the bullying phenomenon

The existence of the third party, as well as the perpetrator and the victim, is reproduced under the assumption that the likelihood of both the tuning and excluding actions is agent-specific, and the exclusion is conducted when the number of values held by the objective agent is lower than that of the active agent, as explained in the result of EC5. Without these conditions, the third party does not emerge in the artificial society.

As for other experimental conditions, the findings are as follows. In the case of experimental condition EC1, all agents come to belong to the same group, and neither the perpetrator nor the victim emerges. In EC2, separate groups emerge, but the agent who excludes others is often excluded, and therefore the victim and perpetrator do not emerge as different, conflicting agents. In EC3 and EC4, the victim and perpetrator emerge as conflicting agents, but the third party does not emerge.

Another feature of bullying, namely that persistent and repeated attacks are conducted by a specific person or group toward another particular person or group, could not be reproduced within the framework of the present model, even when some form of retaliation or reaction was incorporated into the model.

The reasons, mechanisms, and countermeasures for bullying will be discussed in the next section.

Findings related to the mechanism of bullying

First, the fact that the existence of the third party, as well as the perpetrator and the victim, is reproduced in model EC5 indicates that some difference in the individual-specific tuning and excluding characteristics, as well as the interaction among agents, are indispensable items as the cause of bullying. According to the literature [8], the third party consists of assistants and reinforcers of bullies, outsiders, and defenders of the victim. This fact is well reproduced with model EC5, as shown in Fig. 6, which supports this idea.

Second, as is clearly shown in Fig. 8, people who are more likely to tune with others tend to become members of a large group, and are therefore less likely to be excluded by others, whereas those who are less likely to tune with others tend to become solo agents or members of a small group, and are thus more likely to become victims.

Third, the fact that the assumption that an agent excludes others only when the number of values is greater than that of the objective agent is indispensable for reproducing the third party suggests that bullies attack their victims when they recognize that the status or power of the victim is lower than their own.

Based on these results, the basic mechanism of bullying is considered as follows. The people in the organization have the tendency of tuning with others and that of excluding others as essential characteristics. Due to this tendency as well as the effect of the interaction among agents, the agent who is more likely to tune with others tend to become a member of a group with increasing the number of shared values, and is therefore less likely to be excluded by others, while the agent who is less likely to tune with others tend become a solo agent with decreasing the number of shared value and therefore more likely to be excluded by others. Thus, the agent who is the typical case of the former tends to become a perpetrator and the typical case of the latter tends to become a victim, and others are the third-party agents consisting of bystanders, reinforcers of the bullies, and defenders of the bullied.

These results coincide with those described in the literature [7], in which the importance of the role of bystanders as well as the interaction among the peer group is identified.

However, some other factors that are required to be added in the above-mentioned mechanism must exist in the mechanism of bullying, because the present model cannot reproduce another feature of bullying, namely, the persistent and repeated attacks by the specific agents, the perpetrator, toward the particular agents, the victim. Further details are discussed in the next section.

4 Discussion

The fact that persistent attacks by the perpetrator toward the victim, as particular agents, could not be reproduced by the present model indicates that some other factors are responsible for the existence of bullying. What could those factors be?

Some interesting hints can be found in the ideas concerning group involvement in bullying in the literature, although they have not been examined empirically. One example of such views is presented in the review article by Salmivalli [7] as follows.

In social groups where bullying takes place, initiative ‘ringleader’ bullies can be identified [11]. The bullying behavior is motivated by the bullies’ pursuit of high status, which is the individual’s relative standing in the peer hierarchy. The bullies choose their victims who are submissive, insecure about themselves, physically weak, and in a low-power, rejected position in the group, because they can repeatedly demonstrate their power to the rest of the group and renew their high-status position without the fear of being confronted. The bullies’ peer status is enhanced by the bystanders’ positive feedback or reinforcement through verbal or nonverbal cues (e.g., smiling, laughing) while challenging the bully’s power by taking sides with the victim provides negative feedback for them. The bystanders’ reaction affects the victims’ adjustment as well. Victims who have one or more classmates defending them when victimized are less

anxious, less depressed, and have higher self-esteem than victims without defenders [7].

Based on the arguments mentioned above in the literature, additional factors to be implemented in the present model to reproduce another feature of bullying are considered something related to the motivation for the excluding actions as well as the bystanders' reaction which affects the bullies' motivation.

Such factors can be implemented in the present model by assuming additional rules regarding the agents' behavior, which remains as a future subject. Moreover, if such a model successfully reproduces all aspect of the features of bullying, then we can conclude that the same procedure would occur in the real world through the same mechanism as in the modeled society.

From the result of the present study as well as above discussions, the following two countermeasures are considered effective. One is the intentional tuning behavior with the victim which could help him/her to become a member of a group, and therefore less likely to be excluded. Here, being excluded in the model corresponds to being attacked by bullies in the real world. Another one is the bystanders' reaction not to reinforce the bullies so that bullies cannot get positive feedback for their attacks toward the victim.

5 Conclusion

The macrophenomenon associated with bullying is characterized by the emergence of bullies, the bullied, and third-party bystanders, which are the majority. Another characteristic is the persistent and offensive behavior by the perpetrator against a specific person. To elucidate the mechanism of bullying by agent-based modeling, this paper analyzed the structure of ABM, which is considered indispensable in reproducing the phenomenon, by systematically changing the behavioral rules in the simulation. As a result, the following findings were obtained.

The emergence of the third party, as well as the victim and the perpetrator, is reproduced under the assumption that each agent has the characteristic tendency of tuning and excluding behavior that is modeled according to shared values with others, and that exclusion is conducted when the number of values held by the objective agent is lower than that of the active agent.

This result indicates the following with respect to the mechanism of bullying. First, differences in the individual-specific characteristics of the tuning and excluding actions, as well as the interaction among agents, are responsible for the cause of bullying. Second, people who are more likely to tune with others tend to become members of larger groups, and are thus less likely to be excluded, whereas people who are less likely to tune with others tend to become solo agents or members of a small group, and are therefore more likely to become victims. Third, the fact that the assumption that an agent excludes others only when the number of the values is greater than that of the objective agent is indispensable for reproducing the third party suggests that bullies attack their victims when they recognize that the status or power of the victim is lower than their own.

Despite the success in generating the emergence of the third party, this model could not reproduce the emergence of the tendency for intensively repeated attacks by specific perpetrators against specific victims. Some motivation-related factors might be required to reproduce this tendency, which remains a subject for future study.

Based on the findings of the present study, bystanders siding with the victim against the bullies is considered an effective countermeasure against bullying, because intentional tuning behavior with the victim could help him/her become a member of a group, and therefore less likely to be attacked.

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