BACKGROUND

The purpose of this research is to demonstrate that punishments and rewards do not always result in cooperation, and can sometimes lead to negative consequences in a social dilemma. We present the Industrial Waste Illegal Dumping Game, the design of which is closely related to the industrial waste disposal structure in Japan and also encompasses research on social dilemmas. The ultimate goal of the game is to offer new insight regarding social dilemma research from the perspective of simulation and gaming.

First, we introduce social dilemma research particularly relevant to sanctions such as punishments and rewards developed in experimental game studies. Next, we present the advantages of using gaming simulation to emphasize the significance of capturing social dynamics in comparison with laboratory experiments. Then, we explain the current state of industrial waste disposal and illegal dumping in Japan. We regard this problem as a social dilemma and introduce gaming based on this issue. Finally, we discuss the results of executing the Industrial Waste Illegal Dumping Game and the significance of this research.

Effects of sanctions on cooperation in social dilemmas: findings from laboratory experiments

Cooperation is the foundation of our society. Punishments and rewards are used to

promote cooperative behavior. The issue of cooperation can be treated as a social dilemma. A social dilemma is defined as having two characteristics (Dawes, 1980). First, for individuals, choosing non-cooperation is always more profitable than choosing cooperation. Second, if everyone selects cooperation, the individual profits more than when everyone selects non-cooperation.

Studies on social dilemmas have analyzed the effects of sanctions. Sanctions refer to incentives such as punishment and reward. Monitoring people's behavior, punishing non-cooperators, and rewarding cooperators serve as incentives to choose cooperation. The findings of laboratory experiments have shown that sanctions result in cooperative behavior (Balliet, Mulder, & Van Lange, 2011; Fehr & Gächter, 2000, 2002; Yamagishi, 1986, 1992). However, some studies showed that punishment does not always bring about cooperation. Using a repeated Prisoner’s Dilemma, the most simple type of social dilemma, Wu, Zhang, Zhou, He, Zheng, Cressman, and Tao (2009) reported that the cooperation rate did not increase in an experiment when a costly punishment option existed.

However, few studies showed that sanctions induce non-cooperation, although some reported on the detrimental effects of a sanction. Sanctions influence psychological aspects such as making decisions in the interests of the business alone rather than morality

(Fehr & Rockenbach, 2003; Frey, 1993; Gneezy & Rustichini, 2000; Messick, 2000; Tenbrunsel & Messick, 1999). Intrinsic motivation and cooperative motivation can reportedly decline (Lepper & Greene, 1978; Mulder et al., 2006a; Taylor, 1976, 1982; Yamagishi, 1988). Under sanctions, people regard cooperative behavior as instrumental cooperation only. Thus, non-cooperative behavior increases if sanctions are abolished (Kim, Chang, & Kelleher, 2008; Miranda & Aldy, 1998; Mulder et al., 2006b). Furthermore, people do not cooperate if they are given the third choice, which could allow them to escape the sanctions (Mulder, Van Dijk, De Cremer, & Wilke, 2006b). Moreover, Ambrus and Greiner (2012) showed that net payoffs offsetted or decreased even though cooperation increased under the presence of costly punishment and incomplete monitoring. Accordingly, sanctions involve many negative influences on behavior.

Sanctions include not only punishments, but also rewards. However, inconsistent results from different perspectives, sometimes contradicting each other, have been reported regarding the effects of the rewards in comparison with the punishments. Kiyonari and Barclay (2008) revealed that unlike punishment, it is possible to avoid the free-rider problem in the secondary dilemma regarding sanctioning cost and that people will support reward rather than punishment. Conversely, rewards as well as punishment, can reduce intrinsic motivation (Irwin, Mulder, & Simpson, 2014). Furthermore,

Molenmaker, de Kwaadsteniet, and van Dijk (2014) showed that people tend to prefer rewards to punishments, especially in public goods dilemmas rather than commons dilemmas. Mulder (2008) showed that punishments and rewards evoke morality as they can signal whether they are socially acceptable, but the effect is stronger for punishments than for rewards.

We need to consider not only the effects of sanction per se, but also the effects of interactions such as communication and negotiations among people. Communication raises cooperation (Dawes, Alphons, Kragt, & Orbell, 1990; Dawes, McTavish, & Shaklee, 1977; Orbell, Van de Kragt, & Dawes, 1988). However, cooperative behavior varies depending on the framework of the communication. Focusing on non-cooperation results in non-cooperative behavior even if the participants communicate (Deutsch, 1958, 1960; Deutsch, Epstein, Canavan, & Gumpert, 1967). In other words, we should be careful about framing the situation if we wish to achieve mutual cooperation regardless of the existence of sanctions.

Pruitt and Kimmel (1977) proposed the goal/expectation theory, which explained the process of achieving mutual cooperation. If the goal of the players is to exploit each other, the only consequence is retaliation via mutual non-cooperation. To achieve mutual cooperation, it is necessary to share a common goal, so that mutual cooperation is

preferable. Furthermore, the players must not only have a common goal, but also foster the expectation that they are not exploited by their opponents if they choose cooperation. For the sanction system to function as intended, sharing common goals and the expectation of mutual cooperation are essential. If the sanctions fail to foster the expectations, cooperative behavior will not be gained.

Gaming simulation as a tool for observing social dynamics in social dilemmas

We need to understand the social dynamics of the complex interaction process involving sanctions and communication to analyze whether mutual cooperation is achieved or not. The interaction among participants is limited in laboratory experiments because such experiments require that many factors should be controlled. In contrast, gaming simulation encourages active interaction and allows minimum control. The behavior of people influences and transforms others at the same time, and the interactions among individual behaviors lead to consequences for the society. Players experience the process of changing their behavior through feedback loops from active interactions with others, which results in rich social dynamics. Furthermore, the heterogeneous types of players or their asymmetry payoffs in gaming enrich such social dynamics. It is hard to observe such dynamics under controlled experiments. On the other hand, people collaborate with others, deceive others, and interpret rules creatively in gaming. Consequently, people attempt to

adjust the social system as well as adapt to it.

Research on social dilemmas has been carried out using gaming. For example, the Industrial Waste Game is a simple card game on monitoring problems in a social dilemma (Hirose, Sugiura & Shimomoto, 2004). The SIMulated INternational SOCiety game (SIMINSOC) incorporates social dilemma structures and uneven wealth distribution, and has the ability to trigger intergroup conflicts (Hirose, 1997). The Emission Trading Game was developed to demonstrate the process of forming and not forming the expectation of mutual cooperation when regarding global warming as a social dilemma (Nagasaka, Sato, & Ohnuma, 2012). Although the Industrial Waste Illegal Dumping Game introduced later is also a series of gamings incorporating a social dilemma structure, it is advantageous as individuals can make decisions easily and the game's rules, including those associated with sanctions, can be adjusted.

Gaming possesses great significance for investigating social dilemmas compared to laboratory experiments. It is necessary to consider not only the effect of sanctions, but also the interactions between the players and the social structure. The more people devise ways to escape surveillance, the more difficult it becomes to detect non-cooperation. This does not mean that the problem can be resolved by simple surveillance. This is the very issue in social dynamics that needs to be understood better, and gaming offers the

advantage of capturing social dynamics.

Illegal dumping of industrial waste in Japan

The gaming used in the current study simulates the illegal dumping of industrial wastes in Japan, which is a typical example of a social dilemma. Many illegal dumping cases were reported in Japan in the 1990s. The authorities cracked down on the menace in 1998. However, illegal dumping increased unexpectedly (Ishiwata, 2002). The Environmental Bureau reported that approximately 400,000 tons of industrial waste was illegally dumped per year until 2002. Approximately 745,000 tons of illegally dumped waste was discovered in 2003. Miyamoto (2003) reported that the number of illegal dumping case increased because the activity was conducted at a smaller scale, at the unit level, due to the strengthened crackdown. Nagasaki (2003) reported that the negative spiral of illegal dumping had not been resolved although a monitoring and control system had been implemented as a measure against improper disposal. In response to this situation, the government strengthened the penalty for illegal dumping in 2003, 2004, and 2005, namely for three consecutive years. In spite of these efforts, the amount of illegally dumped waste increased (Ono, Endo, and Yamada, 2007). Moreover, penalties were subsequently strengthened in 2011. Nevertheless, 147,000 tons were illegally dumped in 2015. In addition, a new law was introduced in 2017 to increase the fine amount from

2020 onwards. Currently, it is estimated that approximately 40,000 tons of waste per annum is illegally dumped in Japan (Japanese Ministry of the Environment, 2019), but this number may be an underestimate as more cases are still frequently discovered. Although the official statistics report a decline in the tendency for illegal dumping, we need to clarify the process of illegal dumping as undiscovered dumping may be inhibited ingeniously.

Illegal dumping is difficult to track due to the complexity of the industrial waste disposal industry. Various stakeholders are involved in the treatment and disposal of waste, which is generated by various production activities. To reduce the amount of waste sent to the landfill, it should be sorted and recycled, while the remaining is incinerated or crushed. Dedicated facilities and permits are required for these activities, and only industries specializing in intermediate treatment can complete disposal. Intermediate treatment is inevitably necessary, but it increases the risk of fires and soil contamination. Legally, it is necessary that the waste should be treated quickly. However, this may be difficult when the facility's capacity is exceeded.

In order to ensure the legal treatment of waste and detect illegal dumping, the government established the generator responsibility system for industrial waste. Generators must dispose the waste produced by them responsibly. If they cannot complete

disposal on their own, they must ensure that it is handled responsibly by appropriate waste disposers. The generator theoretically bears a heavier responsibility for illegal dumping than the other industries. Most generators are not always equipped for waste disposal, which is thus left to waste disposers. Even though the generator has the major responsibility for the disposal, it is almost impossible to confirm if the waste was disposed as mandated. The discharged waste is transported by many trucks to an intermediate treatment facility, mixed with other generators' waste, and screened for resources. Waste changes shape after treatment and can be categorized into various types. Thus, it is quite impossible to track waste. There is no guarantee that waste placed on a truck dedicated to a recycling unit will not be illegally dumped.

It is difficult to discover illegal dumping, and it is even more difficult to clarify the executor's identity. Furthermore, even if one executor is discovered by chance, it does not necessarily have enough assets or the ability to bear these expenses. Most small- and medium-sized enterprises find it difficult to incur the huge restoration cost. Thus, the local administration introduced subrogation measures via taxes. However, the costs associated with these procedures are enormous. Therefore, to cover the restoration cost of illegal dumping, the generators and disposal industry established a joint fund and introduced a mechanism for raising expenses.

Illegal dumping as a social dilemma and the effects of sanctions

Industrial waste disposal has a very complicated structure, which we simplify here for the sake of explanation. The behavior choices of each company are roughly divided into legal treatment and illegal dumping. The latter option allows a generator or a company to increase its own profit. Thus, we regard the illegal industrial waste dumping problem as a social dilemma and clarify the effect of sanctions and consequences that can arise from institutional interactions in this complex social structure. If each industry executes illegal dumping, the profit is larger. If all industries undertake legal treatment, their profit is larger than when all industries dump illegally. Legal treatment costs more than illegal dumping. Thus, individual industries profit by choosing illegal dumping. However, all generators and members of the disposal industry have to bear the cost of illegal dumping eventually.

The Industrial Waste Illegal Dumping Game was developed by incorporating the Japanese industrial waste disposal structure as a social dilemma (Ohnuma & Kitakaji, 2007). Kitakaji and Ohnuma (2014) verified whether sanctions may cause non-cooperation, and revealed that the presence of surveillance and punishment triggered illegal dumping behavior and prevent the sharing of information essential for mutual cooperation. One possible reason for the increase in non-cooperation was that the

presence of the sanction shifted the focus of communication to non-cooperation, discouraging the expectation of cooperation. The sanction resulted in distrust in others when competitively motivated (Deutsch, 1958, 1960) and decreased intrinsic motivation (Taylor, 1982; Yamagishi, 1988). These motivational factors and the social structure designed in the game prevented the expectation of mutual cooperation from taking shape.

Kitakaji and Ohnuma (2014) examined the effect of surveillance and punishment but did not consider the effect of rewards. Rewards may induce cooperation different from surveillance and punishment. However, the opposite hypothesis may be possible. If rewards are given for legal treatment, it may be considered that it is not necessary to monitor illegal dumping. However, there is no way to ascertain if all the waste is legally treated. Even if rewards are dispensed according to the amount of legally treated waste, companies will be deprived incentives for intermediate treatment, resulting in accelerated filling up of landfill sites. Eventually, it will be necessary to monitor whether the waste was legally treated, and it will be impossible to avoid the negative consequences arising from incomplete surveillance.

Therefore, this study explored the effect of rewards in conjunction with the generator responsibility system. The generator takes all the responsibility for waste disposal when no other company can be specified as the illegal dumper. This point was also applied to

the reward system, which we incorporated fictitiously into the game. Even if people do not know who disposed the waste appropriately, they can determine which generator produced the waste and reward the generator as a representative of the waste disposal industry.

We also expand upon the effects of monitoring and punishing. Kitakaji and Ohnuma (2014) examined the effects of monitoring and punishment by a specific surveillant. There is a possibility that such asymmetry creates a difference between what requires monitoring and what is actually monitored, or what results in punishment and what is punished. They noted that non-cooperative behavior can become a default strategy in such cases. Therefore, we set up situations where everyone can monitor and punish each other, resulting in an unbiased mutual punishment system.

Specificity of the Industrial Waste Illegal Dumping Game compared with the other gamings addressing social dilemmas

A linear division of labor structure was adopted in accordance with the structure of industrial waste treatment in the Industrial Waste Illegal Dumping Game (Nakamaru, Shimura, Kitakaji, & Ohnuma, 2018). In linear division of labor, it is important to choose players for different roles, and the situation is highly interdependent among the players, depending on the associated negotiations, transactions, and/or reputations. This is the

unique point of this gaming simulation compared to other gamings treating social dilemmas. It incorporates the system of industrial waste disposal and communication aspects, such as negotiations and trade, as its rules. Thus, the game can create social dynamics, and it is possible to observe the behavior of people affected by complex factors in a social dilemma.

Moreover, the Industrial Waste Illegal Dumping Game has other unique features. It is hard to detect non-cooperation even though the cost of surveillance is ignorable. This structure makes it possible to demonstrate the process of achieving mutual cooperation under the condition that the other players' behaviors are uncertain. In addition, the consequence of non-cooperation imposes unequal burdens on the players although the structure involves a social dilemma.

INTERVENTION

Structure of the Industrial Waste Illegal Dumping Game

The Industrial Waste Illegal Dumping Game (Ohnuma & Kitakaji, 2007) was developed as a role-playing game in which players play the role of each company within the structure of industrial waste disposal. Players in the game are industrial waste disposers and negotiate face-to-face with other players, transact, or dispose waste. Two or three people are in charge of each of the three companies (as discussed below). A total

of six to eight players participate in a game. This game postulates the following eight structural conditions.

Social dilemma structure

A player's behavior choices can be roughly divided into two types: legal treatment as cooperative behavior and illegal dumping as non-cooperative behavior. As explained earlier, the entire industry must bear the cost of illegal dumping.

Players' roles

There are three roles in the game: generators, intermediate treatment companies, and landfill companies. It is necessary for each industry to implement their respective roles for legal waste treatment. The generator undertakes production and generates money in the game. Waste is generated as a by-product. The intermediate treatment company can reduce the amount of waste legally. However, this entails a cost. Landfill companies landfill the waste, which is regarded as legal treatment. Landfill costs add up in proportion to the quantity of waste.

Payoff structure and initial information

Production, intermediate treatment, and landfilling entail costs, which vary depending on the player's role. At the start of the game, the players are made aware of the payoff structure of their roles alone. For example, only generators know the costs of

production, profits earned, and the amount of waste generated. Similarly, players other than intermediate treatment companies are not notified about the cost of intermediate treatment and the extent to which the industrial waste will decrease due to treatment. This arrangement is necessary for achieving mutual cooperation to gather information on the payoff structure and conduct transactions so that players can agree to cooperative behavior.

One-way flow of waste treatment

Waste treatment and transactions are carried out in the order of the generator, intermediate treatment company, and landfill company. The waste is never committed in the reverse direction nor is a transaction implemented by modifying the order. However, exchange of money is not necessarily carried out in accordance with this flow. For example, there is no prohibition on transferring money from the landfill company to the generator.

Difficulty of surveillance

When the game begins, all players simultaneously negotiate, trade, collude, calculate their profits, and exchange information. Some players may plan to conceal their own illegal dumping, for example, by hiding the illegal dumping site, amid such intermittent interactions. Additionally, many illegal dumping sites exist obtrusively or otherwise. At

times, illegal dumping is only discovered after all the sessions of the game are finished. The game proceeds without players knowing how much illegal dumping has occurred.

Time lag regarding consequences of illegal dumping

There is a time lag before the result of illegal dumping is fed back to the player. Illegal dumping eventually entails a cost (environmental restoration expenses) for all players, but this cost is known only after all the sessions are complete.

Generator responsibility system

As the generator is responsible for waste disposal, it bears the heaviest responsibility for illegal dumping. When illegal dumping is discovered, it is difficult to identify illegal dumpers, but it is relatively easy to identify the source of waste generation. Thus, generators bear a higher restoration cost than other industries.

Manifest

The manifest is a document which confirms that the waste has been legally treated. If an appropriate description is absent in the manifest or it is not returned, the waste is considered to have been illegally dumped. With regard to the generator's responsibility, the incompleteness of the manifest means that the responsibility of the generator has not been fulfilled, and it must pay a large fine. However, there is no way to confirm whether the contents stated in the manifest are in accordance with the facts. Therefore, it is

possible to disguise the manifest as if the waste was legally treated.

General rule of the game

The players are instructed that the goal of the game is to maximize self-interest and they will receive a reward (prize) according to the money earned in the game.

At the start of the game, all players have 10S irrespective of the role. S is the currency unit in the game. Although they can continue the game even if a deficit occurs, they cannot receive a reward at the end of the game.

Player's role

Each player assumes one of three roles: generator, intermediate treatment company, or landfill company. Each company is assigned two to three players. The role of the player is determined by lottery. While conducting transactions, the commission cost and commissioned amount of industrial waste are decided by negotiation between the players.

Venue setting of the game and movement/contact of/with the player

The game was conducted in a room such as a classroom (Figure 1) [insert Figure 1]. Each player prepared desks individually at a reasonable distance from each other and took their respective positions. The same companies were located relatively close, and different companies were located farther apart. The desks were placed facing the wall so that a player could not see what the other players were doing. Therefore, although they can view

each other, they would need to leave their seats and approach the other players if they want to know what they are doing. In order not to give the impression that the facilitator is watching the players, the facilitator was placed in the corridor outside the venue.

Conducting the game

After explaining the rules of the game, the players first experienced a practice session of 20 minutes. Players were invited to seek clarifications on the rules in this session. Then, we started the actual game, which comprised 5 sessions, each of 15 minutes or less. The sessions were terminated within 15 minutes if all the manifests were submitted. Industrial waste that was not landfilled by the end of the session was regarded as illegally dumped. Players chose to legally treat or illegally dump. Players could execute illegal dumping at no cost by simply placing waste in the illegal dumping box (Figure 2) [insert Figure 2] installed at the venue (Figure 3) [insert Figure 3]. Anyone could illegally dump anywhere at any time within the session.

Waste was represented as a small card (Figure 4) [insert Figure 4], and its amount is displayed on it (e.g., 5 or 10 tons). If 100 tons of waste is discharged by production, 10 cards of 10 tons of waste each were introduced to the game. Illegal dumping boxes were located all over (at 20 places inside and outside) the venue. As long as their actions were not witnessed by anyone, no other player or facilitator could know how much waste was

illegally dumped until all the sessions were complete.

After five sessions, the facilitators opened all illegal dumping boxes and measured the amount of illegally dumped waste. Accordingly, all players paid an environmental restoration cost. Next, each player replied to a post-questionnaire about the degree of shared information, collection of information, cooperation with the same/other industries, intent to cooperate, and attitude towards the environment and money in the game. Thereafter, the prizes (snacks) were distributed to the participants according to the final amount of money in their possession.

Debriefing in the game

During the debriefing, all the players remarked about participating in the game and what they feel during the game. They share their impressions of the game. Then, the facilitator explains the events happened in the game referring flow of the game. The facilitator answers the questions from the participants if they have further questions. The facilitator also explains the current situation of illegal dumping of industrial waste in Japan, and the thought of social dilemmas emphasizing how it is crucial to understand how individuals' behaviors lead to consequences for society as a whole. Finally, the facilitator notes that the behavior of the people involved in the game is influenced by the given structures, so as not to attribute any negative events to personal characteristics. This note is important

to avoid carrying over any conflicts stemming from the game into players' daily lives. Again, the facilitator answers any questions posed by the participants until any disputes are dispelled.

Manifest

Players submitted manifests to indicate that the waste was legally treated. Stamped manifest sheets indicate that the player has treated the waste legally when commissioning its disposal to another industry. With the submission of all manifest sheets, the waste was deemed to be legally treated. Only the generator that issued the manifest was fined 50S if one of the following occurred: a manifest was not submitted, it could not be submitted within time, and the necessary stamp was missing.

Notably, there is no way to ascertain whether the waste was truly legally treated even if the manifest sheet contains the stamp; even if it is illegally dumped, it is easy to disguise the manifest and return it to the generator. Players stamp their manifest sheets themselves, and thus, the sheet does not serve as incontrovertible proof of whether illegal dumping or legal treatment occurred. When the legal treatment is complete, the player stamps the manifest sheet. It is regarded as legal treatment if the facilitator can confirm that the manifest sheet carries the needed stamps despite the waste being treated legally or dumped illegally. Since the companies can complete the legal treatment independently,

no other player is aware about whether that company really treated the waste legally. The decision to stamp the manifest is also left to the disposal company. Moreover, one manifest sheet is issued to each contractor, but disposal and consignment can be decided by volume. Separating and consigning waste makes it impossible to be tracked even if it is treated legally. Nevertheless, a generator can avoid a fine if it can submit at least one manifest sheet. As a result, players can use the stamped manifest sheets as a bargaining chip independent from waste disposal transactions.

Restoration cost

At the end of all the sessions, all players must pay the environmental restoration cost. This cost is calculated according to the amount of waste disposed illegally, and is much higher for illegal dumping compared to legal treatment. Moreover, generators bear approximately four times the cost borne by other companies because of the generator responsibility system.

Players' choice and payoff

All players who dump illegally do not have to pay the commission cost for the dumped amount. The commission cost is decided by negotiation between the players. Transactions pertaining to disposal may be committed to only one or more companies. For example, when committing 100 tons of waste, the player can commit 100 tons to one company, or

50 tons, 30 tons, or 20 tons separately to many companies. Likewise, it is possible to divide waste disposal into legal treatment and illegal dumping. Of 100 tons, 50 tons can be committed legally and 50 tons can be dumped illegally.

Flow of transaction and money in a game session

The transaction flow in the session is seen in Figure 5 [insert Figure 5]. First, generators implement production by paying 10S as the production cost, and they receive money and waste. Although the profit and waste amounts are decided according to the roll of dice, the average profit obtained by one generator per production is 75S, and 100 tons of waste is generated. Generators can choose to commit the waste to intermediate treatment companies for legal treatment or dump it illegally. If the generators seek legal treatment, they need to pay a commission cost to the intermediate treatment companies and hand over the waste. The intermediate treatment company can choose whether to treat the waste received from the generator in the following manner: 1) treat intermediately to reduce the waste and commit the reduced waste to landfill companies, 2) consign the waste to the landfill company without intermediate treatment, or 3) dump it illegally. The amount of waste can be reduced by half by intermediate treatment, which is legal. Though the cost for intermediate treatment is high, it is possible to reduce the environmental restoration cost compared to committing it to the landfill company without reducing the amount of

waste. Then, the intermediate treatment companies decide whether to commit the waste to a landfill company. Landfill companies can choose to landfill or illegally dump waste received from intermediate treatment companies. Although legal landfilling is costly, the amount paid by all players as a whole is much lower for legal landfilling than illegal dumping.

In addition to the exchange for transactions, the players are allowed to exchange money between companies for camouflaging manifests, guaranteeing legal disposal, providing information, and so on.

METHOD

Conditions

Using the Industrial Waste Illegal Dumping Game, we conducted a quasi-experiment often used in psychology to compare the effects of sanctions on legal/illegal behaviors. We will clarify the consequences due to the differences in the initial conditions of the game through various interactions. We set three conditions: the reward condition (RW), the mutual punishment condition (PN), and the control condition (CN).

With RW, generators can receive a reward by quickly returning manifests. The session lasts 15 minutes, but submission of the manifest to the facilitator in less time means that the waste has been treated legally, and the generator who submitted the

manifest receives 20S as a reward. The other players were aware of this rule. Generators can also share the reward with someone or monopolize it. As untreated waste can lead to environmental issues, we designed the players to receive rewards if the waste is treated quickly.

Under PN, all players can punish other players. Illegal dumpers must pay a fine of 5S per 5 tons of illegal dumping if a player discovers the illegal dump and reports it to the facilitator. The player discovering the illegal dump receives 2S per 5 tons of illegal dumping from the facilitator. If the punishment functions properly, the incentive for discovering illegal dumping is large, and the fine for illegal dumping should deter the practice. Notably, there is no cost associated with monitoring and punishment.

Under CN, there is no reward for submitting manifests and no punishment for discoveries of illegal dumping. There are no sanctions other than penalties for manifests not adhering to the three above-mentioned conditions.

Participants and procedure

We conducted 10 games in total. A game consisted of 6 to 8 players. Sixty-seven people participated, comprising 26 players for 4 games under RW, 21 players for 3 games under PN, and 20 players of 3 games under CN. The participants were freshmen students of Hokkaido University and were recruited during psychology lectures. The participants

obtained additional credit as part of their respective class. However, we did not collect information on age and gender. After 20-25 minutes of explanation regarding the general rules of the Industrial Waste Illegal Dumping Game, players drew lotteries to decide their roles. Ten minutes were provided for the explanation of the rules for each role. Thereafter, a practice session was conducted for 20 minutes. When the rules were fully understood, the actual game started. This game was conducted over 5 sessions, with 15 minutes spent per session. After completing all the sessions, we collected the restoration cost and the game was over. Then, the players answered the post-questionnaire (15 minutes) after which snacks were distributed to the participants according to the final possession amounts. Then, the debriefing was conducted for approximately 30 minutes. Meanwhile, as players' understanding of the reasons of the other players was deepened by the debriefing, the snacks were observed to have been distributed roughly equally among the players. This was considered to be an indicator that the players were released from their respective roles in the game and no conflicts remained thereafter. It took approximately 3 hours to implement one game.

This research was approved by our institution's research ethics committee.

Dependent variables

Each player filled out the record sheet detailing the illegally dumped amounts and

transaction volumes of waste. In the analysis below, these self-reported illegally dumped amounts were used as a behavior variable for non-cooperation. We chose this value because the total value of each participant almost agreed with the data managed by the facilitator. We analyzed data from all sessions excluding the practice session.

We also required participants to answer the post-questionnaire, the contents of which were as follows. To understand the degree of shared information, we asked, “When did you know the information on the payoff of the (generator/intermediate treatment company/landfill company)?” The players chose from the following options: practice session, sessions 1–5, or did not know until the end of the game. We labeled their responses as “knew” and “didn’t know” in our analysis. We eliminated responses on payoffs within the same industry during the analysis because the players were informed of the payoffs for their own respective roles.

Participants answered the following items on a 7-point scale, from 1 (“I do not agree at all”) to 7 (“I strongly agree”) to describe their feelings after the game.

- On the collection of information: “I gathered information on the payoff structures of other players”
- On cooperation with the same and other industries: “I cooperated with the same industries” and “I cooperated with the other industries,” respectively

- On the intent to cooperate: “If illegal dumping is not found, I may dump illegally (and the converse)”
- On attitude towards the environment and money in the game: “I acted in the game out of concern for the environment” and “I acted in the game to earn money,” respectively.

Statistical analysis

To check differences between conditions or industries, we conducted a three-way analysis of variance (ANOVA) using a mixed model including a factor for game on a session (5: 1–5 sessions) within participants, conditions (3: reward, mutual punishment, and control), and industries (3: generator, intermediate treatment company, and landfill site) between participants. Using the post-questionnaire data, we conducted the χ^2 test for the degree of shared information to clarify to what extent players traded without knowing the payoff of another industry. We also conducted the one-way ANOVA on conditions (3: reward, mutual punishment, and control) between participants including industries (3: generator, intermediate treatment company, and landfill company) as a nested model to investigate players’ perception and behavior regarding collecting information and cooperation with other players.

RESULTS

Amount of illegal dumping

We analyzed the amount of illegal dumping as the dependent variable (Table 1). The results indicated the significant main effect of the condition (F (3,237) = 9.92, $p < 0.001$), the interaction effect of the condition and session (F (2,237) = 4.44, $p < 0.05$), and the interaction effect of the industry and session (F (2,237) = 3.46, $p < 0.05$). Since the main effect of the condition was obtained, the least squares means was examined (significance level 5%, hereinafter the same), and showed a significant difference between CN and RW. The illegal dumping amount was the smallest for CN and the highest for RW. There was no significant difference between CN and PN. With regard to the interaction effect of the condition and session, the illegal dumping amount increased with each session for RW, but decreased gradually under other conditions. With regard to the interaction effect of industry and session, the amount of illegal dumping by the generator increased with each session, but gradually decreased for the intermediate treatment company and did not change so much for the landfill company.

Table 1. Amount of illegal dumping

		Session 1		**Session 2**		**Session 3**		**Session 4**		**Session 5**		**total**	
		M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
CN	Generator	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Intermediate treatment	11.88	16.00	5.00	8.77	11.25	11.53	1.88	3.52	2.50	6.70	32.50	33.97
	Landfill	20.83	20.43	9.17	18.67	13.33	30.32	4.17	7.44	15.00	26.10	62.50	66.61
	Total	11.00	17.01	4.75	12.05	8.50	18.81	2.00	4.87	5.50	16.04	31.75	48.44
RW	Generator	0.00	0.00	0.00	0.00	12.50	20.10	13.75	23.17	30.00	39.22	56.25	78.11
	Intermediate treatment	3.33	9.53	5.56	9.96	7.22	12.41	13.33	21.32	13.89	18.74	43.33	47.07
	Landfill	5.56	15.89	21.67	24.66	10.00	15.26	7.22	9.27	15.56	18.53	60.00	64.18
	Total	3.08	11.06	9.42	18.06	9.81	16.08	11.35	18.86	19.42	27.43	53.08	63.70
PN	Generator	6.67	15.16	1.67	3.79	3.33	7.58	8.33	12.34	15.00	23.30	35.00	37.02
	Intermediate treatment	40.00	33.87	10.00	24.85	29.29	27.44	5.71	9.17	15.71	15.20	100.71	78.80
	Landfill	1.25	3.35	0.00	0.00	4.38	11.72	7.50	9.81	1.88	3.52	15.00	15.81
	Total	15.71	27.31	3.81	15.02	12.38	21.41	7.14	10.35	10.24	16.59	49.29	62.51
All	Generator	2.00	8.76	0.50	2.19	6.00	14.35	8.00	17.00	16.50	30.36	33.00	57.92
	Intermediate treatment	16.88	26.08	6.67	15.59	15.00	20.08	7.29	14.85	10.63	15.63	56.46	61.69
	Landfill	8.04	16.41	10.87	20.29	8.91	19.59	6.52	9.06	10.65	18.75	45.00	57.35
	Total	9.40	19.85	6.27	15.68	10.22	18.70	7.24	13.88	12.39	22.08	45.52	59.69

Note. CN: control condition, RW: reward condition, PN: punishment condition.

M = mean, SD = standard deviation

Post-questionnaire

A significant difference was noted in the proportion of players who did not know the generator's payoff information (χ^2 = 15.08, p < 0.001) and the intermediate treatment

company's payoff (χ^2 = 6.06, p < 0.05), and a marginal significance was observed in the landfill company's payoff (χ^2 = 5.45, p < 0.10). Approximately 85% of the players under CN knew this information, while 80% or more under RW did not know the payoff information of the generator until the end. Information sharing thus did not progress in the RW condition. Although more than 70% of the players under CN and PN shared the payoff information of the intermediate treatment company, approximately 60% or more of the players did not share this information under RW. Less than 30% of the players did not share the payoff information of the landfill site company in CN, but the information was not shared with 70% in RW and approximately 50% of the players in PN (Table 2).

Table 2. Information sharing

		about production		**about intermediate treatment**		**about landfill**	
		knew	didn't know	knew	didn't know	knew	didn't know
CN	*n*	12	2	9	3	10	4
	%	85.7%	14.3%	75.0%	25.0%	71.4%	28.6%
RW	*n*	3	15	6	11	5	12
	%	16.7%	83.3%	35.3%	64.7%	29.4%	70.6%
PN	*n*	7	7	10	4	6	7
	%	50.0%	50.0%	71.4%	28.6%	46.2%	53.8%

Note. CN: control condition, RW: reward condition, PN: punishment condition.

With regard to the one-way ANOVA on conditions, there was a significant difference between the conditions regarding the collection of information (F (2, 36) = 7.34, $p < 0.05$). Results of multiple comparison using the Tukey method indicated a significant difference between RW and the other two conditions, and the information was collected to the greatest extent in CN (Table 3).

Regarding cooperation with the same/other industries, intent to cooperate, and attitude towards the environment and money in the game, the main effect of the condition was not observed (cooperation with the same industry: F (2, 67) = 0.24, *n.s.*, cooperation with the other industry: F (2, 36) = 2.03, *n.s.*, intent to cooperate: F (2, 37) = 0.46, *n.s.*, attitude towards the environment in the game: F (2, 37) = 0.21, *n.s.*, attitude towards money in game: F (2, 37) = 0.48, *n.s.*).

Table 3. Answers to the post-questionnaire

	CN		**RW**		**PN**	
	M	*SD*	*M*	*SD*	*M*	*SD*
collection of information	5.40	1.67	3.35	1.85	4.55	1.47
cooperation with the same industry	4.70	2.68	5.62	1.86	6.14	1.11
cooperation with the other industry	5.16	1.86	3.85	1.85	3.38	1.69
intent to cooperate	4.10	2.15	4.12	2.14	4.71	1.95
attitude towards the environment in the game	4.15	2.52	4.19	2.48	3.67	2.13
attitude towards money in the game	4.55	1.96	4.58	2.04	5.29	1.31

Note. CN: control condition, RW: reward condition, PN: punishment condition.

M = mean, SD = standard deviation

DISCUSSION

Summary of the results

We conducted the Industrial Waste Illegal Dumping game and manipulated the punishment or reward. In spite of the same pay-off structure (except for the sanction system, which we treated as conditions), different behaviors were observed. Illegal dumping was observed to a greater extent in RW than CN. Conversely, when mutual punishment was enforced, no difference in the illegal dumping amount was noted with CN. Information regarding role-specific payoffs was not shared in RW, and participants in RW did not actively collect information. However, there was no difference between the conditions with regard to cooperation with the same/other industries, intent to cooperate, and attitude towards the environment and money. To summarize, although there was no difference among players' psychological aspects; the behavior regarding information collection changed and information was not shared due to the reward, which eventually caused illegal dumping.

We observed many non-cooperative behaviors when the reward existed, rather than when there was no reward. The generator in RW distributed the received reward among

other players, but they illegally dumped more than the other industries, the reason being that players took cognizance of the presence of a reward by coordinating their interests, and their purpose changed to submit manifests and receive the reward rather than promptly treat waste legally through the interaction. However, even if they tried to adjust their interests, they did not care about the payoff information necessary for mutual cooperation; eventually, the players' goal became acquiring and sharing the reward. *It can be inferred that illegal dumping became the means, and the reward, which was initially meant to reduce illegal dumping, became the aim.* The RW condition had two biased systems (manifest and reward). This meant that waste disposal was left to the generator. Generators were able to devise various actions, which were allowed in the game, to earn rewards, with unexpectedly negative effects on themselves.

Although the effect of the reward, which caused non-cooperative behavior, was shown, the effect of punishment was not evident. Even in the case of punishment, non-cooperative behavior did not decrease as compared to the case without punishment. Although players who discovered illegal dumping had incentives to receive returns according to the amount found in PN, they might not be motivated to detect illegal dumping as surveillance was difficult. There were many ways to obtain one's own profit, not just by way of commission for waste treatment transactions, but also by exchanging

money for various nominal items such as the manifest return fee. Accordingly, even though a player can obtain a return by discovering illegal dumping, the player devises a transaction rather than conducting surveillance. Therefore, it would have canceled the effect of punishment and the return offered in PN.

In this game, the players need to understand the other players' costs to select cooperative behavior. Even if the player wanted to treat the waste legally, it was impossible unless he/she received sufficient consignment money. Furthermore, it is necessary to adjust not only the two players directly trade waste but also the profit of the third person not involved in a transaction. Therefore, some players could not cooperate even if they wanted to due to coordination failure. It seems that existing sanctions, which are hard to detect with non-cooperation, have no effect on people's perception. In fact, the very existence of the sanction functioned as a trigger for non-cooperative behavior and caused people, who neglected gathering information, to achieve mutual cooperation. These social dynamics were generated due to the characteristics of gaming, which enable interaction among people and systems. Interestingly, sanctions do not always work to increase cooperation, and sometimes, result in consequences converse to the intention. In sum, the results imply that sanctions should be devised to allow people to expect mutual cooperation; otherwise, they will fail and not achieve their intended purpose.

LIMITATIONS AND SUGGESTIONS FOR FUTURE RESEARCH

The results of this research only focus on the social dilemma analyzed in this paper in terms of a few specific characteristics, and do not discuss social dilemmas in general. However, our study offers new insights into social dilemma-related research from the viewpoint of gaming. Research on social dilemmas has been conducted in various settings such as fieldwork, interviews, laboratory experiments, simulations, and construction of theoretical models. By using gaming, we could demonstrate social dynamics such as incomplete surveillance, diverse roles, ignorance about mutual payoffs, and the possibilities of free negotiation and transactions with regulatory crackdowns, all of which cannot be represented in laboratory experiments simultaneously.

Moreover, this study is designed to observe overall consequences and cannot reveal the effects of individual factors. Therefore, it is necessary to conduct complementary research. Compared with laboratory experiments, it is difficult to control all factors; that is, a gaming simulation suffers from a disadvantage in analyzing the mechanism of an individual player’s decision making. However, it also offers the advantage of providing descriptions of social dynamics. Although this study succeeded in describing such dynamics partially, it would be possible to extend our understanding of these dynamics.

Lastly, while this study shed light on players' behaviors and the self-reported post-questionnaire, the understanding remains limited. Further study will be required for depicting the social dynamics more dynamically.

CONCLUSION

This study revealed that existing rewards directly increase people's non-cooperation. Although many laboratory experiments have proven that sanctions have a strong effect on cooperative behavior, they are also known to have detrimental effects on people's perceptions, or result in undesirable behavior other than non-cooperation. However, it is difficult to directly demonstrate that non-cooperative behavior increases via laboratory experiments. The Industrial Waste Illegal Damping Game contains two notable features: a) non-cooperative behavior is hardly detected irrespective of strengthening surveillance, and b) players assume various roles and do not know the others' benefits. In addition, players perform free negotiations and transactions other than waste disposal, and coordinate their profits. The consequence of this coordination results in the emergence of new game-specific rules and/or norms different from the original settings. Thus, dynamics that cannot be observed in laboratory experiments occur depending on the system created due to the interactions among players in the gaming simulation.

In this study, we used the Industrial Waste Illegal Dumping Game to demonstrate the

negative effect of sanctions in a social dilemma situation, and reproduced social dynamics. The game used in this study maintained a social dilemma structure while having complex structural conditions, much unlike previous research on social dilemmas in laboratory settings, where various factors were controlled. We showed that players used such structures to escape regulatory surveillance. Players showed flexible play that was not limited to cooperation or non-cooperation in the game, and they took advantage of rewards to increase their profits. On the other hand, by sharing information, people make various choices to protect themselves, revealing hints of social systems that assume cooperation, and determine their behavior. Nonetheless, negative consequences occur when interacting with other systems, such as the generator's responsibility, that already exist in the societal framework. It is crucial to understand the kinds of consequences that may arise where players interact with each other, share goals other than mutual cooperation, and adhere to specific rules and norms. The results of this paper shed light on the consequences of sanctions on society, and contribute to social dilemma and gaming research.

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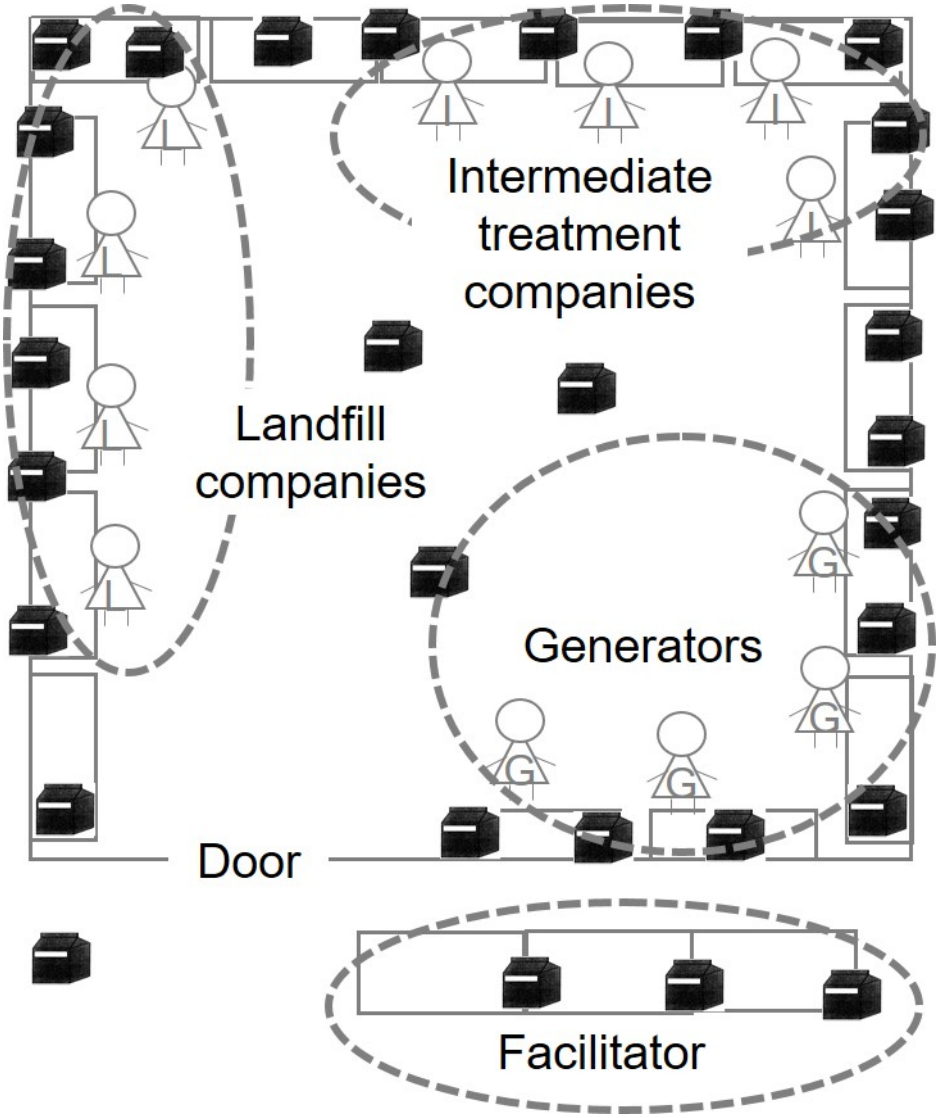

Figure 1. Game floor map.

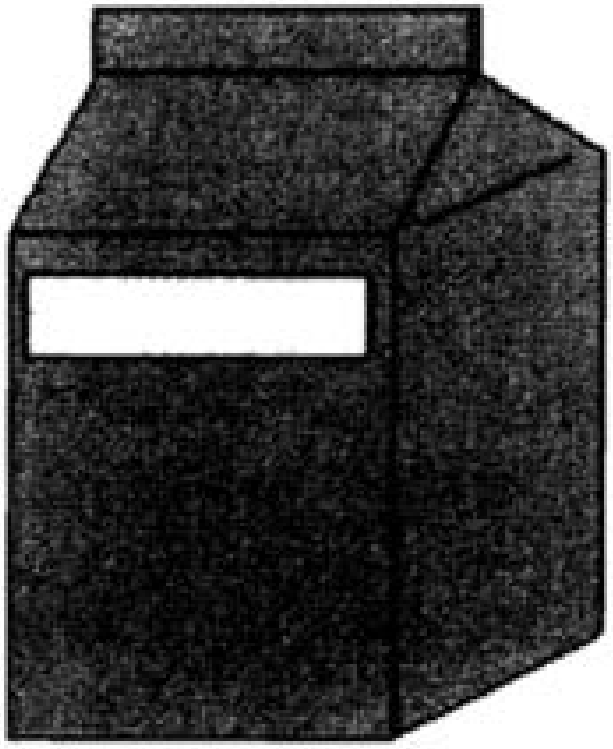

Figure 2. Illegal dumping box.

Figure 3. A player dumping waste illegaly.

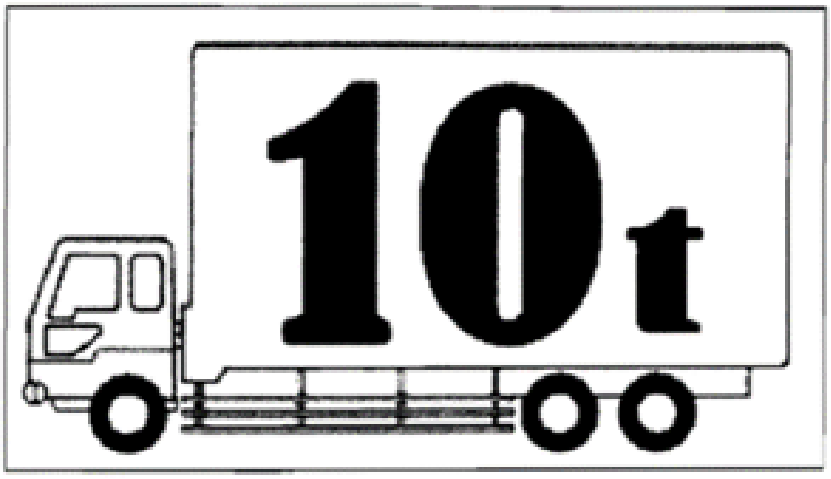

Figure 4. A card denoting the amount of waste generated.

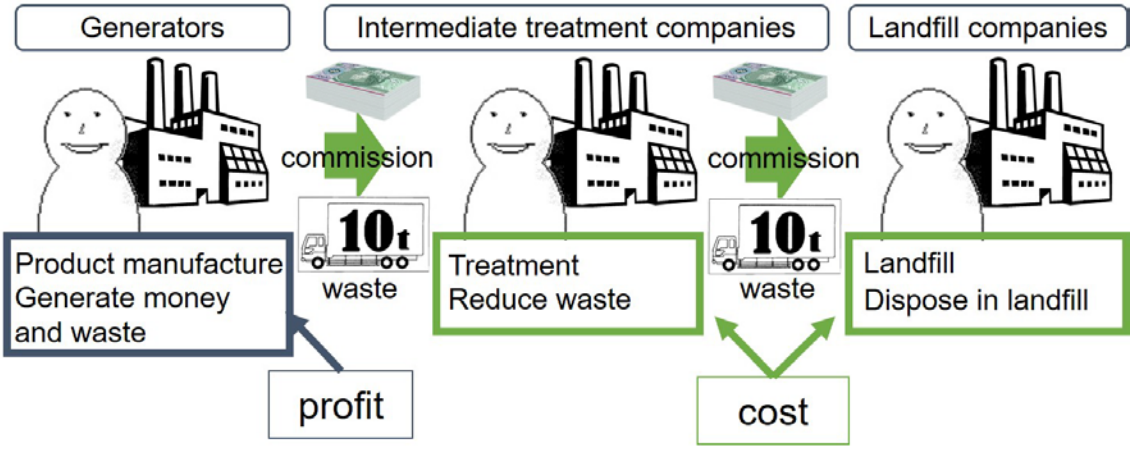

Figure 5. Flow of transaction and money in a game session.