博士論文（要約）

論文題目　Ideal Burden-Sharing in a Heterogeneous Group and the Reality

（非対称集団におけるコスト分担の理想と現実）

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Preface

Groups often need to perform repetitive tasks that require only one member's effort at a time. For example, someone needs to carry garbage to the dumpsite when the garbage bin overflows in a household, order copier paper when it has run out in a workplace, and book a place when social club members hold a meeting. These tasks are commonly referred to as chores, housework or household chores in a household context, and office housework (defined as "menial administrative tasks that keep an office running" according to Jang et al., 2021) in a workplace context.

These tasks seem trivial and are rarely considered seriously. Nevertheless, they may involve a complicated burden-sharing problem, especially when group members differ in their cost to perform the task. Imagine a situation where someone in a group needs to carry garbage to the dumpsite. Everyone can do this, but it may take less effort for some members, possibly because they are physically stronger or have a dumpsite nearby. In this case, what is the most desirable way to share the burdens? Should everyone take it on the same number of times irrespective of the cost heterogeneity, or should members with a lower cost take it on more often? It may also be desirable if members with the lowest cost take it on all the time, which is the most efficient solution.

It is crucial to examine which burden-sharing principle people prefer and whether they can act according to it. Suppose, for example, a scenario where group members collectively believe that members with a lower cost should take on the task more frequently but not every time. If the group members' behavior deviates from the preference for some reason, resulting in everyone taking it on the same number of times, members with a higher cost end up carrying greater burdens than the ideal. Similarly, if members with the lowest cost take it on all the time, they end up shouldering greater burdens than the ideal. These discrepancies between the ideal and the reality might be initially overlooked due to the perceived trivial nature of the task. However, dissatisfaction stemming from such discrepancies would accumulate over time and detrimentally affect group members, particularly those who bear greater costs.

The present research addressed four questions regarding this burden-sharing problem. The first two questions were (i) what kind of burden-sharing principle participants perceived as most desirable and (ii) whether they acted according to it. Since the investigation of these questions revealed that some participants' behavior deviated from the principle that they deemed desirable, it prompted two additional questions: (iii) What was the obstacle to acting according to the desirable principle, and (iv) what kind of group dynamics led participants to act according to the principle even with the obstacle?

When examining these research questions, the present research adopted the framework of the volunteer's dilemma (Diekmann, 1985), which is a type of social dilemmas, specifically

public goods games. A typical linear public goods game represents a group situation where everyone needs to incur a cost to fully produce a public good. In contrast, the volunteer's dilemma is a group situation where only one member needs to incur a cost to fully produce a public good. This kind of situation may seem rare, but it is prevalent in the real world. As the examples above imply, we often face chores that require only one member's effort at a time. The volunteer's dilemma is also depicted in the famous fable Belling the Cat, which narrates the story of a group of mice deciding which mouse will undertake the task of attaching a bell to a cat.

The characteristics of the volunteer's dilemma are detailed in Chapter 1 of the present thesis. To provide a comprehensive theoretical background, Chapter 1 first introduces social dilemmas and classifies them to demonstrate how the volunteer's dilemma is different from other social dilemmas, specifically public goods games. Chapter 1 further classifies the volunteer's dilemma to show that repeated asymmetric volunteer's dilemmas well reflect situations of interest in the present research—the burden-sharing problem introduced at the beginning of this preface. Chapter 2 presents seven empirical studies I conducted to address the research questions (i)–(iv). These studies involved experiments (with surveys and economic games) and computational modeling, all of which used the framework of repeated asymmetric volunteer's dilemmas. The concluding chapter, Chapter 3, discusses the contributions, limitations, and future directions of the findings in Chapters 1 and 2.

1. Theoretical Background

What Are Social Dilemmas?

Introduction

Van Lange et al. (2013, 2014) defined social dilemmas as situations where each individual is (at times) better off when they do not cooperate than when they cooperate (often in the short-term). However, all individuals are better off if all cooperate than if no one cooperates (often in the long-term). Everyday life is rife with such conflicts between short-term individual interests and long-term collective interests. Examples range from organizational citizenship behavior (i.e., focusing only on the assigned tasks that would immediately raise one's own wages vs. taking on extra-role tasks that would enhance the company's productivity in the long-term) (Organ, 1988; Podsakoff et al., 2000; Shih & Chen, 2011) to natural resource management (i.e., excessively consuming natural resources including freshwater, land, and wildlife, for the country's immediate economic interests vs. consuming a limited amount of such resources to preserve the planet for the current and future generations) (Habiba et al., 2013; Hardin, 1976; Van Vugt, 2002).

Brief History

Because of their universality, social dilemmas have attracted enormous attention from researchers in various disciplines since the 1970s (Dawes, 1980; Yamagishi, 1995). However, situations in which a group of people affects each other's interests have been studied by mathematicians since the 18th century (e.g., de Montmort, 1713, as cited in Bellhouse, 2007). While the early mathematicians were motivated by gambling situations in card games and board games, subsequent mathematicians applied their theories to economic problems (e.g., von Neumann, 1928, as cited in von Neumann & Morgenstern, 1944). Such economic studies were introduced by von Neumann and Morgenstern's (1944) seminal book *Theory of Games and Economic Behavior*, which ultimately served as the foundation for modern game theory.

Inspired by this cited book, Luce and Raiffa (1957) introduced game theory to social scientists from empirical fields. Some researchers (e.g., Van Lange et al., 2014; Yamagishi, 1995) pointed out that Luce and Raiffa's (1957) nontechnical depiction of the prisoner's dilemma provoked the interest of social scientists. As I describe in detail in the next section, the prisoner's dilemma is a 2 × 2 game (i.e., two players having two options: cooperation or non-cooperation), where it is always more beneficial for individual interests not to cooperate but it is always more beneficial for collective interests to have more players cooperate. As the prisoner's dilemma was used to examine various real-world situations with a conflict between individual and collective interests (which are called mixed-motive situations), such as a price

war between two stores and an arms race between two countries, its variants also attracted the attention of researchers (Rapoport, 1989; Rapoport & Chammah, 1965).

There were two major ways to investigate such variants. One of them was to examine N-person prisoner's dilemmas, where $N > 2$ (Hamburger, 1973). Two notable works seemed to serve as catalysts for this research trend: the economist Olson's (1965) book *The Logic of Collective Action* and the ecologist Hardin's (1968) article "The Tragedy of the Commons" in *Science*. Olson (1965) focused on the problem of contribution, showing that it is more difficult to have everyone act for collective interests in larger groups. In contrast, Hardin (1968) focused on the problem of conservation. Hardin presented the difficulty of having everyone cooperate to avoid overusing common resources and argued that this poses a serious problem as the population grows. Despite the difference in social issues they addressed, both works impactfully demonstrated that a conflict between individual and collective interests may pose a serious problem in N-person situations. Inspired by these works, sociologists and psychologists developed formal models to analyze such group situations (e.g., Hardin, 1971; Hamburger, 1973; Platt, 1973; Schelling, 1973), which were later integrated as social dilemmas (Dawes, 1975, 1980).

Another major way to examine the variants of the prisoner's dilemma was to investigate other games with a 2 × 2 payoff matrix. For instance, Rapoport et al. (1976) examined all possible 2 × 2 games and found 78 strategically distinct games. This was an important attempt for the literature on social dilemmas. When Dawes (1975, 1980) integrated sociological and psychological works on mixed-motive situations as social dilemmas, it was assumed that social dilemmas were N-person prisoner's dilemmas. However, Liebrand (1983) suggested that three out of the 78 games found by Rapoport et al. (1976)—not only the prisoner's dilemma, but also the stag hunt game and the chicken game—should be classified as social dilemmas. This classification of social dilemmas has been accepted by subsequent researchers (e.g., Heckathorn, 1996; Kollock, 1998; Simpson, 2003; Van Lange et al., 2014; Yamagishi, 1995).

Definition of Social Dilemma

According to Dawes' (1975, 1980) definition of social dilemmas, which is one of the first and most cited definitions, social dilemmas are group situations with two properties: (a) each individual is better off when they do not cooperate than when they cooperate, but (b) all individuals are better off when everyone cooperates than when nobody cooperates. While two- and N-person prisoner's dilemmas always satisfy these properties, two- and N-person stag hunt games and chicken games (or "weak prisoner's dilemmas," according to Rapoport, 1988) do not necessarily satisfy the first property. As I detail in the following sections, whether each individual receives a higher payoff by not cooperating than by cooperating depends on the other players' decisions in stag hunt games and chicken games.

Some researchers proposed more general definitions of social dilemmas to include stag

hunt games and chicken games (e.g., Komorita & Parks, 1996; Liebrand, 1983; Schelling, 1978; Van Lange et al., 2013, 2014). For example, Van Lange et al. (2013, 2014)'s definition, which is introduced at the beginning of this chapter, uses the term "at times" to relax the first property in Dawes' (1975, 1980) definition. The present research revises this general definition to define social dilemmas more precisely.

In the present research, social dilemmas are defined as group situations with three properties. First, cooperation means never diminishing the other players' payoff. Therefore, each player is never worse off when the other players cooperate than when they do not (Property 1). Second, a group yields a higher payoff when everyone cooperates than when nobody cooperates (Property 2). Third, however, each player receives a higher payoff by not cooperating than by cooperating if the other players do not cooperate (which is labeled as fear; e.g., Komorita & Parks, 1996; Macy & Flache, 2002; Płatkowski, 2017; Simpson, 2003) and/or if the other players cooperate (which is labeled as greed; e.g., Komorita & Parks, 1996; Macy & Flache, 2002; Płatkowski, 2017; Simpson, 2003) (Property 3). Social dilemmas involving only fear are stag hunt games, those involving only greed are chicken games, and those involving both are prisoner's dilemmas. These properties are formally described in the following sections.

Overview of Chapter 1

In the rest of this chapter, I classify social dilemmas, drawing on the definition noted above. First, I focus on the three 2 × 2 games that were classified as social dilemmas by Liebrand (1983): the prisoner's dilemma, the stag hunt game, and the chicken game. Second, I suggest how these simplest dilemmas are related to N-person social dilemmas, or more specifically, public goods games. The aim of these classifications is to present the feature of the volunteer's dilemma, which is of interest in the present research. By the end of this chapter, I show that the volunteer's dilemma is a type of N-person chicken games, and demonstrate how the volunteer's dilemma is different from other social dilemmas. Additionally, I classify the volunteer's dilemma to show that one of its variants—repeated asymmetric volunteer's dilemmas—reflects situations of interest in the present research (i.e., situations where someone in a group needs to take on a repetitive task and group members vary in the cost to perform it). Finally, I present problems that are likely to occur in repeated asymmetric volunteer's dilemmas, which would clarify the research questions introduced in the preface.

（５年以内に出版予定）

Volunteer's Dilemma

The volunteer's dilemma is a type of public goods games—specifically, CG2 or step-level public goods games—where only one individual's contribution or volunteering is necessary and sufficient to fully produce a public good (Diekmann, 1985). Although this kind of dilemma may seem rare, it abounds in the real world. As introduced in the section of PD2-2, the volunteer's dilemma has often been used to examine situations with the bystander effect or where someone needs to help a person in trouble (e.g., Diekmann, 1985; Campos-Mercade, 2021; Krueger, 2019; Thomas et al., 2016). Furthermore, the examples introduced in the preface—situations where someone needs to carry garbage, order copier paper, and book a meeting place—imply that various chores in everyday life are the volunteer's dilemma. The volunteer's dilemma is even illustrated in the well-known fable Belling the Cat, in which a group of mice need to decide which mouse will undertake the task of attaching a bell to a cat.

Table 3 presents the payoff matrix of the volunteer's dilemma as a version of step-level public goods games (Diekmann, 1985; Tham et al., 2022; Weesie, 1993). In a group of N members, each member has a choice whether to volunteer and incur a cost of K to produce a public good (i.e., cooperate) or shirk. If at least one member volunteers, the public good is provided, and each member receives a utility of V, where $V > K > 0$. If everyone shirks, nobody receives anything since no public good is produced.

Table 3

Payoff matrix of the volunteer's dilemma

		Number of other cooperators				
		0	1	2	…	$N-1$
Focal member's choice	Volunteer	$V-K$	$V-K$	$V-K$	…	$V-K$
	Not volunteer	0	V	V	…	V

As noted in the section of N-person chicken games (see also Table 2), CG2 is different from other types of social dilemmas in that people need to coordinate decision-making and ensure that cooperators and non-cooperators coexist to maximize both individual and collective interests. In the volunteer's dilemma, people need to coordinate decision-making and ensure that only one member volunteers at a time. As Table 3 presents, it is more beneficial for the focal member to shirk to earn V than to volunteer to earn $V-K$ when someone else volunteers. However, shirking is not a dominant strategy because the focal member earns more by volunteering ($V-K$) than by shirking (0) if no one else volunteers. Additionally, Table 3 implies that coordination is crucial not only for individual interests but also for collective interests. The total payoff of the group is maximized if only one member volunteers ($V \times N - K$). For example, if nobody volunteers, no public good is produced ($0 \times N$), and if everybody

volunteers, a public good is produced but unnecessary costs are incurred ($V \times N - K \times N$).

Previous studies on the volunteer's dilemma examined conditions under which participants succeeded in coordination. They revealed, for example, participants succeeded in coordination when some of them were allowed to send a one-way message to others about whether they would volunteer (Feldhaus & Stauf, 2016), when some of them were recommended to volunteer by an experimenter (Kurz et al., 2018), and when some of them were the only ones who knew the necessity of volunteering (Thomas et al., 2016). However, these cited studies, as well as most other previous studies on the volunteer's dilemma, examined the simplest version of the volunteer's dilemma, which is not the exact situation the present research focuses on. The present research is interested in repeated asymmetric volunteer's dilemmas, whose characteristics are depicted in the following section.

Various Types of the Volunteer's Dilemma

According to Diekmann and Przepiorka (2016), the variants of the volunteer's dilemma (and other social dilemmas) can be classified into one-shot and repeated situations. In one-shot volunteer's dilemmas, players need to decide whether to contribute to a public good only once. In repeated volunteer's dilemmas, players need to make the decision iteratively in the same group. Therefore, while studies on one-shot volunteer's dilemmas mainly reveal people's initial tendency to cooperate or their initial belief about others' cooperativeness, studies on repeated volunteer's dilemmas can reveal how conventions or decision-making patterns emerge through interactions in a group (e.g., Guala, 2013; Voss, 2001). Examining the process of the formation of such decision-making patterns is important because it would deepen our understanding of how people in a volunteer's dilemma, where they need to coordinate decision-making and ensure that only one member volunteers at a time, reduce coordination difficulty by themselves, without relying on external manipulations.

Another key classification made by Diekmann and Przepiorka (2016) is between symmetric and asymmetric situations. Symmetry in this context refers to individual homogeneity: group members do not vary in the cost of producing the public good (K) or the benefit from the public good (V). Thus, in asymmetric volunteer's dilemmas, group members vary in the cost K and/or benefit V. Although it is easier to examine symmetric volunteer's dilemmas, it is important to consider asymmetry because asymmetric situations are more prevalent than symmetric ones, which may be obvious as it is hard to imagine situations where everyone is exactly the same (Van Dijk & Wilke, 1995). In asymmetric volunteer's dilemmas, those with a higher net benefit $V - K$ (i.e., those who incur a lower cost K when producing the public good and/or receive a higher benefit V from the public good) are called "strong" members, and those with a lower net benefit are called "weak" members.

Previous studies have primarily examined the simplest version of the volunteer's dilemma, specifically one-shot symmetric volunteer's dilemmas (e.g., Feldhaus & Stauf, 2016; Goeree

et al., 2017; Heck & Krueger, 2017; Hillenbrand & Winter, 2018; Kurz et al., 2018; Thomas et al., 2016). In contrast, the present research examined repeated asymmetric volunteer's dilemmas mainly for two reasons. First, the framework represents situations of interest in the present research, where a group of people needs to share the burdens of a repetitive task when their cost to perform it varies (i.e., asymmetric). Second, seldom did previous research empirically study repeated asymmetric volunteer's dilemmas (for exceptions, see Diekmann & Przepiorka, 2016; Przepiorka et al., 2021). The present research argues that the framework requires more attention because it is difficult to predict how people address such a situation. As I detail in the next section, this difficulty derives from a trade-off among three burden-sharing principles.

Trade-off Among Three Principles

In repeated asymmetric volunteer's dilemmas, interactions in a group may lead to the development of a decision-making pattern that helps people coordinate their decision-making. However, predicting what specific pattern would emerge is challenging because at least three burden-sharing principles would influence people's behavior in repeated asymmetric volunteer's dilemmas (particularly when they involve a cost asymmetry). The principles include efficiency, net-benefit equality, and output equality.

Consider a repeated asymmetric volunteer's dilemma game that consists of 21 rounds. A group in the game consists of three members: Players A, B, and C. In each round, everyone receives $V = 80$ tokens each if at least one member volunteers. In other words, one member's volunteering provides a public good of 240 tokens (= 80 tokens × 3 members). While Player A (a strong member) needs to pay only ten tokens to volunteer ($K_S = 10$), Players B and C (weak members) need to pay 50 tokens ($K_W = 50$). Table 4 demonstrates how to achieve efficiency, net-benefit equality, and output equality in this game.

Efficiency in repeated asymmetric volunteer's dilemmas means maximizing a group's net benefit from a public good. When group members vary in volunteering cost, the strongest member (i.e., a member with the lowest cost) should always take on the task to achieve efficiency. In the game (Table 4), when Player A volunteers in all rounds (21 rounds), the group can minimize its total cost (10 tokens × 21 rounds = 210 tokens) to produce the public good (240 tokens × 21 rounds = 5040 tokens). Thus, the group can maximize its net benefit (5040 tokens − 210 tokens = 4830 tokens).

Net-benefit equality in repeated asymmetric volunteer's dilemmas indicates minimizing the difference in each group member's net benefit from the public good. The group can achieve net-benefit equality when stronger members volunteer more frequently (in accordance with their relative strength). In the game (Table 4), Player A should volunteer five times more than Players B and C because the volunteering cost of Player A is a fifth of that of Players B and C. If Player A volunteers in 15 rounds and Players B and C volunteer in three rounds each,

everyone incurs the same amount of cost (10 tokens × 15 rounds = 50 tokens × 3 rounds = 150 tokens). Since this game does not involve any individual difference in benefits each member receives from the public good, this burden-sharing results in equal net benefit (80 tokens × 21 rounds − 150 tokens = 1530 tokens).

Output equality in repeated asymmetric volunteer's dilemmas indicates minimizing the difference in each group member's output (in terms of the public good). In the game (Table 4), everyone can provide the same amount of a public good (240 tokens) by volunteering, irrespective of their strength. Thus, when the members volunteer the same number of times (21 rounds / 3 members = 7 times), each provides the group with the same amount of benefit (240 tokens × 7 rounds = 1680 tokens).

Although net-benefit and output equality may seem similar, these two principles have a significant difference. While net-benefit equality focuses on what each member gains from the group, output equality focuses on what each member provides to the group. One might also wonder if net-benefit and output equality are related to the distinction between equity and equality in the literature on social exchange. In the literature on social exchange, equity is typically defined as the ratio of an outcome to input being constant for everyone involved in the exchange (Adams, 1965; Cook & Hegtvedt, 1983), while equality indicates an outcome being constant for everyone, even if input varies from person to person (Mannix et al., 1995). Net-benefit equality vs. output equality in repeated asymmetric volunteer's dilemmas and equity vs. equality in the literature on social exchange may seem similar because both net-benefit equality and equity take into account individual differences (in cost and input, respectively), while both output equality and simple equality do not. However, these distinctions are different. First, the social exchange literature focuses on how to distribute a given amount of resources, while repeated asymmetric volunteer's dilemmas focus on how to distribute burdens to provide a public good that can be accessed equally by anyone. Second, the social exchange literature assumes no difference in the productivity of people involved (i.e., how much cost is required to produce a public good). For example, those who prefer equity to equality, believing that individuals who work harder deserve more rewards, should assume that those who work harder produce more. In contrast, in repeated asymmetric volunteer's dilemmas, those who work harder do not necessarily produce more because of the asymmetric productivity.

The trade-off among the three principles has not been pointed out before. This is because previous research has mainly focused on one-shot or symmetric volunteer's dilemmas, which do not involve the trade-off among the three principles. In one-shot symmetric volunteer's dilemmas, a group can simultaneously satisfy the net-benefit and output equality principles when it has no one or everyone volunteer. These equality principles conflict with the efficiency principle, which is satisfied when only one member volunteers. However, this trade-off would not pose a problem since efficiency is the only principle that aligns with the goal of ensuring

that only one member volunteers at a time in the volunteer's dilemma. As noted above, studies on one-shot symmetric volunteer's dilemmas have focused on how to help people achieve efficiency through, for example, an opportunity for one-way communications (Feldhaus & Stauf, 2016), a recommendation about who should volunteer (Kurz et al., 2018), and the manipulation of knowledge regarding the necessity of volunteering (Thomas et al., 2016).

When a symmetric volunteer's dilemma repeatedly occurs, the three principles can be satisfied simultaneously. This is because efficiency is satisfied when only one member volunteers at a time, and net-benefit and output equality are satisfied when everyone volunteers the same number of times. Previous studies showed that participants in these situations were likely to take turns volunteering, which allowed them to realize the three principles (Diekmann & Przepiorka, 2016; Tham et al., 2022).

In asymmetric volunteer's dilemmas, the trade-off does not pose a problem if it occurs only once. A group in one-shot asymmetric volunteer's dilemmas can simultaneously satisfy the net-benefit and output equality principles when it has no volunteer. These equality principles conflict with the efficiency principle, which is satisfied when only the strongest member volunteers. However, this trade-off would not pose a problem because efficiency is the only principle compatible with the goal of ensuring that only one member volunteers at a time, as in one-shot symmetric volunteer's dilemmas. Consistently, previous studies demonstrated that participants tended to act according to efficiency (i.e., the strongest members volunteered at a high rate while the others rarely volunteered) in one-shot asymmetric volunteer's dilemmas (Przepiorka & Diekmann, 2013; Tutić & Grehl, 2018). In contrast, as described above in this section, it is not straightforward to solve the trade-off in repeated asymmetric volunteer's dilemmas because all the principles align with the goal of ensuring that only one member volunteers at a time.

Table 4

Example of achieving efficiency, net-benefit equality, and output equality in a repeated asymmetric volunteer's dilemma game

	Efficiency	Net-benefit equality	Output equality
Number of times volunteered	(A) 21 times	(A) 15 times	**(A) 7 times**
	(B) 0 times	(B) 3 times	**(B) 7 times**
	(C) 0 times	(C) 3 times	**(C) 7 times**
	(total) 21 times	*(total) 21 times*	*(total) 21 times*
Input (Cost incurred)	(A) 10 tokens × 21 times	**(A) 10 tokens × 15 times**	(A) 10 tokens × 7 times
	(B) 50 tokens × 0 times	**(B) 50 tokens × 3 times**	(B) 50 tokens × 7 times
	(C) 50 tokens × 0 times	**(C) 50 tokens × 3 times**	(C) 50 tokens × 7 times
	(total) 210 tokens	(total) 450 tokens	(total) 770 tokens
Output (Public good provided)	(A) 240 tokens × 21 times	(A) 240 tokens × 15 times	**(A) 240 tokens × 7 times**
	(B) 240 tokens × 0 times	(B) 240 tokens × 3 times	**(B) 240 tokens × 7 times**
	(C) 240 tokens × 0 times	(C) 240 tokens × 3 times	**(C) 240 tokens × 7 times**
	(total) 5040 tokens	*(total) 5040 tokens*	*(total) 5040 tokens*
Benefit earned	*(A) 80 tokens × 21 times*	*(A) 80 tokens × 21 times*	*(A) 80 tokens × 21 times*
	(B) 80 tokens × 21 times	*(B) 80 tokens × 21 times*	*(B) 80 tokens × 21 times*
	(C) 80 tokens × 21 times	*(C) 80 tokens × 21 times*	*(C) 80 tokens × 21 times*
	(total) 5040 tokens	*(total) 5040 tokens*	*(total) 5040 tokens*
Net-benefit (= Benefit - Cost)	(A) 1470 tokens	**(A) 1530 tokens**	(A) 1610 tokens
	(B) 1680 tokens	**(B) 1530 tokens**	(B) 1330 tokens
	(C) 1680 tokens	**(C) 1530 tokens**	(C) 1330 tokens

	(total) 4830 tokens	(total) 4590 tokens	(total) 4270 tokens

Note. In this game, a group consists of one strong member (Player A) who can volunteer at ten tokens and two weak members (Players B and C) who can volunteer at 50 tokens plays a repeated asymmetric volunteer's dilemma game for 21 rounds. If at least one member volunteers, a public good of 240 tokens is provided, and each receives 80 tokens. Numbers in italics are fixed (i.e., cannot be changed by players), and numbers in boldface are essential to achieve each principle.

Importance of Studying the Trade-off

Because of the trade-off among the three principles, it is hard to predict how people address repeated asymmetric volunteer's dilemmas. The present research argues that it is important to empirically investigate people's preferences for the principles and whether their actions align with the preferences in repeated asymmetric volunteer's dilemmas, both for practical and theoretical reasons.

If any discrepancy arises between people's preferences and their actual behaviors, especially those who have incurred higher costs than the ideal would feel dissatisfied. For instance, suppose that group members consider net-benefit equality as the most desirable principle. If circumstances compel them to adhere to efficiency or output equality, strong or weak members find themselves carrying higher costs than the ideal, which would lead to their dissatisfaction. Such discontent could arise as long as there is any discrepancy between the ideal and the reality, no matter which principle is preferred and achieved.

Nevertheless, the negative possibility rarely draws people's attention. This is probably because tasks that occur as a repeated asymmetric volunteer's dilemma in everyday life, such as household chores and office housework, seem inconsequential in the short term. However, since such tasks are likely to recur for a long time (as long as the group remains to exist), any dissatisfaction stemming from the discrepancy between the ideal and the reality would accumulate over time and even escalate into discord within the group. Empirically examining the possibility of the discrepancy and the underlying mechanisms (if any) would offer practical insights into how to prevent such adverse consequences and enhance the overall well-being of group members.

The empirical examination is also important from a theoretical point of view. First, it would deepen our understanding of people's behavior in social dilemmas that require coordination. This is crucial since theoretically predicting how people address coordination problems is difficult, and extensive empirical research on coordination is required (Camerer, 2003).

Second, the empirical examination would also contribute to the literature on distributive justice. Research on distributive justice has revealed that people prefer a "maximin" or "Rawlsian" principle (i.e., the payoff of the least well-off should be maximized) to other cardinal principles such as equality (i.e., everyone's payoff should be the same) and efficiency (i.e., the collective payoff of the group should be maximized) (Charness & Rabin, 2002; Engelmann & Strosbel, 2004; Kameda et al., 2016; Mitchell et al., 1993; Ueshima & Kameda, 2021). In repeated asymmetric volunteer's dilemmas, net-benefit equality fulfills the maximin principle. In other words, the payoff of the least well-off member is higher when the group members act according to net-benefit equality than

when they act according to the other principles (see "Net-Benefit Equality and the Maximin Principle" in the Supplemental Material for the proof). Therefore, the present research can empirically re-test the previous findings on the maximin principle by examining whether people prefer net-benefit equality and whether their behavior aligns with it in repeated asymmetric volunteer's dilemmas.

Furthermore, the empirical examination would deepen our understanding of people's attitudes toward the trade-off among various types of equality. As Messick (1995) argued, achieving equality in some aspects often results in inequality in others. The trade-off between net-benefit equality (ensuring equality in what people receive from their group) and output equality (ensuring equality in what people provide to the group) in repeated asymmetric volunteer's dilemmas is one of the examples. Previous studies showed that when faced with such trade-offs, people tend to apply the equality principle to the aspect they were led to focus on in a heuristic way or without thinking analytically (Messick, 1995; Messick & Schell, 1992). However, there is also empirical evidence showing that when confronted with the trade-off between net-benefit and output equality, participants displayed a strong preference for net-benefit equality and tried to realize it even when they were led to focus on output equality (Ohtsubo & Kameda, 1998)[1]. By empirically examining whether participants prefer net-benefit equality to output equality even in repeated asymmetric volunteer's dilemmas, the present research can reveal the generalizability of people's preference for net-benefit equality.

In this section, I have demonstrated the practical and theoretical importance of empirically examining people's preferences for the three principles and the extent to which their behavior corresponds with these preferences in repeated asymmetric volunteer's dilemmas. As this topic has not been investigated before, I started it in an exploratory manner without establishing any strong hypothesis regarding people's preferences and behavior. However, it was possible to predict that people would prefer net-benefit equality for two reasons. First, net-benefit equality fulfills the maximin principle when it is compared with efficiency and output equality, and previous studies on distributive justice have revealed people's preferences for the maximin principle (Charness & Rabin, 2002; Engelmann & Strosbel, 2004; Kameda et al., 2016; Mitchell et al., 1993; Ueshima & Kameda, 2021). Second, there is empirical evidence showing that people preferred net-benefit equality to output equality even when they were prompted to focus on output equality (Ohtsubo & Kameda, 1998).

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[1] Ohtsubo and Kameda (1998) referred to net-benefit equality as equal sharing of surplus and output equality as equal sharing of total amount (see Figure 1a in Ohtsubo & Kameda, 1998).

Summary of Chapter 1

In this chapter, I classified social dilemmas to clarify the features of the volunteer's dilemma. Specifically, I first showed the difference between the three two-person social dilemmas: the prisoner's dilemma, the stag hunt game, and the chicken game. Then, I extended the discussion to N-person social dilemmas, specifically public goods games. I classified public goods games into seven types based on individual (i.e., whether it is always more beneficial to choose non-cooperation) and collective interests (i.e., whether it is always more beneficial to have more cooperators), according to which the volunteer's dilemma is a type of CG2 (some-must-cooperate N-person chicken games). This indicates that both individual and collective interests are maximized in the volunteer's dilemma when people coordinate decision-making and ensure that cooperators and non-cooperators coexist (specifically, only one member volunteers and the others shirk).

At the end of this chapter, I focused on repeated asymmetric volunteer's dilemmas, which involve the trade-off among three burden-sharing principles: efficiency, net-benefit equality, and output equality. Since each of the principles is consistent with the goal of ensuring only one member volunteers at a time, it is hard to predict how people address the trade-off. In the next chapter, I empirically examined (i) which principle participants perceived as most desirable and (ii) whether they acted according to it. After investigating these questions, I found that some participants' behavior deviated from the principle that they deemed desirable. Therefore, I additionally examined the mechanisms underlying the discrepancy between the ideal and the reality. Specifically, I examined (iii) what was the obstacle to acting according to the desirable principle, and (iv) what kind of group dynamics led participants to act according to the principle even with the obstacle.

（５年以内に出版予定）

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論文の内容の要旨

Groups often need to perform repetitive tasks that require only one member's effort at a time. For example, someone needs to carry garbage to the dump site when the garbage bin overflows in a household, order copier paper when it has run out in a workplace, and book a place when social club members hold a meeting. These tasks are commonly referred to as chores, housework or household chores in a household context, and office housework in a workplace context.

These tasks seem trivial and are rarely considered seriously. Nevertheless, they may involve a complicated burden-sharing problem, especially when group members differ in their cost to perform the task. Imagine a situation where someone in a group needs to carry garbage to the dump site. Everyone can do this, but it may take less effort for some members, possibly because they are physically stronger or have the dump site nearby. In this case, what is the most desirable way to share the burdens? Should everyone take it on the same number of times irrespective of the cost heterogeneity (to achieve output equality), or should members with a lower cost take it on more often (to achieve net-benefit equality)? It may also be desirable if members with the lowest cost take it on all the time, which realizes efficiency.

The present research examined this burden-sharing problem, adopting the framework of the volunteer's dilemma. The volunteer's dilemma is a type of social dilemmas, specifically public goods games. While a typical linear public goods game represents a group situation where everyone needs to incur a cost to produce a public good fully, the volunteer's dilemma is a group situation where only one member needs to incur a cost to produce a public good fully. This kind of situation may seem rare, but it is prevalent in the real world. As the examples above imply, we often face chores that require only one member's effort at a time. The volunteer's dilemma is also depicted in the famous fable Belling the Cat, which narrates the story of a group of mice deciding which mouse will undertake the task of attaching a bell to a cat.

I detailed these theoretical backgrounds regarding the volunteer's dilemma in Chapter 1 of the present thesis. Specifically, Chapter 1 first introduced a brief history of social dilemmas, provided a definition of them, and classified them based on individual (i.e., whether it is always more beneficial for an individual to choose non-cooperation) and collective interests (i.e., whether it is always more beneficial for a group to have more cooperators). The aim of this classification was to demonstrate how the volunteer's dilemma was different from other social dilemmas, specifically public goods games. Furthermore, Chapter 1 classified the volunteer's dilemma to show that repeated

asymmetric volunteer's dilemmas well reflect situations of interest in the present research—the burden-sharing problem introduced above. Finally, Chapter 1 demonstrated that repeated asymmetric volunteer's dilemmas involved the trade-off among three burden-sharing principles: efficiency, net-benefit equality, and output equality.

Chapter 2 introduced seven studies (n = 1,789) that addressed four questions regarding the trade-off among three principles in repeated asymmetric volunteer's dilemmas. The first two questions were (i) which burden-sharing principle participants perceived as most desirable and (ii) whether they acted according to the principle. As detailed in Chapter 2, I conducted Study 1 to examine the first question. Specifically, I carried out an experiment to examine participants' attitudes toward the three principles in repeated asymmetric volunteer's dilemma games. The results showed that participants perceived net-benefit equality as the most desirable principle when they were asked to imagine a situation of the games from a third-party perspective.

In Study 2, which addressed the second research question, I carried out an experiment to investigate participants' actual behavior in repeated asymmetric volunteer's dilemma games. Participants were matched with two other participants and played a game for 20–30 rounds. Some participants played a game as a "strong member," who can volunteer at a lower cost than the other group members, while others played it as a "weak member." The results revealed that while strong members acted according to the ideal (i.e., net-benefit equality), weak members' behavior deviated from it; they acted according to output equality.

In Study 3, I re-examined the first research question to confirm that net-benefit equality was deemed most desirable not only from the perspective of a third party but also from that of a weak member. The results of an experiment showed that participants deemed net-benefit equality as most desirable from the perspective of a third party, strong member, and weak member. Therefore, I concluded that there was some obstacle for weak members to act according to their ideal. This finding prompted the third research question: (iii) What was the obstacle to acting according to the desirable principle?

In Studies 4, 5a, and 5b, I addressed the third research question, examining three hypotheses: the perspective-taking-difficulty hypothesis (i.e., weak members may have misbelieved that strong members intended to achieve output equality), calculation-difficulty hypothesis (i.e., weak members may have failed to correctly calculate how many times each member should volunteer to achieve net-benefit equality), and coordination-difficulty hypothesis (i.e., weak members may have been uncertain about who should volunteer in each round to achieve net-benefit equality and failed to coordinate their decision-making with other group members). I conducted repeated

asymmetric volunteer's dilemma games similar to those in Study 2. The results supported the coordination-difficulty hypothesis; weak members could not act according to net-benefit equality because they had difficulty coordinating their decision-making.

Even with coordination difficulty, weak members' behavior in some groups was closer to net-benefit equality than that in other groups. Thus, Study 6 addressed the fourth research question: (iv) What kind of group dynamics led some weak members to act according to net-benefit equality even with coordination difficulty? In Study 6, I first formally modeled participants' decisions in the repeated asymmetric volunteer's dilemma games in Studies 2, 4, and 5b. I compared seven models that assumed participants' tendency of reinforcement learning, net-benefit/output inequality aversion, and/or inclination to volunteer. After determining the best-fit model, which consisted of reinforcement learning, net-benefit inequality aversion, and inclination to volunteer, I conducted a regression analysis. The dependent variable was the extent to which weak members acted according to net-benefit equality, and the independent variables included the parameters estimated in the best-fit model (e.g., the tendency of net-benefit inequality aversion of strong members). The results showed that weak members tended to act according to net-benefit equality when strong members consistently tried to achieve net-benefit equality, specifically when they volunteered once their net benefit became higher than other group members.

These findings have several contributions. As written in Chapter 3, for example, the finding that participants preferred net-benefit equality would be helpful in devising guidelines for real-life burden-sharing situations. Without knowing the trade-off among the three principles and people's preference for net-benefit equality, one may intuitively develop a rule that deviates from net-benefit equality. Such rules include having everyone take turns performing a repetitive task irrespective of how much cost each member needs to complete it (which aligns with output equality) and consistently assigning the task to a group member who can complete it with the lowest cost (which aligns with efficiency). These rules involve a discrepancy between the ideal and the reality, potentially leading to dissatisfaction among group members and even discord within the group. The present research suggests that creating guidelines that align with net-benefit equality would prevent such adverse outcomes.

In addition, the finding that coordination difficulty was the obstacle to acting according to net-benefit equality has several implications. First, it reveals the importance of studying situations entailing coordination. Although previous studies showed that coordination played a crucial role when people collaborated, most studies on social dilemmas mainly examined situations that did not involve coordination. Given that

extensive empirical research on coordination is required because theoretically predicting how people resolve coordination problems is challenging, future work should concentrate on enhancing our understanding of how people address situations with coordination difficulty. Another implication of the finding is that, although people may feel frustrated as they cannot realize the principle they deem desirable in everyday burden-sharing situations, they may resolve the problem if coordination difficulty is eliminated. It is important for future work to identify practical ways to reduce coordination difficulty in various real-life situations.