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A group decision experiment on discussion contexts that encourage deeper reflection on residents left behind in the sustainable recovery from nuclear disaster in Japan

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Abstract

Participatory citizen deliberation is essential for achieving a sustainable recovery from nuclear disasters. Therefore, it is crucial to evaluate the discourse quality and identify the conditions that enable constructive discussions, especially when addressing conflicting issues.

This study focuses on the final disposal of removed soil outside Fukushima Prefecture, a potentially contentious issue involving multiple values of social desirability, namely, the 'common good,' such as reducing risks and costs, sharing the burden, and considering the Fukushima residents who have borne the burden, all of which are indispensable for a sustainable recovery. We focus on discussion contexts as the conditions that affect how an issue is discussed, thereby enabling impartial deliberation by considering the diverse common good.

We conducted a group-decision experiment and manipulated the discussion context to be competitive or cooperative. Statements in the discussions were evaluated using the Discourse Quality Index (DQI) to compare the content of utterances across conditions and participants' initial positions on the issue.

The results revealed that in the competitive-context condition, the common good mentioned by participants varied significantly depending on their initial positions. In contrast, participants in the cooperative-context condition impartially referred to various common good regardless of their initial positions. Furthermore, participants in the cooperative-context condition tended to contemplate the issue from their opponents' perspectives.

This study clarifies the conditions that enable inclusive deliberation over diverse values and demonstrates the effectiveness of DQI in evaluating discourse quality, which would help achieve the Sustainable Development Goals to leave no one behind.

1. Introduction

Sustainable Development Goals (SDGs) constitute a set of internationally shared objectives that call for countries to take proactive action toward achieving integrated sustainability [1]. SDG 16 advocates "peace, justice, and strong institutions." In particular, achieving Target 16.7—ensuring responsive, inclusive, participatory, and representative decision-making at all levels—requires public deliberation that enables broad citizen participation [2–4]. Such deliberation is crucial for realizing a society that leaves no one behind, which is the core principle of the SDGs [5], as well as for ensuring a sustainable recovery from nuclear disasters. The implementation of participatory programs is increasing [6]; nevertheless careful attention must be paid to the design and implementation of such processes. For instance, if participating citizens are biased and social representativeness is not guaranteed, the process itself cannot be sustainable [7, 8]. To ensure sustainability, methods for public participation, such as cooperative discourse [9] and mini-publics [6, 10–12], have been developed and proactively implemented. Although many good practices of citizen participation in public deliberation have been reported, most cases involve

issues where value conflicts are unlikely to arise, and relatively few contentious cases characterized by such conflicts have been examined [13].

Engaging in constructive controversy regarding issues involving conflicting values and related opinions is challenging, even among members of the public who are not direct stakeholders. If participants cling to their initial positions on issues on which opinions are divided, the statements tend to be biased, leading to a one-sided understanding of the issue [14–17]. Consequently, differing opinions may be less recognized, making constructive and inclusive controversies more difficult.

Moreover, even when public interest beyond self-interest is deliberated, organizing a constructive controversy is difficult, particularly when all values are significant but contradictory. Previous research (cf. [18, 19]) has argued that a typical example of this value conflict arises from the tension between utilitarianism, which prioritizes maximizing welfare for the greatest number [20–22], and distributive justice [23, 24], which emphasizes reducing inequalities and includes the maximin principle, improving the condition of the least advantaged [25]. Therefore, when engaging in public deliberation on issues that encompass contradictory values, a fundamental research question is how to design an arena that enables participants to listen carefully and reflect on heterogeneous values, those that differ from their own.

Recovery from nuclear disasters is an issue where value conflicts are likely to arise. Previous studies have demonstrated the importance of enabling residents to participate in the formulation of recovery plans during recovery from natural disasters such as typhoons and earthquakes [26, 27]. In such processes, building a consensus on recovery policies between local communities and administrative authorities at both local and national levels is essential. Similarly, in the context of recovery from nuclear disasters, residents of affected areas have engaged in dialogue with experts and scientists on radiation [28, 29]. However, certain issues require the involvement of not only local residents, but also the broader public. For example, national debates on site selection for nuclear waste disposal have been held in several countries, including Switzerland and the United Kingdom [30–32]. Nonetheless, few studies have examined how the public should be involved in recovery from nuclear disasters, partly because of the limited number of such cases.

This study examines the final disposal of removed soil from Fukushima Prefecture as a subject of public discourse. This issue is critical to Fukushima's recovery and requires nationwide public discourse for a resolution (details are provided below). Moreover, the issue of removed soil encompasses diverse and often conflicting values, and these perspectives appear incompatible. If citizens engaged in public discourse fail to deliberate on the removed soil issue through the lens of diverse values and differing perspectives, it will become impossible to ensure responsive, inclusive, participatory, and representative decision-making at all levels targeted by the SDGs. Instead, crucial opinions that deserve consideration will be discarded, leaving individuals who are then overlooked in resolving the removed soil issue and in the overall recovery process. This directly impedes the realization of a sustainable society where no one is left behind. To prevent such outcomes, examining how to design sustainable public discourse becomes essential.

The remainder of this paper is organized as follows. First, an overview of the issue of removed soil is provided, including the requirements for public discourse. Second, the indicators used to assess whether the issue was discussed constructively are introduced. Third, the discussion context is described as a factor influencing the evaluations relevant to these indicators. Based on the above, this study conducts a group decision experiment to examine how the quality of discourse on the issue of removed soil varies across different discussion contexts. As described in detail below, the issue of removed soil calls for public discourse in the near future, making it essential to carefully examine how discussion settings should be designed. This study tests the effects of discussion context on discourse quality in group decisions by manipulating it and provides foundational insights for designing public discourse in practice, leading to a sustainable recovery process from the nuclear disaster.

1.1 Case: The final disposal of removed soil outside Fukushima Prefecture

1.1.1 Overview of the removed soil issue

The 2011 Fukushima Daiichi Nuclear Power Plant accident released large amounts of radioactive material into the environment. To mitigate its impact on human health and living conditions, decontamination efforts have been conducted across Fukushima Prefecture. Although many areas were restored, these efforts led to the generation of large amounts of removed soil. To manage this soil safely, an interim storage facility was built in the towns of Okuma and Futaba. Approximately 80% of the land is privately owned [33]. Before the accident, it consisted of villages and agricultural fields central to local life. Residents of Okuma and Futaba not only had to evacuate because of the disaster, but also had to provide their ancestral land for storage. Some residents of Okuma and Futaba still wish to return and restore ties with their communities. While recovery progress allows residents to return in many other areas, the residents of these two towns can be viewed as having been left behind in the recovery process. In other words, a truly sustainable recovery has not yet been achieved.

The law stipulates that the final disposal of the removed soil should be conducted outside Fukushima Prefecture within 30 years of transportation to the interim storage facility [33]. This stipulation reflects the heavy burden borne by Fukushima residents, including the Okuma and Futaba residents. However, no specific candidate sites have been identified. Moreover, unless the broader public understands the significance and necessity of final disposal outside Fukushima and reaches a policy agreement, the law is unlikely to be effective.

Disposing the total volume of removed soil outside Fukushima is less feasible because of the required land area; therefore, reducing the amount of soil for final disposal is key to realizing this goal. The national government aims to promote the recycling of low-concentration soil (below 8,000 Bq/kg) under conditions where management and accountability are clear, provided that safety is ensured [34]. The threshold of 8,000 Bq/kg for recycling is based on the lower reference level recommended by the International Commission on Radiological Protection (ICRP) for radiation protection strategies [35], which

does not exceed an additional dose of 1 mSv per year. The amount of removed soil transported to the Interim Storage Facility is approximately 13 million cubic meter, of which approximately 25% exceeds 8,000 Bq/kg, whereas approximately 75% is below this threshold [33]. Recycling demonstration projects have been conducted in Minami-soma and Iitate in Fukushima Prefecture, with safety confirmed for each project [33, 36, 37].

Fostering national understanding and encouraging public discourse involving a broad range of citizens are essential for final disposal outside Fukushima and promoting soil recycling (cf. [38]). In other words, without fostering a nationwide understanding and promoting public consensus through public discourse, it is less likely that the final disposal outside the prefecture or the reuse of the removed soil will be utilized. At present, no candidate sites have been identified and public discourse has not been initiated. Under these circumstances, it is valuable to explore the factors that may influence the public discourse on the issue of removed soil through laboratory experiments.

1.1.2 Approaches to the issue of removed soil

The disposal of the removed soil is implemented after its safety has been scientifically verified; therefore, the probability of substantial harm to residents who accept it is considered low. Moreover, because the removed soil does not require stringent management such as that required for high-level radioactive waste, disposal and recycling can be performed at a relatively low cost. Nevertheless, moving the removed soil outside Fukushima gives rise to communities and individuals who will take the burden anew. Here, “burden” does not simply mean radiation risks but also includes social risks such as negative reputational effects and stigmatization. However, if no one takes on such a burden, Fukushima residents who have already borne it will continue to do so in the future. In this sense, this issue can be regarded as a matter of burden distribution across Japan.

When considering how the burden of the removed soil should be allocated across society, what social values are relevant to public deliberation? This study refers to three values reflected in public decisions (common good) proposed by Souma et al. [39]. The first concern is concentrating on the burden of the removed soil at a single location to reduce disposal risks and costs. The second relates to the distribution of the burden across multiple locations. The third focuses on improving the circumstances of the residents of Okuma and Futaba towns, who have borne the burden to date.

In relation to these value-based criteria, Souma et al. [39] conceptualized the issue of removed soil as involving two stakeholder groups that deserve consideration. The first group comprises residents of Okuma and Futaba towns, who have borne the burden of removed soil to date. The second group comprises the residents of communities who may assume the burden of the removed soil, although the specific locations remain undetermined.

From the above, the question arises as to whether citizens can deliberate while accounting for diverse values and both key stakeholder groups in terms of burden distribution, and in which discussion contexts they can deliberate in a manner that satisfies discourse criteria.

1.2 Evaluation tool for public discourse: Discourse Quality Index (DQI)

1.2.1 Overview of Discourse Quality Index

An evaluation tool is necessary to assess the content of discourse, whether citizens engage in deliberations grounded in multiple social values (i.e., the common good), and whether due consideration is given to those who have borne the burden and those who may bear it in the future. A widely used tool for assessing discourse content based on these criteria is the Discourse Quality Index (DQI).

Steenbergen et al. [40] introduced the DQI based on discourse ethics [41], which emphasizes that ideal deliberation involves listening to diverse opinions and considering the common good over self-interest. DQI has been applied to citizen participation contexts primarily in Western countries [42–45], and Japan [46, 47]. Himmelroos [48] identified key elements in DQI evaluations of citizen participation, including "level of justification," "content justification," and "respect."

Steenbergen et al. [40] described several conceptual dimensions: "Content justification" concerns whether arguments focus on self-interest or the common good for society, which includes multiple values such as utilitarianism and the maximin principle [49]. "Respect" concerns whether participants value the opinions of others and those affected by decisions. "Level of justification" refers to whether arguments are supported by rational reasoning.

However, reasoning in deliberation is not limited to rational forms. Bächtiger et al. [50] argued that storytelling is a key component of deliberation. Storytelling, which involves sharing personal experiences, helps individuals from diverse backgrounds engage in dialogue [51] and legitimizes marginalized voices [52]. Such personal narratives are often used to support arguments [53] and positions in discussions [54, 55]. By extending this argument, the emotions and experiences of others can serve as reasoning just as much as one's own. Applying this to the issue of removed soil, people might put forward arguments based on the emotional experiences of those in Okuma and Futaba towns who were forced to evacuate because of the nuclear accident, as well as those who are now taking on a new burden related to the soil.

1.2.2 Key DQI items for evaluating arguments on the issue of removed soil

The DQI framework can be applied to key concepts in public discourse on the removed soil issue.

First, the values reflected in public decision on removed soil correspond to the "content justification" dimension of the DQI. Souma et al. [39] identified the minimization of risks and costs, the sharing of burden, and consideration for Fukushima residents as key concepts for content justification and incorporated them into the DQI dimension. Within this dimension, arguments emphasizing the reduction in risks and costs associated with disposal can be regarded as justifications grounded in utilitarianism [20–22]. This is because in traditional risk analysis, minimizing risks and balancing costs and benefits are

considered rational (cf. [56]), and this approach is grounded in utilitarian principles [57]. Distributing the burden across multiple locations can be regarded as a justification grounded in distributive justice [23, 24] because sharing the burden of removed soil across regions would mitigate inequities, thereby satisfying distributive justice. Improving the circumstances of residents in Okuma and Futaba towns can be regarded as a justification grounded in the maximin principle [25]. This is because the residents of Okuma and Futaba towns who provided land for the Interim Storage Facility and wish to return to their homes can be defined as the most disadvantaged.

Next, consideration for those who have borne the burden and those who may bear it in the future corresponds to the “respect” dimension of the DQI. More specifically, consideration for residents of Okuma and Futaba towns, who have previously borne the burden, as well as for residents of communities that may newly assume it, falls under the DQI category of respect for those affected by the decision. Therefore, this study introduces the items “respect for Fukushima residents” and “respect for those who will take on a new burden” as DQI items. In this context, “respect” encompasses not only esteem but also careful consideration and sympathetic regard.

In addition to content justification and respect, this study examines the viewpoints of reasoning opinions. For example, individuals who argue based on values such as risk reduction and cost minimization are more likely to justify their positions from perspectives grounded in scientific and economic rationality. In contrast, individuals who prioritize values such as reducing the burden on Fukushima residents or sharing it across regions may be more likely to ground their reasoning in the emotional experiences of those who have borne or may bear the burden, as well as in empathy for them. The original DQI includes an item that assesses the extent to which statements are supported by rational reasoning. However, the original DQI does not distinguish between different types of reasoning. When applied to discourse on the removed soil, two distinct forms of reasoning can be identified: reasoning grounded in scientific and economic rationality, and reasoning grounded in the subjective emotional experiences of those who have borne, or may bear, the burden. These emotional experiences include what is heard from others. Thus, this study establishes the items “rational reasoning” and “emotional reasoning” as DQI items.

Ideally, all DQI items should be addressed during public deliberation to enable a comprehensive judgment. However, in reality, the aspects stated may be biased depending on an individual’s stance on the final disposal of the removed soil outside Fukushima. For instance, those in favor of final disposal outside Fukushima may base their arguments on the excessive burden borne by Fukushima residents. In other words, their statements emphasize distributive justice and the maximin principle, showing greater consideration for the Fukushima residents. Conversely, those against final disposal outside Fukushima may focus on the risks and costs of transporting the removed soil and the cost-effectiveness of constructing a final disposal site. Thus, their statements are likely to be biased toward utilitarian principles and economic rationality. Such biases in statements may lead to an increased entrenchment of positions, making consensus on the removed soil issue more difficult. What can be done to foster multifaceted arguments and avoid adherence to personal opinions and values?

1.3 Discussion contexts: Competitive or cooperative

A helpful approach for resolving such conflicts is constructive controversy ([58], among others). Constructive controversy is defined as a situation in which one person's ideas, information, conclusions, theories, and opinions are incompatible with those of another, and the two seek to reach an agreement [58]. Previous studies have shown that constructive controversy generates higher-quality solutions than debates or concurrence-seeking [59, 60] and stimulates idea generation [61].

However, merely engaging in a controversy with individuals holding different views does not always yield high-quality outcomes.

A key condition for making a controversy constructive is the presence of a cooperative goal structure. Deutsch [62] argued that when people face conflict situations, the resolution process may follow either a competitive or cooperative process, leading to different forms of interaction and outcomes. Competitive processes involve negative interdependence, in which one person's goal achievement reduces that of another. Cooperative processes involve positive goal interdependence, in which individuals' goal attainment mutually supports one another. According to Deutsch [62], controversy inherently entails conflict and becomes truly constructive only when resolution follows a cooperative process.

A competitive context refers to a situation in which differences of opinion are explicit, and participants engage in rebuttals against opponents' contentions.

If the debate on the final disposal of the removed soil outside Fukushima occurs in a competitive context, a particular discourse pattern can be anticipated. That is, participants who support final disposal outside Fukushima are likely to emphasize the need to alleviate the burden borne by Fukushima residents and distribute it across other regions. In contrast, participants who oppose final disposal outside Fukushima are likely to argue that the increased risks and costs of transporting the removed soil outweigh its benefits. In this context, participants tend to articulate arguments that support their initial positions (i.e., support or oppose the final disposal of removed soil) and refute opposing views to influence group decisions. Conversely, a cooperative context involves participants with heterogeneous opinions engaging in mutual examinations. Similarly, discourse on the final disposal of removed soil outside Fukushima in a cooperative context can be considered. In this context, proponents and opponents of the final disposal outside Fukushima are likely to examine each other's arguments. Regardless of their initial positions, participants tend to articulate viewpoints that draw on a range of considerations, including reducing risks and costs, sharing burden, and alleviating the burden on Fukushima.

Such differences in the discussion context may influence the content of utterances as measured by DQI items.

In short, a cooperative context may better enable participants to account for diverse values and the perspectives of key stakeholder groups than a competitive context. However, in public deliberations on the issue of removed soil in Japan, no empirical research has examined which kinds of arguments emerge in either context or whether and how discourse quality differs between contexts. By conducting a

controlled group decision experiment, this study aims to provide empirical insights for designing public deliberations on the disposal of removed soil.

1.4 Purpose and hypothesis

Public deliberations on removed soil will be required in the near future for sustainable recovery from the nuclear disaster. It is essential to provide insight into how public deliberation should be designed to achieve the SDGs' vision of fostering decision-making at all levels that is responsive, inclusive, participatory, and representative. Therefore, this study examines how discussion contexts influence discourse content in group decision-making regarding removed soil. To this end, this study conducts a group decision experiment in which the discussion context is experimentally manipulated. The content of discourse is evaluated using the DQI, focusing on the following items: "reduction of risks and costs," "sharing of burden," "consideration for the Fukushima residents," "respect for Fukushima residents," "respect for those who will take on a new burden," "rational reasoning," and "emotional reasoning."

Differences in the discussion context are expected to lead to the following hypotheses: In a competitive context, the frequency of utterances corresponding to specific DQI items is expected to vary according to participants' initial positions regarding the final disposal of removed soil outside Fukushima as a means to refute opposing views and support their own.

Specifically, participants who oppose the final disposal of the removed soil outside Fukushima prioritize risk and cost reduction and justify their positions primarily in terms of scientific and economic rationality. In other words, they are likely to produce a relatively higher proportion of utterances that fall under the DQI categories of "reduction of risks and costs" and "rational reasoning," compared to those who support the final disposal outside Fukushima. In contrast, participants who support the final disposal outside Fukushima emphasize values such as alleviating the burden borne by Fukushima residents and sharing them across multiple regions, accounting for the residents of Fukushima who have borne them. Accordingly, they are likely to produce a relatively higher proportion of utterances corresponding to the DQI categories of "sharing of burden," "consideration for the Fukushima residents," and "respect for the Fukushima residents," compared to those who oppose the final disposal outside Fukushima.

Conversely, in a cooperative context, differences in initial position have less impact on how frequently DQI items are referenced. This is because in a cooperative context, participants engage in deliberation from both positions—supporting and opposing final disposal outside Fukushima Prefecture—thereby reducing the initial bias in their opinions.

Notably, no differences based on participants' initial positions are expected for "respect for those who will take on a new burden" or "emotional reasoning," in either a competitive or cooperative context. This is because "respect for those who will take on a new burden" can be expressed in both supportive and opposing arguments regarding final disposal outside Fukushima. For example, participants in a supportive position may argue that given the final disposal outside Fukushima, distributing the burden across multiple regions would mitigate the burden on the host communities. Conversely, participants in an opposing position may be concerned about potential damage to communities outside Fukushima that

are unrelated to the removed soil and may argue that final disposal should remain within Fukushima. Similarly, “emotional reasoning” appears in both pro- and con arguments regarding final disposal outside Fukushima. For example, participants in a supportive position may appeal for sympathy by arguing that it is heartbreaking to continue imposing a burden solely on Fukushima’s residents. Conversely, participants in opposing positions may argue that by accounting for the emotions and feelings of communities that would be newly burdened, final disposal should be avoided.

2. Methods

2.1 Experiment overview

The experiment was approved by the Ethics Review Committee of the Center for Experimental Research in Social Sciences, Hokkaido University (Approval Code: R4-05) and was conducted from June to October 2023. Participants collectively discussed and decided whether the final disposal of removed soil outside Fukushima was acceptable. Discussion contexts were manipulated as follows: a competitive-controversial context, in which the divide between support and opposition was explicit and participants were encouraged to refute opposing views; and a cooperative-controversial context, in which participants, despite differing opinions, were expected to consider both perspectives.

2.1.1 Participants

All participants were Japanese university students and discussions were conducted in groups of four. The group size was set to four to reduce the likelihood of majority-based decisions and ensure that each member had sufficient opportunity to exchange opinions within a limited time. Participants were recruited via the Sona System, an online platform. In this system, experimenters post available time slots, and registered participants sign up for slots that best fit their schedules. Participants were not informed of the detailed content in advance and received a full explanation upon arrival at the laboratory. None of the participants were previously acquainted.

Based on a power analysis for a t-test (statistical power $\beta = 0.80$, Cohen’s [63] $d = 0.50$, $\alpha = .05$), a sample size of 16 groups (64 participants) per conditions was determined. This sample size was based on individual-level analyses, and was therefore insufficient for group-level analyses. The final sample comprised 128 participants. In terms of gender, 70 participants identified as male (competition: 38; cooperation: 32), 57 as female (competition: 25; cooperation: 32), and one as neither male nor female/preferred not to answer (competition: 1; cooperation: 0). Regarding academic disciplines, 38 participants were from humanities and social sciences (competition: 19; cooperation: 19), and 90 were from science and engineering (competition: 45; cooperation: 45). These demographic variables were not controlled during group formation. None of the participants were from Fukushima.

2.1.2 Creation of informational materials regarding the final disposal of removed soil

Before the discussion, participants were provided with information on the issues related to the removed soil. Five experts from various fields reviewed the materials to ensure the accuracy, neutrality, and clarity. They evaluated whether the information was balanced and understandable for first-time learners. The revisions continued until all experts approved the materials.

The final materials consisted of 19 slides, including an overview of the process from the generation of the removed soil to its final disposal. For example, a table compares scenarios of final disposal and recycling at one site versus multiple sites, highlighting trade-offs such as concentrated versus distributed risks and burden. The materials also showed that concentrating disposal at one site could minimize costs, whereas multiple sites could reduce the burden on each location. The materials also included statements from the mayors of Okuma and Futaba towns hosting the interim storage facility, describing residents' struggles such as the loss of ancestral land and decision-making under evacuation pressure. Despite these hardships, they accepted the facility for Fukushima's recovery, offering participants an insight into the burden they had already borne. The materials were common to both the competitive and cooperative conditions and were available throughout the discussion. The materials are included in the Supplementary Material (Informational_materials.pdf).

2.1.3 Experimental procedure

Upon arrival, participants provided informed consent and consent for audio and video recordings. Participants were informed that they could withdraw from the experiment at any time if they did not agree to participate or chose to participate without audio or video recordings. Next, the participants received informational materials and watched a 10-minute instructional video covering the same content.

The participants then completed a pre-discussion questionnaire to evaluate whether the information was adequate, sufficient, understandable, or unbiased. The results of the evaluation of the provided information are reported in the Supplementary Material (evaluation_of_provided_information.xlsx). Their initial positions (support or opposition) toward the final disposal of the removed soil outside Fukushima were also measured and used to assign participants to conditions to ensure equal proportions of support and opposition across conditions.

Following this, the discussion context for the assigned conditions was introduced.

Afterward, participants received "individual opinion sheets," on which they wrote their initial thoughts before discussion, and were given five minutes to organize their opinions on the final disposal and recycling of the removed soil. If necessary, they were given a few additional minutes. Subsequently, the researcher reintroduced the discussion section. Participants were instructed to record their group's decisions on a sheet at the end of the discussion. Each group was provided with a single sheet. Participants were required to select one option from the sheet. Additionally, they were told that one member of each group would present their group's decisions after the discussion. The experimenter did not determine who would present; instead, group members voluntarily selected a presenter.

The discussion lasted for 40 min. No facilitator was present; instead, participants managed and facilitated the discussion themselves, as this study intended to observe interactions solely among participants and to ensure the effects of the manipulated discussion contexts. After the discussion, one participant from each group presented the group's decisions, while the others could provide additional comments, if necessary.

2.1.4 Condition manipulation

To ensure that the participants adopted a competitive or cooperative controversy mindset, the following manipulations were implemented.

First, "position plates" were placed in front of participants only in the competitive condition based on their responses to the pre-discussion questionnaire, which asked whether they supported or opposed the final disposal of the removed soil outside Fukushima. In the competitive condition, participants were told that their position on their plates corresponded to their pre-discussion questionnaire response, which was their initial position. The "position plates" were visible to anyone, including the participants. In contrast, in the cooperative condition, "position plates" were not placed, meaning that their initial position were not visible at the beginning of the discussion, although participants answered the same question as those in the competitive condition.

Second, different discussion methods were used for each condition. In the competitive condition, participants were told to "assert your position and persuade opponents to adopt it as the group decision" and to "decide whether to approve or disapprove the disposal by the discussion's end." In the cooperative condition, they were instructed to "consider both supporting and opposing stances, critically evaluate the pros and cons of disposal outside Fukushima" and "decide on an action by the discussion's end." After receiving these instructions, participants answered questions to confirm their understanding of the discussion. Specifically, they were asked, "Regarding the upcoming discussion, please select one of the following options that best describes what you should do." The two options were: (1) "Assert your own position so that it becomes the group's decision, refute or persuade others with differing opinions, and decide whether to approve or disapprove the final disposal of removed soil outside Fukushima," or (2) "Consider both supporting and opposing standpoints, examine both the advantages and disadvantages of the final disposal of removed soil outside Fukushima, and decide collectively what should be done on the issue." In the competitive condition, 22 out of 64 participants selected option 1, and 42 selected option 2. In the cooperative condition, two out of 64 participants selected option 1, and 62 selected option 2.

Third, the "individual opinion sheets" on which participants wrote their ideas for individual thought before the discussion differed across conditions. In the competitive condition, participants were asked to complete: 1) their position on the final disposal outside Fukushima (as written on the position plates), 2) arguments to support their position, 3) counterarguments presented from the opposing position, and 4) arguments to rebut the counterarguments.

In the cooperative condition, participants tried to fill in: 1) their position on the final disposal outside Fukushima (the same as the position they answered in the pre-discussion questionnaire), 2) the merits of the final disposal outside Fukushima, 3) the demerits of the final disposal outside Fukushima, and 4) considering both supportive and opposing arguments to conceive ideas acceptable to individuals with diverse perspectives.

Finally, the response sheets for group decisions differed by condition. In the competitive condition, the sheet provided three options—“Approve,” “Disapprove,” or “Not decided”—regarding final disposal outside Fukushima. In the cooperative condition, the sheet included four options—“Approve,” “Disapprove,” “Other” (with space to specify), and “Not decided.” Only participants in the cooperative condition could select the “Other” option, as including this option in the competitive condition might have reduced the level of contention in the discussion.

2.2 Rating with DQI

The DQI was used to analyze the content of the discussion. Table 1 lists the measurement items used in this study. Additional items are provided in the Supplementary Material (All_DQI_measurement_items.pdf).

Table 1
DQI measurement items used in the following section

Dimensions	Measurement items	Reference point
Justification of content (common good)	Reduction of risks and costs	Statements reflecting the common good based on the reduction of risks and costs
	Sharing of burden	Statements reflecting the common good based on the fair distribution of burden
	Consideration for Fukushima residents	Statements reflecting the common good based on the condition of Fukushima residents
Respect	Respect for Fukushima residents	Statements that express esteem or sympathetic consideration for Fukushima residents
	Respect for those who will take on a new burden	Statements that express esteem or sympathetic consideration for those who will take on a new burden
Reasoning	Rational reasoning	Statements that provide reasons based on scientific or economic rationality
	Emotional reasoning	Statements that provide reasons based on emotional and empathetic considerations

The DQI coding focused on statements made during the 40-minute discussions, with each utterance (defined as an uninterrupted segment until another participant spoke) serving as the unit of analysis. We analyzed 1,327 utterances in the competitive condition and 1,370 utterances in the cooperative condition.

The original DQI [40] uses a multi-graded scale for each conceptual category. For instance, the "justification of content" dimension ranges from 0 (self-interest or group interest) to 1 (neutral statements), 2a (utilitarian common good), and 2b (common good based on the maximin principle). However, Souma et al. [39] noted that this scale could not accommodate utterances meeting multiple reference points within the same dimension and therefore restructured the items into a binary format (1 = meets the reference point, 0 = does not). This study followed Souma et al. [39] and used a binary coding system, allowing each utterance to be coded as 1 for multiple DQI measurement items. For example, a single utterance can be coded as "1" for multiple items, like "respect for Fukushima residents," "emotional reasoning," and "consideration for Fukushima residents."

Two independent raters who were unaware of the experiment's purpose and did not participate conducted the coding. Five raters were involved in coding rater pairs that varied across discussions.

The coding process was as follows. One of the two raters was present in the laboratory and took notes during the discussion to verify and correct the transcripts from the audio recordings. Based on these transcripts, the researcher created a coding sheet. The two raters independently coded the utterances using this sheet. The raters were allowed to consult the experimenter if they had any uncertainties. The experimenter reviewed the coding sheet only when consulted and provided interpretations of unclear sections. The raters revised their coding based on this feedback. Simple kappa coefficients were calculated to assess the inter-rater agreement. The simple kappa coefficient measures the extent to which two observers agree on their ratings of a phenomenon. The results showed that the kappa coefficient was $\kappa = .64$ for the competitive condition and $\kappa = .60$ for the cooperative condition, showing a sufficient match rate[1].

3. Results

3.1 Group decisions

Table 2 shows the distribution of initial positions on the final disposal of the removed soil outside Fukushima and group decisions by condition. Fisher's exact test was used to examine whether the proportions of initial positions and groups reaching approval decisions differed between conditions. No significant differences were found ($p = 0.85$, odds ratio = 1.15, 95% CI [0.51, 2.62]; $p = 1.00$, odds ratio = 0.68, 95% CI [0.04, 7.74], respectively). However, in the competitive condition, 5 of the 16 groups concluded "Not decided," whereas 6 of the 16 groups selected "Others" in the cooperative condition.

Table 2
Distributions of initial positions on the final disposal of removed soil outside Fukushima and decisions in each condition

initial position		condition	group decision			
support	opposition		approve	dis-approve	Not decided	Others
4	0	competitive	5	0	0	-
		cooperative	3	0	0	0
3	1	competitive	1	0	5	-
		cooperative	3	1	0	3
2	2	competitive	2	1	0	-
		cooperative	1	0	0	3
1	3	competitive	0	1	0	-
		cooperative	1	1	0	0
0	4	competitive	0	1	0	-
		cooperative	0	0	0	0
total		competitive	8	3	5	-
		cooperative	8	2	0	6

Note. The “Others” option could be selected only in the cooperative condition due to the experimental manipulation.

3.2 Differences in the DQI scores based on discussion context and initial positions

The coded DQI scores were then analyzed. Table 3 lists the total number of utterances and proportions coded as 1 for each DQI measurement item according to condition and initial position. The total number of utterances for each measurement item was calculated based on the coding by the two independent coders. An utterance was counted as 1.0, if both coders assigned it a value of 1 and as 0.5 if only one coder did so. Moreover, the method for calculating proportions varied by item. For the common good measurement items—“reduction of risks and costs,” “sharing of burden,” and “consideration for Fukushima residents”— the proportion of utterances coded as 1 was calculated for each participant and each item. Specifically, the numerator was the number of times a value of 1 was assigned to the focal item (e.g., “reduction of risks and costs”) for that participant, and the denominator was the total number of times a value of 1 was assigned across the three items for the same participant.

For the measurement items of “respect for the Fukushima residents” and “respect for those who will take on a new burden,” the proportion of utterances coded as 1 was also calculated for each participant and each item. For each participant, the proportion of utterances coded as 1 for the focal measurement item (e.g., “respect for Fukushima residents”), relative to the total number of utterances produced, was calculated.

For “rational reasoning” and “emotional reasoning,” the proportion of utterances corresponding to each type of reasoning was calculated. For each participant, the proportion of utterances coded as 1 for the focal measurement item (e.g., “rational reasoning”) relative to the total number of utterances coded as 1 for the “reasoning” category was calculated; this category coded an utterance as 1 when a statement included a reason, regardless of whether the reasoning was rational or emotional.

Table 3
Total number of utterances and proportions matching each DQI measurement item

Dimensions	Measurement items	Competitive		Cooperative	
		opposition	support	opposition	support
Justification of content (common good)	reduction of risks and costs	67.5	104.5	75.5	154.0
		(75.88%)	(45.58%)	(59.00%)	(52.36%)
	sharing of burden	9.5	79.0	35.5	95.5
		(14.66%)	(33.76%)	(27.40%)	(35.03%)
	consideration for the Fukushima residents	6.5	48.5	14.0	38.5
		(9.45%)	(20.67%)	(13.61%)	(12.61%)
Respect	respect for the Fukushima residents	18.5	87.0	36.0	85.5
		(4.34%)	(10.21%)	(7.60%)	(12.99%)
	respect for those who will take on a new burden	24.0	55.0	38.5	85.0
		(5.46%)	(6.28%)	(8.21%)	(10.72%)
Reasoning	rational reasoning	94.0	215.5	133.0	296.5
		(65.09%)	(63.37%)	(65.50%)	(76.11%)
	emotional reasoning	30.0	106.5	44.0	73.5
		(20.75%)	(31.58%)	(22.67%)	(21.81%)

Note. The top row shows the total number of utterances that matched each DQI measurement item and the bottom row shows the proportions calculated using the method described above. “Opposition” indicates the mean proportions for participants opposing the final disposal of removed soil outside Fukushima, and “support” indicates the mean proportions for those supporting it.

Next, to examine whether the proportion of utterances coded as 1 varied by condition or initial position, a multiple regression analysis was conducted using the DQI scores. The predictor variables included the discussion context (with competitive condition as the reference), initial position (opposing final disposal outside Fukushima as the reference), and their interaction. For multiple regression analysis, the proportions shown in Table 3 were standardized and treated as dependent variables. Group effect was treated as a random intercept. Details of the regression analysis results are provided in the Supplementary Material (Results_of_multi_regression_analysis.xlsx). To facilitate the interpretation of the regression results, typical statements coded as 1 for each measurement item are provided below.

Figure 1 The mean of standardized proportions for “reduction of risks and costs” (left), “sharing of burden” (center), and “consideration for Fukushima residents” (right)

A multiple regression analysis for “reduction of risks and costs” was conducted and revealed an interaction between condition and initial position (β = 0.99, 95% CI [0.27, 1.68]). In the competitive condition, participants who initially opposed the final disposal of removed soil outside Fukushima referred to risk and cost reduction more frequently than those who supported it. For example, participants who initially opposed it stated the following:

I think it would be better to dispose of it at a single site within Fukushima. The first reason is that it’s easier to manage if everything is kept in one place. There are still areas where people can’t return. Therefore, rather than taking it to other prefectures that are currently safe and not contaminated by radiation, I feel it might be more rational to keep it where it is.

However, in the cooperative condition, the difference based on the initial position was small (left side of Fig. 1).

For “sharing of burden,” a main effects of both condition and initial position were observed (β = 0.66, 95% CI [0.04, 1.28]; β = 0.98, 95% CI [0.48, 1.49]). Participants in the cooperative condition mentioned burden-sharing more frequently than those in the competitive condition. Additionally, participants who initially supported the final disposal of removed soil outside Fukushima were more likely to refer to burden sharing than those who opposed it (center of Fig. 1). For example, in the cooperative condition, participants who initially supported the final disposal outside Fukushima stated the following:

I think dispersing the soil across many areas would be the better approach. If the removed soil is concentrated in a limited region, the area may become a target of negative perceptions and stigma. People in other regions may see this as someone else’s problem, which could worsen the disposal area’s reputation. However, if many regions share the burden, it could shift this to being “ourselves” problems. Thus, spreading the burden across multiple regions might help prevent reputational damage.

The results for “consideration for Fukushima residents” revealed an interaction effect between condition and initial opinion (β = -0.97, 95% CI [-1.65, -0.27]). In the cooperative condition, the difference based on initial position was small (right side of Fig. 1). However, in the competitive condition, participants who initially supported the final disposal of removed soil outside Fukushima expressed more consideration for

Fukushima residents than those who opposed it. For example, participants who initially supported it stated:

Having the people of Fukushima bear the burden of final disposal in addition to the nuclear power plant accident seems too awful and heavy a responsibility for the residents. I believe that the Japanese citizens should support them nationwide.

In Fig. 2, the mean of standardized proportions for each measurement item of “Respect” by discussion contexts and initial positions is presented.

The results of the multiple regression analysis for “respect for Fukushima residents” showed a main effect of initial position (β = 0.61, 95% CI [0.14, 1.10]). Specifically, participants who initially supported the final disposal of the removed soil outside Fukushima were more likely to express empathic considerations toward Fukushima residents than those who initially opposed it (left side of Fig. 2). For example, participants who initially supported it stated:

Places like Okuma and Futaba are more than just towns—they hold the memories, history, and thoughts or feelings of those living there. It should not just be about compensating those suffering economic losses to make up for it. Additionally, we must pay regard to the memories of those who live in these areas.

In contrast, for “respect for those who will take on a new burden,” no significant effect was found (right side in Fig. 2). For example, one participant stated,

I think that if multiple regions, including Fukushima, were to share the load for the final disposal, it would lessen the psychological burden than to dispose at only one site.

Figure 3 presents the mean standardized proportions for each measurement item of “reasoning” by discussion context and initial position.

The analysis of “rational reasoning” revealed an interaction effect between condition and initial opinion (β = 0.60, 95% CI [0.02, 1.18]). Specifically, we found no significant difference in the proportion of “rational reasoning” in the competitive condition based on initial position. However, in the cooperative condition, participants who initially supported the final disposal of the removed soil outside Fukushima were more likely to provide rational reasons than those who initially opposed it (left side of Fig. 3). In other words, even those who supported final disposal outside Fukushima in the cooperative condition expressed concerns about the increased risks and costs. For example, participants in the cooperative condition who initially supported the final disposal outside Fukushima provided logical reasons for the risks and costs, as follows:

I think that if final disposal is carried out in multiple locations, the risk would be scattered and the cost of transporting the waste to various locations would be high, which would be a problem and a disadvantage.

For “emotional reasoning,” a main effect of initial opinion was observed (β = 0.57, 95% CI [0.08, 1.06]). Participants who initially supported the final disposal of the removed soil outside Fukushima were more likely to provide emotional reasons than those who initially opposed it (right side of Fig. 3). For example, participants who initially supported it said the following:

I cannot fully grasp the number of residents exposed to stress. However, anyone who has lost family or friends in an unprecedented tsunami in their region and has their hometown taken away is likely to feel indescribable stress and emotional pain. Considering this, I believe the final disposal should be conducted outside Fukushima.

4. Discussion

4.1 Summary of results and interpretation

This study examined the impact of the discussion context on public deliberation regarding the final disposal of removed soil outside Fukushima. The results of the group decision experiment showed that participants in the competitive condition were more likely to persist in arguing solely from their initial positions than those in the cooperative condition. In the competitive condition, the multiple regression analysis for “reduction of risks and costs” showed that opponents of final disposal outside Fukushima focused more on reducing risks and costs than supporters did. For example, participants who opposed the final disposal outside Fukushima typically argued that the removed soil should remain within Fukushima Prefecture rather than be transported to other regions that are currently safe and not contaminated by radiation. Moreover, in the competitive condition, the multiple regression analysis for “consideration for Fukushima residents” showed that participants who initially supported final disposal outside Fukushima expressed greater concern for Fukushima residents than those who initially opposed it. For instance, participants who supported final disposal outside Fukushima argued that it was unjust to impose an additional burden of final disposal on Fukushima residents who had already borne significant hardship. Conversely, in the cooperative condition, participants who initially opposed final disposal outside Fukushima appeared to be influenced by those who initially supported it, particularly regarding respect for Fukushima residents. Participants in the cooperative condition who initially supported the final disposal outside Fukushima appeared to adopt alternative perspectives by considering their opponents’ arguments. Interestingly, the multiple regression analysis for “rational reasoning” revealed that participants who initially supported the final disposal outside Fukushima provided more logical reasons regarding risks and costs than those who initially opposed it.

Therefore, these findings largely support our hypothesis that, in the competitive condition, the frequency of utterances meeting the reference points of DQI measurement items likely depends on participants’ initial positions regarding the final disposal of removed soil outside Fukushima.

For “sharing of burden,” “respect for the Fukushima residents,” and “emotional reasoning,” main effects of initial position were observed. Participants who initially supported final disposal outside Fukushima were more likely to refer to these aspects than those who opposed it, with a consistent trend across both

discussion contexts. Typical statements emphasized the importance of sharing the burden of the removed soil across multiple regions: respect for the evacuation experiences, hardships, and pain endured by Fukushima residents, and reasoning rooted in these emotional factors.

For “respect for those who will take on a new burden,” there was no significant difference between conditions or initial positions, and typical statements included consideration for the psychological burden of residents who accept the removed soil. Respect for those who will take on a new burden appears to be commonly mentioned regardless of the discussion context or the individual’s initial position.

4.2 Limitations

Despite these findings, two methodological limitations should be noted. First, the original DQI developed by Steenbergen et al. [40] and the adapted version used in this study may have subtle conceptual discrepancies. Although the DQI was modified to fit a specific context, these adjustments may have led to a slight divergence from the original DQI concepts. However, when using the DQI, the measurement items must be tailored to the subject under discussion. Researchers applying DQI to public deliberations on specific topics should clarify how adjusted items align with the original concepts while capturing the unique features of the issue. More case studies utilizing DQI are required to refine its application. While this study is one such case in Japan, it demonstrates both the generalizability of DQI concepts and the challenges of applying them to specific topics.

Second, the extent to which these findings can be generalized to a broader population warrants further investigation. Specifically, because this study was conducted among university students, its applicability to discussions involving the general public remains unclear. However, this study contributes to discussion design by using controlled group decision experiments that enable a focused examination of how discussion contexts shape discourse content. While it is possible to examine the effects of discussion contexts in real-world citizen participatory workshops, caution should be exercised, especially when applying a competitive context, as it may lead to confusion. Moreover, manipulating and comparing conditions can be challenging, and may not be feasible in real-world settings. Therefore, although applying these findings to real-world discourse is important, the direct transfer of insights from controlled experiments should be approached carefully. Future research should apply the DQI measurement items used in this study to evaluate workshops involving the general public.

4.3 Implications of this study

Despite these limitations, this study provides valuable insights worth considering not only for the specific case of the removed soil issue but also for public deliberation.

4.3.1 Insights for the issue of removed soil

The results of the experiment suggest that, in competitive discussion contexts, those who supported the final disposal of removed soil outside Fukushima focused on burden sharing and consideration for Fukushima residents, whereas opponents focused on reducing risks and costs. The issue of removed soil

requires consideration not only of scientific evidence and economic rationality but also of distributive justice and the maximin principle, including sharing the burden and acknowledging the challenges faced by those already affected. However, using a competitive context may lead participants to view the issue as a dichotomy— either supporting or opposing the final disposal outside Fukushima—and force them to choose between scientific and economic rationality and distributive justice or the maximin principle. This framing can prevent people from reaching consensus or harmonious compromises. In other words, this could prevent ensuring the inclusive and representative decision-making at all levels, as advocated by the SDGs. Conversely, participants in the cooperative condition engaged in discussions from diverse perspectives regardless of their initial positions. Therefore, a cooperative discussion context is preferable, as it allows for a more balanced consideration of the issue's various aspects. Consequently, this approach is expected to advance a sustainable society where pluralistic values are included and no one is left behind.

However, one could argue that the cooperative context is primarily effective because participants in public deliberation are not stakeholders. Naturally, stakeholders are likely to remain committed to their own interests, and attempts to suppress their values and opinions in discussions are likely to fail. In the decision-making process, achieving consensus or agreement on the issue of removed soil requires both public deliberation involving a broad range of citizens and dialogue with stakeholders. Therefore, integrating these processes into Public and Stakeholder Engagement (PSE) approaches is important [38]. Given that the procedure for selecting final disposal sites remains undecided, it is crucial to explore a discussion design for public deliberation. This study focuses on this area, and its findings offer useful implications for designing deliberative settings. Further research is needed to examine how to reflect the voices of residents who have already borne the burden of removed soil, as well as those who will bear a new burden for sustainable recovery. Moreover, integrating these forums into a comprehensive, stepwise process should be explored to realize the SDGs' ideal, that no one is left behind in the recovery from the nuclear disaster.

4.3.2 Suggestions for public deliberation

This study provides valuable insights into public deliberations, particularly during contentious discussions. Specifically, binary and competitive contexts can cause participants to become entrenched in their views, preventing them from hearing and effectively considering opposing opinions. This can lead to the perception that different perspectives or values are incompatible, making it difficult to reach a consensus. In contrast, cooperative discussion contexts, which promote addressing multiple aspects of an issue, facilitate the mutual consideration of differing viewpoints. This approach can help generate ideas that integrate diverse perspectives and facilitate consensus-building.

Conversely, for issues where disagreements rarely arise, such as urban planning and achieving SDGs, the choice of discussion context may be less important. Public participation in such cases is widely practiced [6]. However, public deliberation on contentious issues remains challenging [13]. This study shows that appropriate discussion contexts can facilitate deliberation even in contentious cases with conflicting values and interests.

As mentioned earlier, applying a cooperative context to discussions with stakeholders may be ineffective, and this study does not address such dialogue. However, the DQI measurement items are still useful for evaluating whether those affected by decisions are respected, and whether participants focus on the common good rather than self-interest. If evaluations of discourse based on these items are used as feedback, the practical relevance of the DQI can be further enhanced.

Moreover, cultural differences must be considered to determine the discussion contexts to adopt. While Japanese participants tend to avoid adversarial debates, Western culture often embrace them. Whether the cooperative context is especially suited to cultures such as Japan, or whether it can work in Western contexts, remains to be determined. Evaluations using the DQI may be useful in cross-cultural research; however, its application should ensure relevance to specific cultural and contextual settings while remaining within the original conceptual framework. Cross-cultural comparisons can help identify a universal form of public deliberation.

Despite cultural and contextual diversity, collectively sharing participants' opinions can facilitate the development of better compromises or higher-level principles that incorporate diverse values–in other words, *aufheben*. Although there are multiple ways to achieve this, this study provides one such approach by using the DQI as an evaluative tool. This approach could help realize the SDGs' ideals by ensuring responsive, inclusive, participatory, and representative decision-making at all levels.

4.4 Conclusions

To achieve a sustainable society that leaves no one behind, it is essential to engage in an ongoing process in which goals are refined and shared through continuous deliberation. Therefore, it is necessary to continually examine the conditions that enable constructive discussions even when the issues at hand are contentious and divisive. The DQI evaluates whether a discussion has been fruitful. This study not only theoretically explores the ideal form of discourse but also empirically assesses its quality and identifies the factors that influence statements made in discussions. Consequently, the insights from this study can contribute not only to a sustainable recovery from nuclear disasters but also to the broader creation of a sustainable society.

Declarations

5. Funding Statement

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6. Ethical Statements

6.1 Ethical approval statement

All procedures involving human participants were conducted in accordance with the ethical standards of the institutional and/or national research committee and the 1964 Declaration of Helsinki and its later amendments or comparable ethical standards. This study was approved by the Ethics Review Committee of the Center for Experimental Research in Social Sciences, Hokkaido University (No. R4-05, April 22, 2022).

Although this study involves human subjects, it is not a clinical trial; therefore, a clinical trial number is not applicable.

6.2 Informed consent statement

Written informed consent was obtained from all participants before commencement of the experiment. Consent forms were distributed individually by the researcher, and consent was confirmed through the participants' signatures. As this study involved non-interventional research, all participants were fully informed in advance of the research purpose, data anonymization, and potential academic publication of the results.

6.2.1 Consent to participate

By signing the consent form, all participants agreed to take part in the experiment.

6.2.2 Consent for data collection

By signing the consent form, all participants agreed to have their discussions recorded and filmed.

6.2.3 Consent to publish

By signing the consent form, all participants agreed that their data would be anonymized and might be used in the academic publication of results.

7. Author contributions Statement

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This author contributed equally to this work: S. O.

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All authors have read and agreed to the approved published version of the final manuscript.

8. Data Availability

All relevant anonymized data and analysis code are available from the Open Science Framework (OSF) repository at [https://osf.io/fkj2y/overview?view_only=94e338f2194843dc9c5caa35776faeb1].

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Footnotes

1. Simple Kappa coefficients between 0.41 and 0.60 are considered moderate agreement, while those between 0.61 and 0.80 are considered considerable agreement [64].

Figures

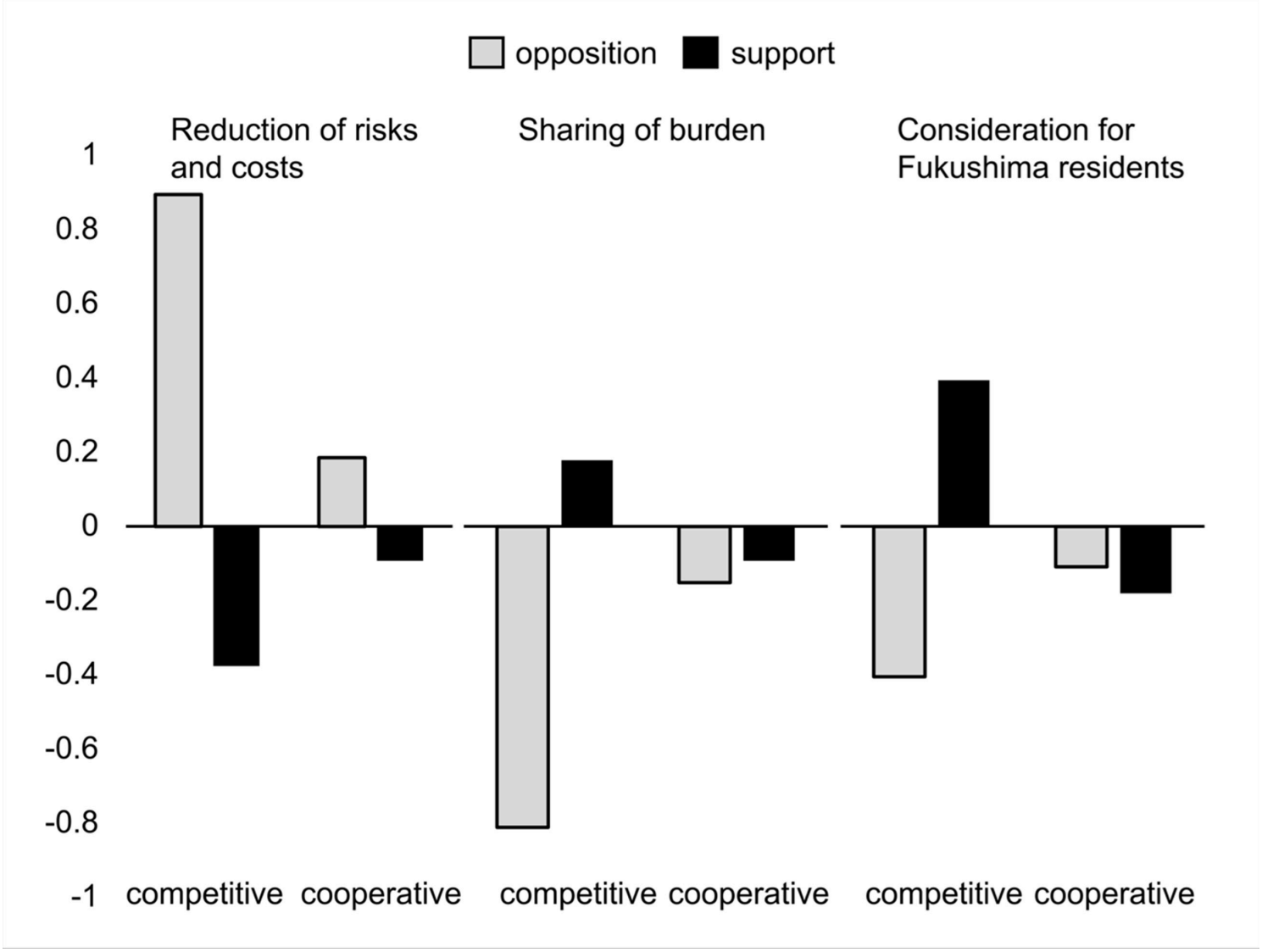


Figure 1

The mean of standardized proportions for “reduction of risks and costs” (left), “sharing of burden” (center), and “consideration for Fukushima residents” (right)

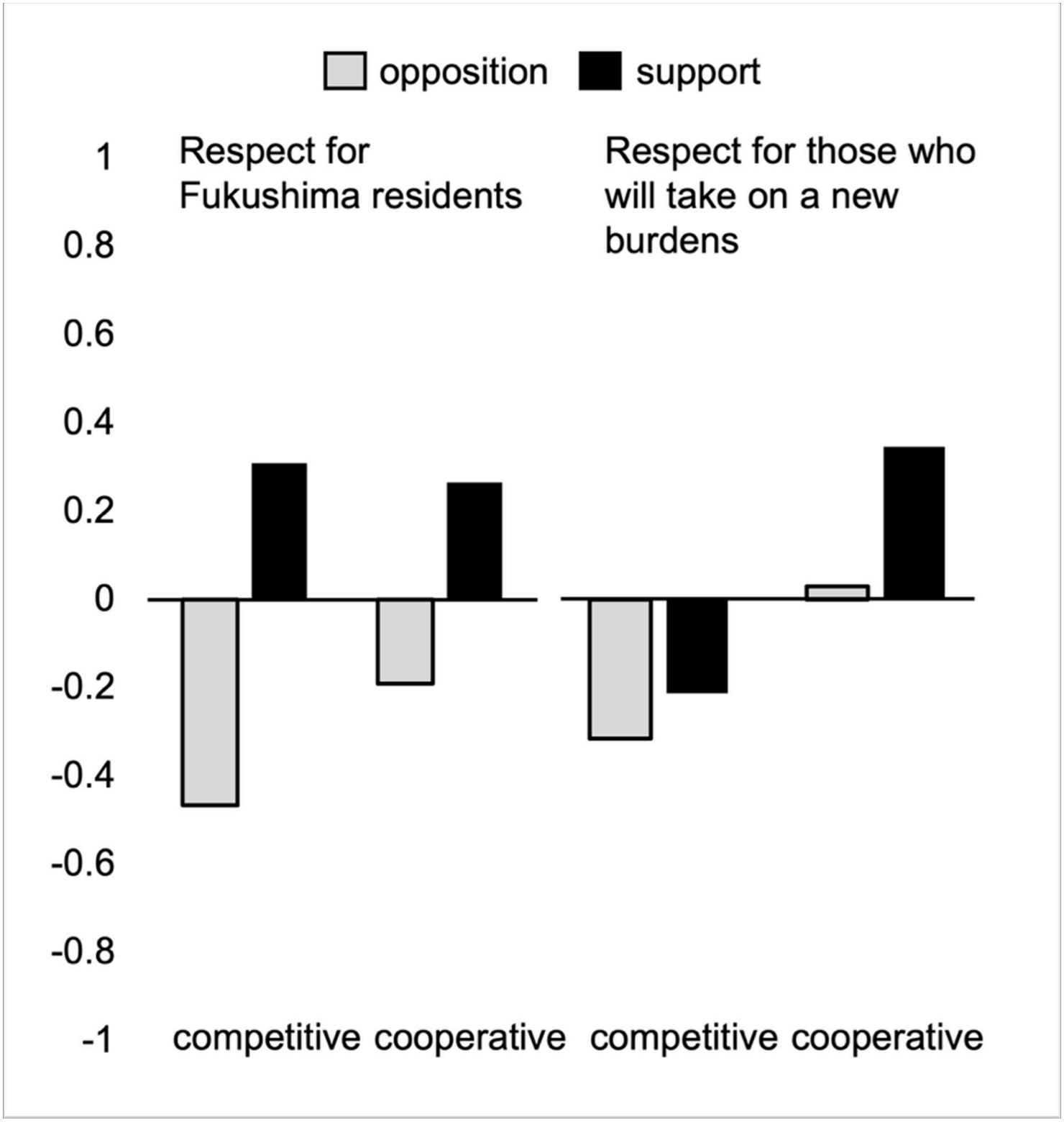


Figure 2

The mean of standardized proportions for “respect for Fukushima residents” (left) and “respect for those who will take on a new burden” (right)

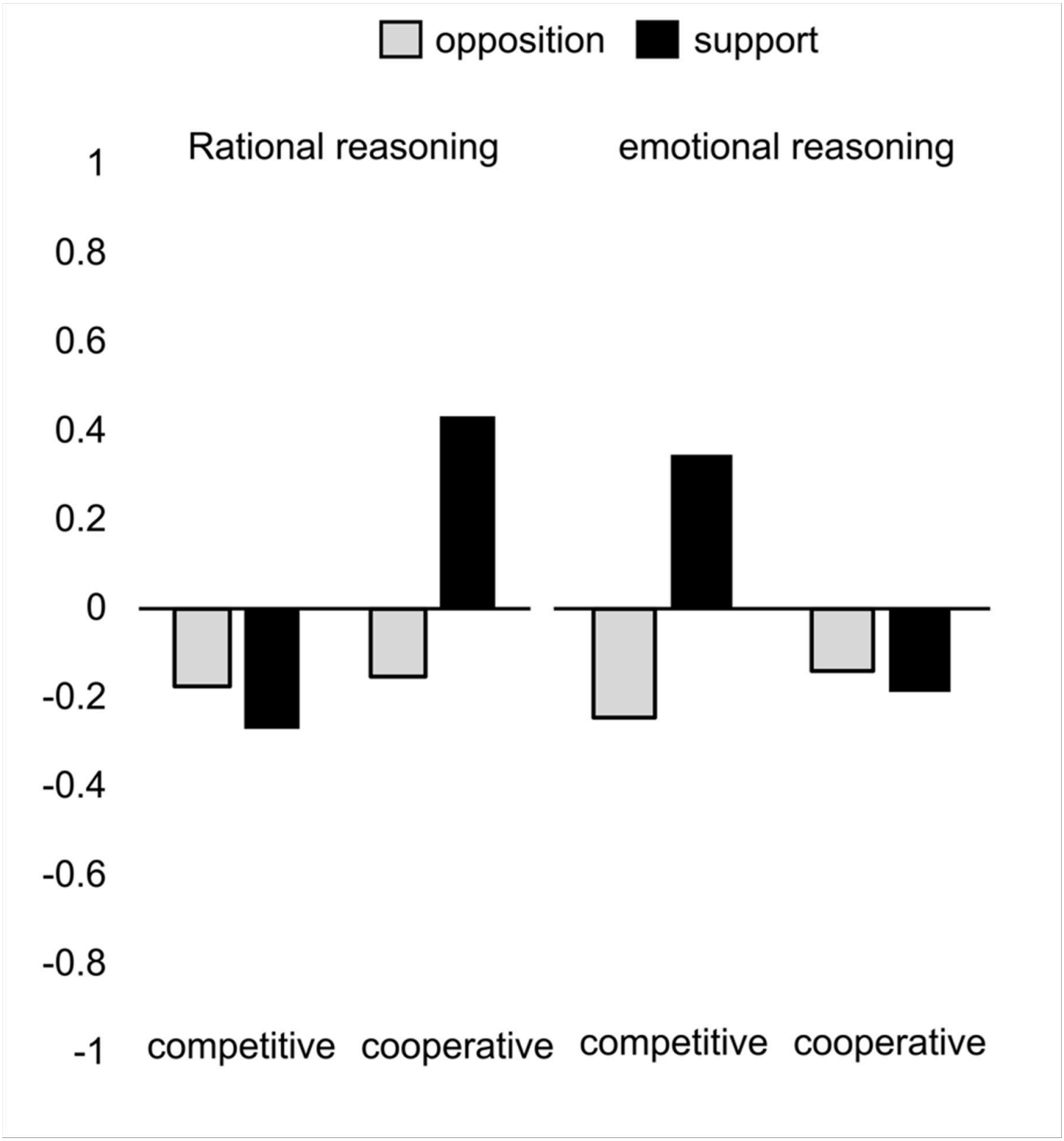


Figure 3

The mean of standardized proportions for “rational reasoning” (left) and “emotional reasoning” (right)

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