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Deliberative forms of democracy and intergenerational sustainability dilemma

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Abstract

Intergenerational sustainability (IS) has emerged as the most serious social problem reflecting climate change and accumulation of public debt in modern democratic societies, undermining the potential interests and concerns of future generations. However, little is known about whether or not deliberative forms of democracy with majority voting helps support at maintaining IS by representing future generations' potential interests and concerns. We institute intergenerational sustainability dilemma game (ISDG) with three forms of decision-making models with majority voting and examine how they maintain IS in laboratory experiments. In ISDG, a sequence of six generations is prepared where each generation consisting of three subjects is asked to choose either maintaining IS (sustainable option) or maximizing their own generation's payoff by irreversibly costing the subsequent generations (unsustainable option) with anonymous voting systems: (1) majority voting (MV), (2) deliberative majority voting (DMV) and (3) majority voting with deliberative accountability (MVDA). In MV and DMV, generations vote for their choices without and with deliberation, respectively. In MVDA, generations are asked to be possibly accountable for their choices to the subsequent generations during deliberation, and then vote. Our analysis shows that decision-making models with only majority voting generally does not address IS, while DMV and MVDA treatments induce more and much more generations to choose a sustainable option than MV, respectively. Overall, the results demonstrate that deliberation and accountability along with majority voting shall be necessary in models of decision making at resolving IS problems and representing future generations' potential interests and concerns.

Key Words: democracy; decision-making; majority voting; deliberation; intergenerational accountability; intergenerational sustainability; experimental research; future generations

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Nomenclature

IS Intergenerational Sustainability

ISD Intergenerational Sustainability Dilemma

ISDG Intergenerational Sustainability Dilemma Game

MV Majority Voting

DMV Deliberative Majority Voting

MVDA Majority Voting with Deliberative Accountability

IA Intergenerational Accountability

NE Nash Equilibrium

SVO Social Value Orientation

KUT Kochi University of Technology

RA Research Assistants

JPY Japanese Yen

1 Introduction

People generally consider democracy to be a better option than some authoritarian system, and believe that it represents people, their interests and concerns (Przeworski et al., 1999, Fiorino, 2018, MacKenzie and Caluwaerts, 2021). With this belief, contemporary societies have adopted democracy and succeeded in achieving various economic, social and political objectives, such as poverty reduction, job creation, education and improvements in health-care facilities. However, modern democratic societies face intergenerational sustainability (IS) problems, such as climate change, resource sustainability, public debt accumulation and environmental pollution, and these problems are reported to affect future generations' welfare (Shearman and Smith, 2007, Gonzalez-Ricoy and Gosseries, 2016, Hansen and Imrohoroglu, 2016, Steffen et al., 2018, Caney, 2018, Bamber et al., 2019). IS problems arise when the current generation fails to consider the interests and concerns of future generations into their decision-making processes under a democratic system (Thompson, 2010, Gonzalez-Ricoy and Gosseries, 2016, MacKenzie, 2018).

Literature reports that some features of democracy, such as election cycles, the dominance of political interests and the existence of some myopic voters, develop short-term tendencies (or presentism) in people's attitudes and behaviors, inducing the current generation not to consider future generations (Smith, 2003, Thompson, 2010, MacKenzie and O'Doherty, 2011, MacKenzie, 2016, 2018, Saijo, 2020). The short-term tendencies in democracy are exacerbated, especially when people become autonomous and alienated from societies with limited social interactions, making themselves myopic (Jacobs and Matthews, 2012, List et al., 2013, Saijo, 2020). There are uprising voices and demands to address IS problems so that future generations' welfare, concerns and voices should be reflected in the current practices of democracy (Mansbridge, 2003, Caney, 2018, Bogacki and Letmathe, 2021). Public protests around Greta Thunberg can be considered such an example for future generations' voices in relation to climate change (Bogacki and Letmathe, 2021).

Representation of future generations' voices in decision-making processes is claimed to be challenging under a democratic system (Strandberg, 2008, Fishkin, 2009, Gronlund et al., 2009, Geissel and Newton, 2012, Dangelico and Pontrandolfo, 2013, MacKenzie, 2016, Stoiciu and

Gherghina, 2021). In numerous democratic countries, children and/or women are not permitted to vote in elections, and it highlights that underrepresentation of some groups other than future generations emerge as a general social problem. Such an underrepresentation problem is present in IS problems, such as climate change, where future generations cannot participate in the current decision-making process as they are yet to born (MacKenzie, 2018, Shahen et al., 2021). It affirms that a democratic system may need some new devices, innovations, reforms or transformations for addressing the underrepresentation as not only social but also IS problems (Geissel and Newton, 2012, Gonzalez-Ricoy and Gosseries, 2016, Elstub and Escobar, 2019b,a, Allegretti, 2014, Pickering et al., 2020). A group of scholars argues that deliberative forms of democracy can influence the current generation to consider future generations and their potential interests and concerns, possibly inducing them to be more sustainable or future-oriented (Gronlund et al., 2010, MacKenzie, 2018). However, little is known how deliberative forms of democracy with voting can resolve IS problems and represent future generations' potential interests and concerns.

We systematically examine how two deliberative forms of democracy with majority voting enhance IS as compared to majority voting without deliberation. One of the specific IS problems is described by "intergenerational sustainability dilemma" (ISD), which is a situation where the current generation chooses to maximize (or sacrifice) its own benefits without (or for) considering future generations, compromising (or maintaining) IS (Kamijo et al., 2017, Shahrier et al., 2017b, Shahen et al., 2021). Thus, we institute intergenerational sustainability dilemma game (ISDG) with three forms of decision-making models with majority voting by experimentally manipulating prevoting components and examine how they maintain IS in laboratory experiments. In ISDG, a sequence of six generations is prepared where each generation consisting of three subjects is asked to choose either maintaining IS (sustainable option) or maximizing their own generation's payoff by irreversibly costing the subsequent generations (unsustainable option) with anonymous voting systems: (1) majority voting (MV), (2) deliberative majority voting (DMV) and (3) majority voting with deliberative accountability (MVDA). In MV and DMV, generations vote for their choices without and with deliberation, respectively. In MVDA, generations are asked to be possibly accountable for their choices to the subsequent generations during deliberation, and then vote. Our analysis shows that decision-making models with only majority voting generally does not address IS, while DMV and MVDA treatments induce more and much more generations to choose a sustainable option than MV, respectively. Overall, this study contributes to the literature by demonstrating that deliberation and accountability shall be necessary in decision-making models with majority voting at resolving IS problems. The message can be considered important when democratic countries and societies seek to address intergenerational fairness and/or justice along with an underrepresentation problem of future generations as argued by Caney (2018).

2 Theoretical section

The concept of democracy is too broad to cover in the limited space of a single study and there exists numerous definitions of democracy (May, 1978, Elliott, 1994, Przeworski et al., 1999, Dahl, 2001, Diamond and Plattner, 2006). For example, May (1978) defines "democracy as a responsive rule *qua* necessary correspondence between acts of governance and the desires with respect to those acts of the persons who are affected." Przeworski et al. (1999) defines democracy as a form of rules, and Dahl (2001) refers to democracy as actual governments that meet the following criteria: effective participation, voting equality, enlightened understanding, agenda control and inclusions of adults. Regardless of the aforementioned variations, it appears to takes two main forms: (i) direct democracy and (ii) representative democracy. Direct democracy allows people to equally and directly participate in the decision-making process, such as discussion, voting or other acts of politics, and the examples include electronic, participatory and/or deliberative forms of democracy (Przeworski et al., 1999, Geissel and Newton, 2012, Warren, 2017, Haas, 2019). Representative democracy allows people to participate indirectly in the decision process and choose the representatives that make decisions on behalf of them. The examples include parliamentary and presidential forms of democracy (Przeworski et al., 1999, Diamond and Plattner, 2006). This study focuses on deliberative forms of democracy with voting in a class of direct democracy, considering that it is the first step to analyze their effects on human behaviors in IS under laboratory settings.

Several scholars have attempted to characterize democracy through models of decision making (Austen-Smith and Banks, 1996, Austen-smith and Feddersen, 2006, Jackson and Tan, 2013). The model of decision making is defined as a function which takes the votes (or choices) as input from the members in a group or society, delivering a collective decision as output (List, 2018). The model of decision making is claimed to consist of two components (i.e., components of models of decision making): (1) Prevoting component – a prior environment for people to engage, communicate and discuss socially on the common concerns, issues and agendas; and (2) Voting component – a rule that aggregates individual independent choices to a collective decision (Austen-Smith and Banks, 1996, Jacobs and Matthews, 2012, List, 2018). Deliberation and voting are regarded as components of the decision-making models, and majority voting is widely adopted (Warren, 2017). Literature suggests two main models of deliberative decision making: a pure deliberation model where participants deliberate and reach (or aim to reach) consensus for a collective decision without individual voting; and a mixed model of deliberation where participants deliberate and make a collective decision through individual voting (Austen-Smith and Banks, 1996, Jacobs and Matthews, 2012, List et al., 2013, List, 2018). Some theories suggest that deliberation (i.e., pure deliberation model) can play the following roles: (i) it enhances responsiveness to the people, groups and agendas (Warren, 2017); (ii) it connects people's preferences to a collective will by potentially generating epistemic and ethical goods through their reasons and arguments (Estlund, 2009, Mercier and Landemore, 2012, Landemore, 2013) and (iii) it helps to make a collective decision by agreements and commitments to the decision (Habermas, 1984, Elster, 1997, Habermas, 1994, Chambers, 2003, Mansbridge, 2003, Delli Carpini et al., 2004, Mansbridge et al., 2010, MacKenzie, 2018, MacKenzie and Caluwaerts, 2021). Warren (2017) argues that deliberation is weak to be able to represent some groups, such as young and ethnic groups, suggesting that some supplementary or complementary components, such as voting, may be necessary.

Past literature has examined the influence of the mixed model (i.e., deliberation is supplemented by individual voting) on human behaviors and the problem of underrepresentation for some groups by conducting surveys or controlled experiments (Strandberg, 2008, Dietz et al., 2009, Gronlund et al., 2009, Goeree and Yariv, 2011, Gherghina and Geissel, 2017, 2020, Setala, 2017, Setala et al., 2020). Luskin et al. (2002) conduct deliberative polls in UK and find that deliberation affects public preferences on some policies. List et al. (2013) find that the deliberation before voting brings a higher proximate single-peakedness in voters' preferences than the majority voting only utilizing deliberative polls data. In experimental studies, for example, Simon and Sulkin (2002) analyze the role of deliberation, concluding that deliberation enhances equitable outcomes for intra-generational members. Goeree and Yariv (2011) experimentally evaluate the effects of deliberation under various decision-making rules and demonstrate that it improves the efficiency of institutional decisions. Persson et al. (2012) analyze people's behaviors through field experiments and find that deliberation with voting increases perceived legitimacy of democratic procedure compared to non-voting. Ideally, deliberative forms of democracy should come with active participation of stakeholders and it may be necessary to include possible underrepresented groups in a decision-making process (Habermas, 1996). Stoiciu and Gherghina (2021) analyze the role of deliberation for underrepresentation problems, finding that it promotes inclusion of opinions from women, various social strata, ethnic and other minorities. However, another group of studies points out that deliberation may not be sufficient to resolve underrepresentation of some groups, especially young and uneducated people (Dalton et al., 2001, Jeydel and Steel, 2002, Gronlund et al., 2009, Strandberg, 2008, Gherghina and Geissel, 2017, 2020, Setala, 2017, Setala et al., 2020, Barbosa, 2020).

In the context of IS problems, future generations tend to be underrepresented in collective decision making (MacKenzie, 2016, 2018, Bogacki and Letmathe, 2021). The difficulty arises because future generations can neither communicate nor represent their voices with the current generation, especially when they do not have overlapping life time. For instance, climate change problems shall adversely affect future generations that are not born yet, however, such unborn future generations do not have any means to convey what they want to the current generation in the decision-making process. Several researchers have empirically and experimentally studied IS problems, employing some decision-making models of deliberation and/or voting (Fischer et al., 2004, Setala et al., 2010, Himmelroos and Christensen, 2013, Hauser et al., 2014, Sherstyuk et al., 2016, Fochmann et al., 2018, Kamijo et al., 2019, Nakagawa et al., 2019, Dryzek and Niemeyer, 2019, Katsuki and Hizen, 2020, Pandit et al., 2021, Bogacki and Letmathe, 2021, MacKenzie and Caluwaerts, 2021). Gronlund et al. (2009) compare people's knowledge and opinions on long-run energy politics under traditional face-to-face and online deliberation, suggesting that both settings enhance only people's knowledge. Setala et al. (2010) conduct pre-post surveys and deliberation on people's knowledge for the use of nuclear power plants, finding that deliberation promotes their knowledge than without deliberation. Himmelroos and Christensen (2013) examine public opinions on the use of nuclear power plants through conducting quasi-experiments, demonstrating that deliberation with high-quality arguments brings people's opinion changes. Hauser et al. (2014) analyze groups behaviors for IS by conducting intergenerational goods games and suggest that voting reduces the exploitation of resources by restraining defectors. MacKenzie and Caluwaerts (2021) conduct online experiments and analyze group decisions for climate policies, showing that deliberation induces groups to support the policies.

Another group of studies focuses on how ISD can be resolved by deliberation or some institutions to represent future generations through conducting ISDG laboratory and/or field experiments under non-overlapping generation settings. Kamijo et al. (2017) conduct ISDG laboratory experiments with a student subject pool and show that introduction of a imaginary future generation (IFG) who are assigned to represent future generations in deliberation enhances IS. Shahrier et al. (2017b) and Timilsina et al. (2021) conduct ISDG field experiments using a subject pool of the general public in urban and rural areas of Bangladesh and Nepal, respectively, and show that rural people choose sustainable options much more often than do urban ones. Shahrier et al. (2017a) further conduct ISDG field experiments in Bangladesh with subjects of urban people, demonstrating that future ahead and back mechanism (FAB that asks people to take the standpoint of future generations and to think about their requests to the current generation) induces people to choose sustainable options. Timilsina et al. (2019) conduct ISDG field experiments with a subject pool of general people in Nepal and conclude that intergenerational accountability (IA that asks people to be accountable for their decisions to future generations) is effective at maintaining IS. Katsuki and Hizen (2020) address people's behaviors under some voting rules in laboratory settings, finding that they fail in enhancing IS. Overall, these studies demonstrate that some attempts and institutions (with deliberation), such as IFG, FAB and IA, shall be able to address underrepresentation of future generations as well as to maintain IS.

In political science, *accountability* refers to a responsibility of decision makers on behalf of people spanning the obligations to report, explain and answer for the resulting consequences where people can sanction (or reward) the decision makers (Przeworski et al., 1999). Accountability holds when decision makers and receivers are engaged in two-way communication, and it is established that people become fair and/or just when they are accountable for their decisions (Tetlock, 1983, 1985). In the context of IS problems, such a two-way communication between the current and future generations is not always possible especially in the long-run perspective of non-overlapping generations (Shahen et al., 2021), and the only possible communication path is unidirectional or one-way communication from the current to future generations. Given this state of affairs, this research suggests IA mechanism along with deliberation in which people in the current generation are asked to be accountable for their decisions and leave their written reasons & advice to future generations, hypothesizing that IA brings fair and sustainable decisions of the current generation for IS.

In some real-life decision-making contexts, societies deliberate and conclude with majority voting on some salient and/or long-term problems, such as Brexit (in UK) and other instances. For examples, countries (e.g., Ireland and Iceland), political parties (e.g., Alternativet Party of Denmark, Czech Pirate Party of Czech and Demos Party of Romania), country representatives (e.g., UN) and officials follow deliberation and/or voting for making decisions whose influence affect future generations in the long run (Geissel and Newton, 2012, Vodova and Voda, 2020, Gad, 2020, Gherghina and Geissel, 2020, Gherghina and Stoiciu, 2020). In summary, not only the literature but also real-world social movements reveal that underrepresentation of future generations is considered a fundamental problem for democracy and IS (Habermas, 1984, 1994, Chambers, 2003, Mansbridge, 2003, Delli Carpini et al., 2004, Warren, 2017, MacKenzie, 2018, MacKenzie and Caluwaerts, 2021). To address the problem, we hypothesize that deliberation and/or IA induce people in the current generation to represent future generations' interests and concerns (or to be fair and/or just across generations), enhancing IS. Specifically, this research examines how two models of deliberative decision making with individual voting enhance IS as compared with individual voting without deliberation by conducting laboratory experiments. The following hypotheses are posed:

- **Hypothesis** 1: Intragenerational deliberation and individual voting results in higher IS than only with individual voting.
- **Hypothesis** 2: Intragenerational deliberation with intergenerational accountability and individual voting results in higher IS than only with individual voting.
- **Hypothesis** 3: Intragenerational deliberation with intergenerational accountability and individual voting results in higher IS than only with intragenerational deliberation and individual voting.

One important measurement is the frequency in generation sustainable choice and it is considered a good approximation of IS. To answer the three hypotheses, we empirically compare and characterize the frequencies in generation sustainable choice across three models of decision making by including other control variables (SVO, sociodemographic factors and others) that will be discussed in the following section of experimental design.

From a game theoretical view, choosing an unsustainable option is a Nash equilibrium (NE) strategy as well as a dominant strategy for each generation in ISDG, because it maximizes their own payoff, irrespective of how other generations chose in the past and will choose in the future within the same sequence. On the other hand, all allocations in ISDG are Pareto optimal in the sense that every allocation cannot be Pareto improved by any other feasible allocation. For example, when every generation keeps choosing an unsustainable option, the resulting allocation is still considered Pareto optimal. These features of ISDG arise from the fact that the current generation unidirectionally affects future generations, representing how it is challenging to maintain sustainability (Kamijo et al., 2017, Shahrier et al., 2017b, Saijo, 2020, Katsuki and Hizen, 2020). There exists a unique allocation that leads to sustainability and maximizes the sum of payoffs for all the generations (i.e., social welfare) in ISDG. When every generation keeps choosing a sustainable option, the resulting allocation shall be considered socially desirable by not only maintaining sustainability but also maximizing the sum of payoffs for all generations. The theoretical prediction suggests that people choose an unsustainable option and fail to maintain IS under ISDG in any models of decision making. However, some behavioral and experimental studies in economics establish that people do not always follow NEs and dominant strategies in some situations (McKelvey and Palfrey, 1992, Binmore, 1994, Ochs, 1995, Goeree and Holt, 1999, Charness and Rabin, 2002, Holt and Roth, 2004, Garcia-Pola et al., 2020).

3 Experimental design

3.1 Experimental setup

We conducted laboratory experiments by following intergenerational sustainability dilemma game (ISDG), a social value orientation (SVO) game and questionnaire surveys for each subject's critical thinking disposition, empathic concern and sociodemographic information. Experiments were carried out in the laboratory of the Kochi University of Technology (KUT) with a total of 312 Japanese students, including 145 female and 167 male, aged between 18 and 23. The subjects were recruited from the student subject pool of KUT with various specializations, such as economics, engineering, management and natural sciences.

3.1.1 Intergenerational sustainability dilemma game (ISDG)

We implement ISDG following the laboratory and field experiments of Kamijo et al. (2017) and Shahrier et al. (2017b). Building upon previous ISDG experiments, we add a new element of individual voting mechanism to the experimental design, the details of which are discussed later in this section. ISDG consists of a sequence of six generations. A "generation" is a group of three members, while in a "sequence," six chronologically arranged generations share the same resource (X) one after another. In ISDG, each generation is asked either to maintain intergenerational sustainability (IS) by choosing option B (sustainable option) or to maximize their own generation's payoff by choosing option A, imposing an irreversible cost to the subsequent generations (unsustainable option). By choosing option A, each generation receives a share of X. On the other hand, the generation receives a share of $X - 900$ by choosing option B.

We randomly assign each generation to the 1st, 2nd, $\dots$ and 6th generations, respectively. The current generation's decision affects the subsequent generations such that subsequent generations' shares decline irreversibly and uniformly by 900 when the current generation chooses option A, otherwise not. For instance, suppose that $X = 3600$ and the 1st generation chooses option A. Then, the 2nd generation will face a game in which they receive 2700 and 1800 for choosing options A and B, respectively. However, if the 1st generation chooses option B, the second generation faces the same decision environment as that of the 1st generation faces. That is, when the 1st generation chooses option B, the 2nd generation faces the game receiving 3600 and 2700 by choosing options A and B, respectively. Following the same rules, the game continues for the subsequent generations (i.e., between ith and $i + 1$th generations) in a sequence. Hence, option B can be considered the "sustainable option," whereas option A is the choice that compromises IS and can be considered as the "unsustainable option."

In the experiments, the 1st generation starts the game with a share of $X = 3600$ experimental points, by choosing option A, the generation earns 3600 points, where by choosing option B, the generation earns 2700 points. Consequently, members of this generation split the points equally among themselves and each member earns 1200 points by choosing option A and 900 points by choosing option B as a generation share, respectively. ISDG experiment is designed in a way that the 5th and 6th generations possibly face the situation in which options A and B are associated with zero and negative shares, respectively. When the generations from the 1st to the 4th choose option A, then the 5th generation will face the game in which they receive generation shares of zero points and -900 points by choosing options A and B, respectively. If the generation's share is negative, say, $-Z$, each generation member will receive the equal points of $-Z/3$. When the subjects receive negative points, each of them needs to refund $Z/3$ points to the experimenter. In such situations, the points of $Z/3$ are deducted from each member's participation fee of 600 points so that individual payoff becomes at least nonnegative (See appendix).

As shown in figure 1, we prepare three treatments namely, (1) majority voting (MV), (2) deliberative majority voting (DMV) and (3) majority voting with deliberative accountability (MVDA) that are as follows:

- **MV** (base group treatment): Three members in a generation are asked to cast their anonymous and independent votes for option A or option B. The members in a generation see the faces of each other, but they are not allowed to communicate before they vote. After each member's voting, the generation decision between options A and B is made by majority rule. Specifically, the majority rule means that the generation decision is made as A (or B) if two or all three members vote for option A (or option B).

- **DMV**: Three members in a generation are asked to deliberate over choosing between options A and B up to 10 minutes before they vote. After that, the members cast their anonymous and independent votes for option A or option B. The generation decision is made by majority rule as in MV.

- **MVDA**: Three members in a generation are asked to deliberate and collectively provide reasons & advice for their possible generation decision to the subsequent generations over choosing between options A and B up to 10 minutes. When the generations are not the 1st one, they receive reasons & advice from the previous generation(s) before deliberation. After that, the members cast their anonymous and independent votes for option A or option B. The generation decision is made by majority rule as in MV and DMV.

Hypotheses 1, 2 and 3 can be statistically examined and tested by comparing the likelihood for generations to choose a sustainable option B between the two treatments (Hypothesis 1: MV versus DMV, Hypothesis 2: MV versus MVDA and Hypothesis 3: DMV versus MVDA).

[Figure 1 about here.]

3.1.2 Social value orientation (SVO) and psychological factors

We use the "slider method" to identify the subjects' social preferences by understanding their social value orientation (SVO) (Murphy et al., 2011). SVOs are already well established to be stable for a long time (See, e.g., Van Lange et al. (2007) and Brosig-Koch et al. (2011)). The slider method consists of 6 items where each subject is asked to share an amount of money or points with another subject. Each item consists of nine pairs of distributions for self and the other. The average allocation of oneself $\overline{A_s}$ and average allocation for the $\overline{A_o}$ are computed from all 6 items. Then, 50 is subtracted from $\overline{A_s}$ and $\overline{A_o}$ to shift the base of the resulting angle to the center of the circle $(50, 50)$. The index of a subject's SVO is given by SVO = arctan $\frac{(\overline{A_s}-50)}{(\overline{A_o}-50)}$. We combine "altruist (SVO $> 57.15°$)" and "prosocial ($22.45° <$ SVO $< 57.15°$)" types into a single category of "prosocial;" "individualist ($-12.04° <$ SVO $< 22.45°$)" and "competitive (SVO $< -12.04°$)" to "proself" as it is often done in psychology research for presenting results in a simple way. The subjects are informed in detail that their total payoffs from the SVO game are dictated by their own and anonymous pair's choices. The subjects are instructed about the game rules, points and total payoffs they receive from the game. The subjects perform the SVO tasks individually and submit their sheets to research assistants (RAs). RAs calculate the total payoff by randomly matching between the subjects from the same days session.

3.2 Experimental procedures

The first author administered the experiments with research assistants (RAs). One session comprises ISDG, SVO, sociodemographic questionnaires and payments. For each session, 18

subjects ($=6$ generations) were gathered at an instruction room, and one treatment among MV, DMV and MVDA was randomly assigned (Figure 2). We announced that no communications were allowed without any permission. Then, the 18 subjects read and watched written and video instructions for ISDG. We also made an oral presentation, conducting Q&A and quizzes for double-checking subjects' understanding. Unless the subjects correctly answered, we did not proceed to ISDG. At the beginning of ISDG, each subject drew a chip from a bag to determine his/her sequence (i), generation (j) and individual IDs (k). Each chip displays a letter (e.g., P, Q, R) corresponds to $i \cdot j$ - k (Figure 2). In each session, the i takes one letter out of three from $\{P, Q, R\}$ and j takes one number out of $\{j', j'+1\}$ for $j' = \{1, 3, 5\}$ (e.g., $j = \{1, 2\}$ when $j' = 1$; $j = \{3, 4\}$ when $j' = 3$). In figure 2, for example, $P1$ and $P2$ corresponds to j' and $j'+1$ when $j' = 1$ for the sequence $i = P$. The k takes one number out of $\{1, 2, 3\}$ as an individual ID in a generation. The subjects whose generation IDs belong to a class of $i \cdot j'$ (e.g., $P1, Q1, R1$) first moved to different game rooms and went through ISDG. Those with $i \cdot j' + 1$ (e.g., $P2, Q2, R2$) stayed in the instruction room and filled out SVO and questionnaires, while waiting. Second, the subjects with $i \cdot j' + 1$ moved to the game rooms and went through ISDG as the next generation, after confirming that the subjects with $i \cdot j'$ finished and were ready to get back to the instruction room to complete SVO and questionnaires. In this step, we were careful about the routes and logistics in the way that the subjects with $i \cdot j' + 1$ neither meet those with $i \cdot j'$ nor find which room each subject in the previous generation was in.

[Figure 2 about here.]

One RA was present in each game room, and three subjects in a generation were guided to take their respective independent seat according to the individual IDs and to check their understanding about the prevoting procedures per treatment (See figure 1 for the detailed procedures per treatment). The members were also guided to observe the previous generations' decisions and their payoffs between options A and B on a white board in the room. When subjects were in the 1st generation, the RA told them that they did not have any previous generation. After confirming the understanding and situations associated with payoffs in ISDG, subjects went through all the procedures per treatment under the RA's support, and each subject anonymously and independently voted for option A or option B. The RA counted their votes, announcing the generation decision by majority voting rule in each room. The three subjects recorded their individual and generation decisions and returned to the instruction room, finalizing the remaining tasks, such as SVO and sociodemographic questionnaires. Finally, the subjects received their payments with some exchange rates according to their decisions. The payment for each subject was calculated as a summation of his/her earnings from the (i) participation fee, (ii) ISDG with 1 point $= 2$ JPY and (iii) SVO game with 1 point $= 1$ JPY where each subject receives on average 300 JPY, 1970 JPY and 900 JPY, respectively. In total, 17 sessions were completed and 312 subjects (or 104 generations) participated where one session was conducted with 24 subjects.

4 Results

Table 1 presents the definitions and descriptions of sociodemographic and psychometric variables used in the analyses. A total of 312 (104) subjects (generations) participate in the experiments with 105 (35), 99 (33) and 108 (36) in majority voting (i.e., MV), deliberative majority voting (i.e., DMV) and majority voting with deliberative accountability (i.e., MVDA) treatments, respectively (See table A3 in appendix). Similarly, $46.47\,\%$ female subjects participate in the experiments, and the percentages are $51.42\,\%$, $43.43\,\%$ and $44.44\,\%$ in MV, DMV and MVDA treatments, respectively. These facts reflect that there is a proper gender balance across the treatments. Past literature establishes that gender affects attitudes and behaviors and might bring differences in preferences between males and females in some contexts of economic decision making (Croson and Gneezy, 2009).

[Table 1 about here.]

Table 2 presents the frequencies and the percentages of generation choices between options A and B in ISDG by treatments. As shown, only 2 $(5.71\,\%)$ of the total 35 generations choose option B in MV. Among the 33 generations, 4 ($12.12\,\%$) choose option B in DMV. Of the total 36 generations, 10 ($27.78\,\%$) choose option B in MVDA. The results show that generation choices of option B are higher in DMV and MVDA than those in MV. To test whether the distributions of generation choices between options A and B are independent of the treatments, we perform chi-squared (χ^2) test by taking the following pairs: MV vs. DMV, MV vs. MVDA and DMV vs. MVDA, using the frequencies as summarized in table 2. A null hypothesis is that the distribution of generation choices between options A and B are the same for each pair of treatments. The results reject the null hypothesis for MV vs. MVDA. However, we fail to reject the null hypotheses for MV vs. DMV and DMV vs. MVDA. Overall, the results confirm that the distributions of the generation choices between options A and B in MVDA are different from those in MV.

[Table 2 about here.]

For a robustness check, we apply nonparametric test by considering the correlation among the observations of generation choices within a sequence. To this end, we cluster the generation choices at a sequence level. There is a total of 19 sequences, six each in MV and DMV, while there are seven in MVDA. We calculate the average for each sequence of generations that choose option B and run Mann-Whitney test to confirm the null hypotheses that the distributions of the averages for the sequences are the same in each pair of treatments. We find that the distributions of averages for the sequences of generations that choose option B are different and significant at $1\,\%$ for MV vs. DMV, MV vs. MVDA, and DMV vs. MVDA, respectively. Overall, the generations in DMV and MVDA appear to choose option B more often than those in MV treatment.

[Table 3 about here.]

Finally, to characterize the effects of treatments on generation choices of option B, we run logit regression by taking generation choices between options A and B as the dependent variable that takes unity when a generation chooses option B, otherwise zero. The independent variables are the treatment dummies (DMV and MVDA), a number of prosocial members in a generation (prosocial), average critical thinking disposition, average empathic concern and average personal distress and gender (a number of females in a generation). Since generation decisions are taken at the generational level, we take an average or a summation of independent variables for the analyses (See the definitions of independent variables in table 1). We report the marginal effects of the treatment dummies and other independent variables from models 1 to 3 in table 3. The marginal effects of the treatment dummies can be considered causal due to their random assignments Angrist and Pischke (2009). In model 1, we present the marginal effects of the treatment dummies. In model 2, we add a number of prosocial individuals in a generation. Finally, in model 3, we further add other sociodemographic variables, such as gender, average critical thinking disposition, average empathic concern and average personal distress, for a robustness check.

Models 1, 2 and 3 in table 3 show that the marginal effects of DMV on generation choices of option B are economically and statistically significant ($P = 0.076$). They demonstrate that the generations in DMV have $7\,\%$ higher probability of choosing option B than those in MV, holding all other factors fixed. We also find that the marginal effects of MVDA on generation choices of option B are economically and statistically significant ($P < 0.01$), reflecting that the generations in MVDA have $13.8\,\%$ higher probability of choosing option B than those in MV. In summary, deliberation and accountability (i.e., DMV and MVDA treatments) result in higher percentages of option B choices than without deliberation (i.e., MV treatment). The results support hypotheses 1 and 2, being consistent with the theories related to deliberation, such as "the theory of communicative actions," advocating that deliberation among the participants along with reasoning helps achieve better social outcomes (Habermas, 1984).

We conduct further analysis by running logit regressions to estimate the IA effect on generation choices of option B. For this, we take DMV treatment dummy as the base group, excluding the observations in MV. Our result shows that the generations in MVDA are $5\,\%$ more likely to choose option B than those in DMV (See table A5 in appendix). The result can be interpreted as an additional effect of IA on generation choices of option B. This result supports our hypothesis (3) that intragenerational deliberation with intergenerational accountability (i.e., MVDA treatment) results in higher percentages in generation choices of option B than does deliberation (i.e., DMV treatment). Note that generation members in MVDA need to deliberate about the reasons & advice for their possible decision between options A and B. We realize that those who choose option B have often written *"we should not harm others,"* and/or *"we feel bad to hurt others, therefore, we have chosen option B."* as part of their reasons & advice. Such statements imply that IA might have influenced the generation members to be sympathetic with and/or take future generations' perspective, choosing option B. On the other hand, generations that choose option A have typically written *"we choose option A since it gives us more points,"* and *"we should think about ourselves, not about others,"* reflecting their self-maximization motives. Overall, IA appears to function as a one-way communication device via receiving and giving reasons & advice over generations for maintaining IS in comparison with DMV treatment where such a communication opportunity is missing.

Models 2 and 3 in table 3 show that a number of prosocial members per generation is economically and statistically significant ($P < 0.01$) (See also table A4 in appendix). The results demonstrate that the generations are $11.2\,\%$ more likely to choose option B with an increase in prosocial members per generation. The results are consistent with previous studies that find the positive influence of prosociality on people's behaviors for IS (Hauser et al., 2014, Shahrier et al., 2017b, Kamijo et al., 2017, Timilsina et al., 2017). The result in table 3 shows that the generations are $1.9\,\%$ more likely to choose option B when the average empathic concern of generation members increases by one additional point ($P < 0.01$). Our result is consistent with previous findings, showing that empathic concern induces people to value others' benefits (Kirman and Teschl, 2010, Artinger et al., 2014, Font et al., 2016). The result shows that the generations are $1.6\,\%$ less likely to choose option B with an additional unit increase in average personal distress of a generation members, implying that personal distress might induce people to make more unsustainable choices (Sapolksy, 2017).

5 Discussion & conclusion

We institute ISDG with three forms of decision-making models by experimentally manipulating prevoting components and examine how they maintain IS in laboratory experiments. Game theory predicts that generations choose an unsustainable option in ISDG, and our results in the base group (MV) are in line with the prediction. Other two models of deliberative decision making (i.e., DMV and MVDA) are found to be more effective than MV. We also find that a majority of generations still chooses an unsustainable option in all treatments. The results imply that maintaining IS shall be very challenging with majority voting, especially when generations are neither biologically nor socially connected, i.e., non-overlapping generation. However, when deliberation and one-way communication (IA) from the current generation to future generations are introduced along with majority voting, generations choose to be sustainable.

Deliberative theories and the associated empirical studies reveal that the effect of deliberation is context-specific as argued before, and it is well known that the deliberation effect can be either positive or negative to have a socially desirable outcome (Habermas, 1994, Pettit and Rabinowicz, 2001, List, 2006, MacKenzie, 2018, Delli Carpini et al., 2004, Warren, 2017). Delli Carpini et al. (2004) summarize that deliberation can be ineffective or counterproductive in some situations. Game theory also predicts that a majority of people should choose an unsustainable option as suggested by NE and dominant strategies. These facts imply that ISDG can be interpreted to be one specific situation where deliberative forms of democracy with voting does not have a huge positive effect on IS. The interpretation appears to reflect our results that the percentages of generations that choose a sustainable option in DMV and MVDA treatments remain low around $12.12\,\%$ and $27.78\,\%$, respectively.

We conjecture that people in MVDA treatment are engaged more seriously in deliberation than those in DMV treatment through being accountable (i.e., writing and leaving their reasons & advice to future generations, i.e., IA mechanism), inducing people to choose a sustainable option. We raise the three possible channels: (i) warm-glow (or guilt aversion), (ii) legacy motive (as a cooperator) and (iii) moral commitment (Charness and Dufwenberg, 2006, Thompson, 2010, Fox et al., 2010, MacKenzie, 2018, Wade-Benzoni, 2019). First, people in the current generation may feel warm-glow or guilt aversion by leaving nice reasons & advice to future generations associated with a sustainable option choice (MacKenzie, 2018). Second, IA might have functioned as a one-way communication device for the current generation to have a legacy motive of being a cooperation initiator or successor, giving an opportunity of receiving and sending generations' decisions with reasons & advice (Kotre, 1996, 1999, Timilsina et al., 2019, Wade-Benzoni, 2019). Third, IA might have triggered people to have a moral commitment across generations in the sense that being accountable is known to signify fairness and/or justice concerns in people's judgment and decisions (Tetlock, 1983, 1985, Self et al., 2015). Thompson (2010) and MacKenzie (2018) also argue that children and/or future generations are main subjects of such a moral commitment.

Nearly $60\,\%$ of the countries and four billion people of the world have adopted democratic institutions in the last century (Roser, 2018). Most of these democratic countries and populations rely on anonymous voting to make important social or political decisions that have future consequences for the subsequent generations without requiring deliberation and accountability. Importantly, it is very likely that societies and countries will continue voting as a democratic mechanism in future (Hill, 2013). In the real world, however, there are several examples of deliberation and accountability practices (See Geissel and Newton (2012), Vodova and Voda (2020), Gherghina and Geissel (2017), Gad (2020), Stoiciu and Gherghina (2021)). Some mini-publics, local assemblies (called "gram shabhas") and ad hoc committees are reported to be successful in development activities by introducing deliberation practices in collective decision making, materializing their social goals (MacKenzie and O'Doherty, 2011, Geissel and Newton, 2012, Ban et al., 2012, Warren and Gastil, 2015, Parthasarathy and Rai, 2017, Setala, 2017, Setala et al., 2020). Wales has attempted to institutionalize public accountability for future generations' wellbeing that can be considered one example of accountability practices in public policy (Davies, 2016, 2017). To resolve not only for IS but also for the problem of underrepresentation of future generations, it shall be necessary to institutionalize deliberation and accountability, as far as democracy remains as a main form of political systems (Gad, 2020, Stoiciu and Gherghina, 2021). Although it would be challenging to implement large-scale deliberative and accountability processes, there are several advanced technologies that could enable this, such as social media and online platforms (Strandberg, 2008, Gronlund et al., 2009). It is our belief that deliberation and accountability are integral elements for human societies to transition to be sustainable, and it shall be possible when technologies are integrated with democratic systems.

Finally, we note some limitations and possibilities for future research. First, we should not overlook that generations fail in ensuring IS under three models of decision making, implying that some drastic change or new forms of social institutions along with democracy may be necessary as discussed in literature (Kamijo et al., 2017, Shahrier et al., 2017b, Saijo, 2019, Bogacki and Letmathe, 2021, Saijo, 2020). Second, we only consider direct democracy as experimental treatments in this research. However, in the contemporary world, representative (or indirect) democracy is popular. It is important to examine IS under some forms of indirect democracy in the future. Third, as posited by Habermas, the deliberation in our experiment does not satisfy the "ideal speech" condition (Habermas, 1984, 1994), and the number of generation members is limited to be three. Future studies should be able to investigate IS by extending the deliberation conditions, such as the number of generation members. Fourth, this study includes only Japanese students from the student subject pool of KUT so that the effects of treatments can be under or overestimated. Future studies in this domain should examine IS by taking subjects from a general public pool for external validity. These caveats notwithstanding, we believe that this work is an essential step as experimental research, suggesting how two forms of deliberative democracy can enhance IS and represent potential interests of future generations.

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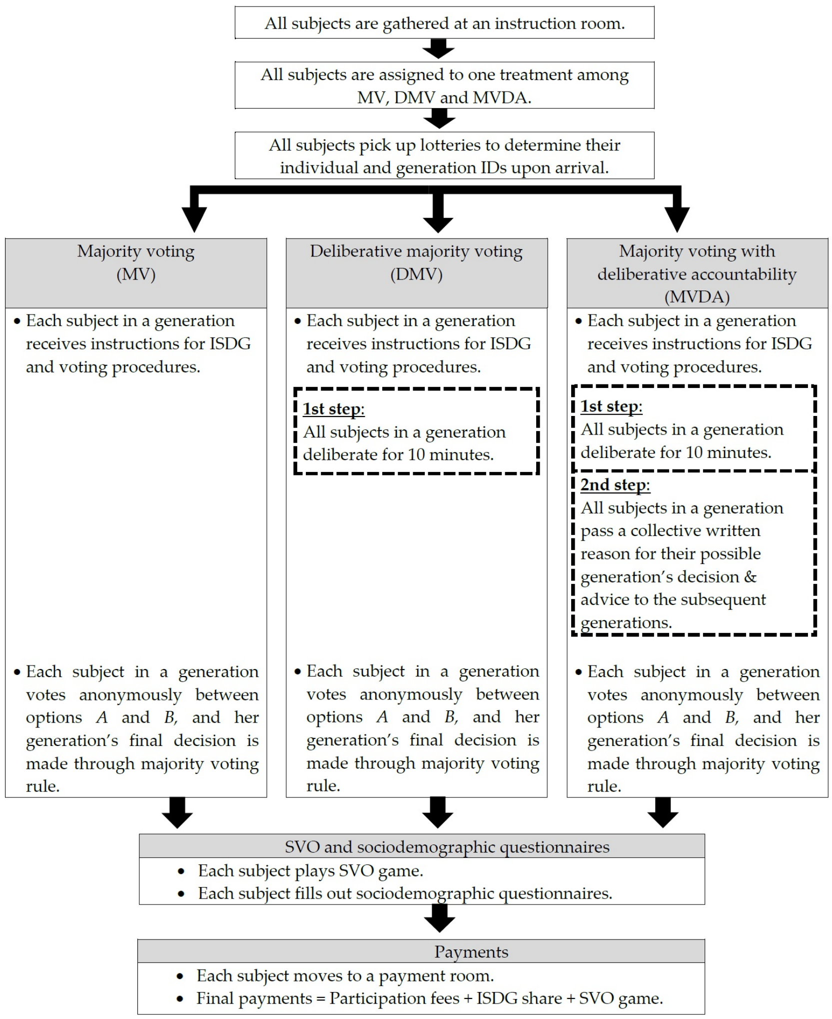

Figure 1: A flow chart of procedures for a subject to participate in the experiment.

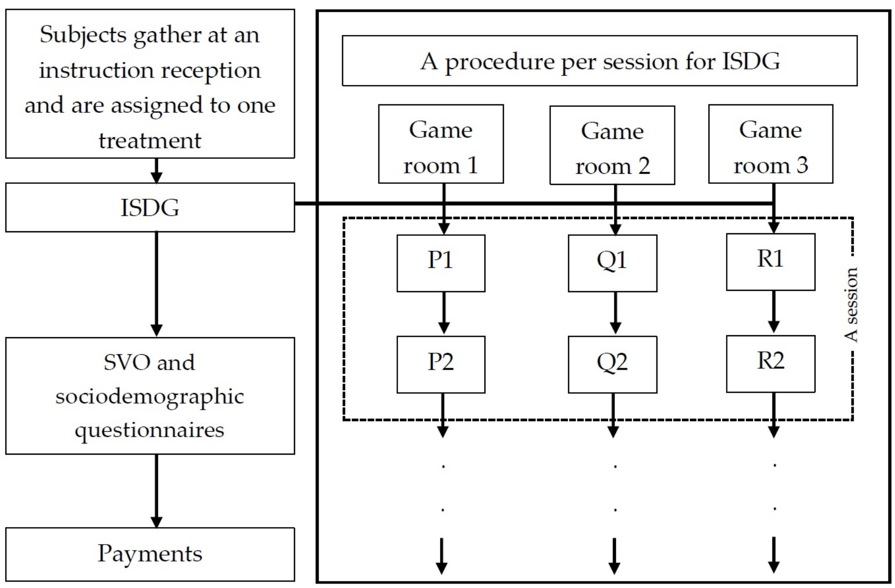

Figure 2: A flow chart of the procedures for one session.

List of Tables

Table 1: Definitions & descriptions of the variables.

Variables	Definitions & descriptions
Dependent variables	
Choice B	A dummy variable that takes 1 if a generation chooses option B; otherwise, 0.
Independent variables	
Treatment dummies (Base group = MV)	
DMV	A dummy variable that takes 1 if a generation is in DMV treatment; otherwise, 0.
MVDA	A dummy variable that takes 1 if a generation is in MVDA treatment; otherwise, 0.
Sociodemographic and psychometric variables	
Prosocial	A number of members in a generation whose social value orientation is categorized as "prosocial."
Gender	A number of female members in a generation.
Empathic concern	Summation of a subject's empathic concern measured in 5-points Likert scale, ranging from 0 to 28 points.
Personal distress	Summation of a subject's personal distress measured in 5-points Likert scale, ranging from 0 to 28 points.
Critical thinking disposition	Summation of subject's critical thinking dispositional scale measured from 5-points Likert scale, ranging from 13 to 65 points.

Table 2: The frequencies and percentages of generation choices between options A and B by treatments.

	Frequency and percentage of option B choice			
Choices A or B	MV (N = 35)	DMV (N = 33)	MVDA (N = 36)	Overall (N = 104)
A	33 (94.29 %)	29 (87.88 %)	26 (72.22 %)	88 (84.62 %)
B	2 (5.71 %)	4 (12.12 %)	10 (27.78 %)	16 (15.38 %)
Subtotal	35 (33.66 %)	33 (31.73 %)	36 (34.61 %)	104 (100 %)

Note: MV vs. DMV ($\chi^2 = 0.867, P = 0.352$), MV vs. MVDA ($\chi^2 = 6.151, P = 0.013$) and DMV vs. MVDA ($\chi^2 = 2.610, P = 0.106$)

Table 3: Marginal effects of independent variables on the probability of option B choice in logit regressions (base group = option A choice).

	Option B choice		
	Model 1	Model 2	Model 3
Independent variables			
Treatment dummies (base group = MV)			
DMV	0.064*	0.087**	0.070*
	(0.038)	(0.040)	(0.040)
MVDA	0.221***	0.140***	0.138***
	(0.042)	(0.036)	(0.036)
Sociodemographic and psychometric variables			
Prosocial		0.116***	0.112***
		(0.016)	(0.016)
Gender			−0.016
			(0.016)
Empathic concern			0.019***
			(0.006)
Personal distress			−0.016**
			(0.007)
Critical thinking disposition			1.964×10^{-4}
			(0.006)
Observations (generations)	104	104	104

Note: (1) Standard errors clustered at the sequence level are in parenthesis, (2) *** $P < 0.01$, ** $P < 0.05$, * $P < 0.10$ and (3) Marginal effects are calculated at the same means of independent variables.