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Abstract: Does voting solve intergenerational sustainability dilemma? Do voting rules matter for inducing people to collectively select a sustainable alternative that leaves more resources for future generations? To answer these questions, we conduct a laboratory experiment with human subjects in the framework of intergenerational sustainability dilemma game, in which the own-payoff maximizing choice by the current generation decreases the size of resource left for the subsequent generations. The choice is made by voting among the members of each generation, and we compare three voting rules, ordinary voting, whereby each person has one vote, proxy voting, whereby a part of people are given an extra vote on behalf of the subsequent generations, and two-ballot voting, whereby all people are given an extra vote. We observe that proxy voting and two-ballot voting improve the frequency of sustainable choice in comparison with ordinary voting, but the frequency is still low. This result implies that having people vote individually hardly achieves sustainable choices by successive generations even if the rules of voting are elaborated to some extent.

Keywords: proxy vote; intergenerational sustainability dilemma; future generation; laboratory experiment

1. Introduction

Voting is a widely used means of determining policies in modern societies. However, only people of the current generation can participate in the vote, and future generations, who would be affected by the outcome of the vote but do not exist yet, cannot participate. The absence of future generations in voting makes it difficult for intergenerational opinions, especially those that strongly consider the interest of future generations, to be reflected in voting results. This is the fundamental issue in creating a sustainable society from a political aspect [1].

The intergenerational issue also exists between elderly and younger people within the current generation. Children under the legal voting age are not given the right to vote. Furthermore, the proportion of younger people is getting smaller under the aging of population in developed countries, and hence their opinions are less likely to be reflected in voting outcomes. As a solution to this problem, giving extra votes to parents with children under the voting age is argued in terms of intergenerational justice. Van Parijs [2] (p. 309) provides an example of parents' vote in the French protectorates of Tunisia and Morocco in the Interwar period: each father of four children or more was given a second vote. He points out that, although the introduction of parents' vote is rare, it has been discussed repeatedly in France from a natalist point of view. Recently, parents' vote was discussed in the German parliament and envisaged in the draft new constitution of Hungary, but it was not adopted. Aoki & Vaithianathan [3] conducted an online questionnaire survey to find out

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Japanese voters' attitudes toward the idea of parents' vote. The percentages of approval for parents' vote were 68.2% among parents with children under the voting age, 31.5% among parents with children over the voting age, and 44.5% among adults without children. Wolf et al. [4] argue that parents' vote is justifiable, but its success or failure depends on whether parents use their proxy votes faithfully to their children's preferences, which must be tested empirically. Kamijo et al. [5] conducted an online experiment in which parents voted to choose an amount of money donated from their endowment to non-profit organizations whose activities were beneficial to future generations. They observed that females with children under the voting age indicated a larger amount of donation than others when they were given one vote each, but that this distinction disappeared when they were given an extra vote on behalf of their children.

Neither children of the current generation nor people of future generations have the right to vote yet, but their fundamental difference is whether to exist currently or not yet. If they exist currently, we can apply the one-person-one-vote principle to entrust their votes to their parents or their legal guardians. Otherwise, we cannot. Wolf et al. [4] (p. 364) state that "voting rights for children do not give a voice to the not-yet-born. If a society wants to give the interests of non-yet-existing individuals their weight too, other tools are needed." Kamijo et al. [6], Miyake [7], and Kamijo et al. [8] consider an extension of the idea of proxy vote to future generations such that extra votes are given to a part of people of the current generation with the explanation that they are proxy votes for future generations who cannot join the vote, and hence they are cast on behalf of future generations. They conduct laboratory experiments to test the effectiveness of such proxy votes in a framework of one-shot game. In their experiments, participants are divided into groups of three, and two of the three are assigned the role of current generation whereas one remaining participant plays the role of future generation. The two participants of the current generation vote to determine how to divide an amount of money among the three participants. It is whether to divide it equally among the three people or to give more to themselves at the expense of future generation's share. A proxy vote for the future generation is given to one of the two participants of the current generation. They observe that proxy voting does not enhance the choice of future-friendly alternative because proxy votes are not necessarily cast for the future-friendly alternative, and because one-ballot voters often switch from the future-friendly alternative to the own-payoff maximizing alternative if another voter is given an extra vote.

We conduct a similar test but it is in the framework of intergenerational situation where six generations make successive decisions and the decision by each generation affects the amount of resource left for the subsequent generations. This intergenerational situation is invented by Kamijo et al. [9] and called intergenerational sustainability dilemma game (ISDG). The ISDG has been used to test the effectiveness of various types of face-to-face discussion in solving the dilemma [10-13]. In the experiment of Kamijo et al. [9], each three-person group (i.e., generation) chose either an own-payoff maximizing alternative or a sustainable alternative by 10-minute face-to-face discussion. Group members also determined how to divide the revenue among themselves as a part of their earnings from their participation in the experiment. Kamijo et al. [9] found that if one of the three members in each group was assigned a role of "imaginary future generation," who was instructed to negotiate with the other two members on behalf of the subsequent generations, then the frequency of sustainable choice improved significantly.

In our experiment, we observe that proxy votes improve the frequency of sustainable choice in comparison with the ordinary one-person-one-vote rule, but the frequency is still low. This result implies that the introduction of proxy votes is not sufficient to achieve sustainability, which is consistent with the results of the previous literature using the framework of one-shot game explained above. Therefore, we need to invent another version of proxy voting, other voting rules, or even other political institutions. Our result is in contrast to Hauser et al. [14]. In their experiment of intergenerational goods game, sustainability was achieved with the introduction of voting. We will discuss about the factors that have possibly generated these different results.

This paper is organized as follows. Section 2 describes the design of our experiment. Section 3 explains the experimental procedure. Section 4 shows our results. Section 5 discusses about the results. Section 6 concludes. Appendix A provides the instructions for our experiment.

2. Experimental Design

2.1 Intergenerational Sustainability Dilemma Game

We introduce voting as a way for group members to select an alternative in the intergenerational sustainability dilemma game (ISDG) invented by Kamijo et al. [9]. Participants are divided into six groups (i.e., generations) of three members each. They successively choose one of two alternatives, A (own-payoff maximizing choice) and B (sustainable choice). If the first group chooses A, it obtains 3,600 Japanese yen as a group. If it chooses B, it obtains 2,700 yen.

After alternative A is chosen by the first group, the revenue from each alternative for the second group decreases by 900 yen. That is, the second group obtains 2,700 yen if it chooses A, whereas it obtains 1,800 yen if it chooses B. On the other hand, after alternative B is chosen by the first group, the revenue from each alternative for the second group is the same as for the first group. Such a reduction by 900 yen for the next group after choice A is common to all the subsequent groups. That is, if alternative A keeps being chosen, the revenue from A keeps decreasing from 3,600 yen to 2,700 yen, 1,800 yen, 900 yen, and 0 yen.

2.2 Three Voting Rules

We compare three voting rules. All the voting rules select one of alternatives A and B as the winner by the majority rule. That is, the alternative that attracts a greater number of votes is determined as the group decision among the three members. Ties are broken randomly. For simplicity, the revenue determined by voting for each group shall be equally divided among the three members. Abstention is not allowed, and each participant is required to cast each vote for either alternative A or B.

The only difference among the three voting rules is the number of votes given to each member. Under *ordinary voting*, every member has one vote. Under *two-ballot voting*, every member has two votes. The instructions explain that the first vote is given as each member's own vote while the second vote is given as a proxy vote for the subsequent groups who cannot participate in the vote. Under *proxy voting*, only one of the three members has two votes while the other two members have one vote each. The same explanation about the extra vote as two-ballot voting is given to all the members.

The proxy vote is introduced with the intention of reflecting the interests of future generations into the current voting results. Hence, for the institution designer, it is ideal that 100% of proxy votes are cast for sustainable alternative B. However, there is no guarantee that the proxy vote is actually cast for B because casting it for B does not maximize the payoff for each member of the current generation.

Proxy voting creates asymmetry in the number of votes among voters. In the case of parents' vote, it could be justified by the one-person-one-vote principle including children. However, if the proxy vote is on behalf of future generations, that principle does not apply. The two-ballot voting in our experiment is intended to avoid such asymmetry among voters but reflect the interests of future generations into the current voting result.

2.3 Group Assignment

As described in Table 1, we had two types of sessions. In ordinary/two-ballot sessions, participants made decisions under ordinary voting and two-ballot voting in random order. In proxy sessions, each participant voted in the following two circumstances in random order under proxy voting: he or she and another member had one vote each while the remaining member had two votes, and he or she had two votes while the other two members had one vote each. In both types of sessions, each participant experienced both decisions with one vote and decisions with two votes.

Table 1. Two types of sessions

Session name	Decisions with one vote	Decisions with two votes
Ordinary/two-ballot	Ordinary voting	Two-ballot voting
Proxy	Proxy voting with one vote	Proxy voting with two votes

Note: We had two types of sessions. In ordinary/two-ballot sessions, participants made decisions under ordinary voting and two-ballot voting in random order. In proxy sessions, they made decisions in two circumstances in random order under proxy voting, where they were given one vote and where they were given two votes.

Participants were assigned either the ordinary/two-ballot sessions or the proxy sessions according to the date of their participation. They were also assigned from the first group (i.e., generation) to the sixth group according to the time of their participation. The experiment began with the first group and continued through the sixth group. As we see in Appendix A, the instructions differed between the two types of sessions in terms of voting rules, but were the same among the six groups within each type of session. Participants were informed of their own generation on their voting-decision form distributed after the instructions.

Although participants of the sixth generation received the same instructions as the previous five generations and were given a monetary incentive for their own gratuity determined by their vote, the instructions did not mention the sixth generation and beyond. They merely mentioned that each group belonged to a sequence of groups but did not mention how long the sequence continued. In fact, we did not have sessions for the seventh generation and beyond.

The participants who gathered at each time in the laboratory were divided into three-member groups and assigned the same generation. Each group would be connected with other five groups chosen randomly from the other five generations respectively to form a sequence. In ordinary/two-ballot (proxy, respectively) sessions, participants of the first group made decisions on whether to vote for alternative A (3,600 yen) or B (2,700 yen) under ordinary voting and two-ballot voting (in the two circumstances with one vote or two votes under proxy voting) respectively in random order. Experimenters determined randomly which voting rule would be employed (who would be assigned one vote or two votes among the three members of each group) to calculate participants' earnings. We employed a strategy method to collect data from the subsequent groups. For example, the second group made voting decisions for the possible two cases after the first group had chosen A and after it had chosen B in random order. The revenue for each group of the second generation was determined by the group's choices for the possible two cases under each voting rule (circumstance) and the actual choice of a group selected randomly from the first generation into the same sequence. Similarly, subsequent groups made voting decisions for all possible cases. That is, under each voting rule (circumstance), there are four cases for the third group, eight cases for the fourth group, sixteen cases for the fifth group, and thirty-two cases for the sixth group.

3. Experimental Procedures

Participants were recruited from the subject pool of Kochi University of Technology that consisted of undergraduate students from various academic disciplines. The total of 156 participants got together at the social science laboratories in December 2018 and January 2019. Twelve of the 156 were to make sure there was no particular difference between the university's two campuses. Therefore, we use the data of 144 participants for our analysis, which consist of 4 groups of 3 participants in each of the 6 generations for each of the 2 types of sessions. Experimenters were also undergraduate students.

In each session, 12 participants took seats separated from each other by partitions so that they could not see faces each other but could see the top of heads. Participants drew lots and were divided into four groups of three people each, although they stayed at seats and could not identify who belonged to the same group as themselves.

Participants read the instructions silently along with an experimenter reading them aloud. As in the experiment of Kamijo et al. [9], we avoided using words such as generation, sustainability, or any others that could hint at the purpose of our experiment to the participants. After the instructions, a sheet of paper with several quizzes was distributed, and participants answered them to check their comprehension of the instructions. Then, a voting-decision form was distributed, on which the participants' generation was written. They made voting decisions as explained in Subsection 2.3. Finally, a questionnaire was distributed, and participants answered questions asking about their voting decisions during the experiment as well as their attributes and questions measuring their social value orientation (SVO) [15]. The SVO questions classify participants into prosocial people and others according to their answers. Prosocial people are defined as people who are willing to divide an amount of hypothetical resource equally with an anonymous person; prosociality refers to behavior (i.e., to share an amount of resource with others) while altruism refers to motivation. After completing the questionnaire, participants received the gratuity determined in the voting experiment as well as 900 yen as honorarium for their participation.

This experiment was conducted as a part of voting-experiment project that received an ethical approval from the research ethics committee of Kochi University of Technology (code: 35-C1). Participants participated in the experiment anonymously using their IDs. They simply marked one of the two alternatives A and B on the paper, and hence there was no physical or psychological influence. We followed standard procedures in experimental economics.

4. Experimental Results

4.1 Voting Outcomes

We compare the three voting rules with respect to the frequency of sustainable choice B. Since participants in our experiment were randomly divided into three-person groups without identifying their group members, the actual voting result of each group (i.e., A or B) was merely one of the various possibilities. For example, suppose that six participants of a generation voted for alternatives A, A, A, A, B, and B respectively under ordinary voting when they faced a particular choice history of the previous generations. If one group were formed with three participants who chose A, A, and A while another group were formed with the remaining three participants who chose A, B, and B, then the decisions made by the two groups would be A and B. On the other hand, if the six participants were divided into participants with A, A, and B and participants with A, A, and B, then the group decisions would be A and A. To take such randomness of group-level observations into account, we conduct, after the experiment, the following four-step computer simulation regarding the group formation by using the data on each participant's choice for each possible choice history of the previous generations under each voting rule.

Step 1: From the first generation of 12 participants, the computer selects 3 participants randomly to form a group. Under proxy voting, the computer also determines randomly who is given two votes. The computer determines the group's decision (i.e., A or B) using the data on the 3 participants' actual decisions collected in the experiment. If alternatives A and B are in a tie, the computer selects one of them randomly.

Step 2: For the second generation of 12 participants, the computer performs the same group formation as in step 1. The computer determines the group's decision (i.e., A or B) using the data on the 3 participants' actual decisions made after the group decision of the first generation determined in step 1.

Step 3: The computer repeats the same procedure as in step 2 until the sixth generation. Then the computer obtains the number of times alternative B is selected in the sequence of six generations.

Step 4: The computer repeats the above three steps 50,000,000 times for each voting rule. Then the computer obtains 50,000,000 sequences of group decisions made by six generations for each voting rule.

Table 2 shows the results of the computer simulation based on the actual decisions made by the participants in our experiment. The rows represent the number of times alternative B is selected as a group decision in a sequence of six generations, whereas the columns represent voting rules. For example, "0" in the cell of row "6" and column "Ordinary" indicates that, according to our data, there never happens that all the six generations choose alternative B under ordinary voting even if 50,000,000 sequences of six generations are randomly created. The distributions of the number of times alternative B is selected among six generations are different between any two of the three voting rules at the 1% level of statistical significance by the Kolmogorov-Smirnov test.

Table 2. Simulation results of the number of times alternative B is selected among six generations

		Voting rule		
		Ordinary	Two-ballot	Proxy
Number of times alternative B is selected among six generations	6	0 (0.000%)	22,969 (0.046%)	15,920 (0.032%)
	5	5,974 (0.012%)	289,459 (0.579%)	166,605 (0.333%)
	4	90,390 (0.181%)	1,822,002 (3.644%)	640,143 (1.280%)
	3	474,954 (0.950%)	3,312,781 (6.626%)	2,892,368 (5.785%)
	2	4,329,254 (8.659%)	10,234,731 (20.470%)	8,468,484 (16.937%)
	1	17,267,664 (34.535%)	12,062,625 (24.125%)	14,866,201 (29.732%)
	0	27,831,764 (55.664%)	22,255,433 (44.511%)	22,950,279 (45.901%)
Sum		50,000,000 (100.000%)	50,000,000 (100.000%)	50,000,000 (100.000%)

Note: For example, "0" in the cell of row "6" and column "Ordinary" indicates that, according to the data from our experiment, there never happens that alternative B is selected six times among six generations under ordinary voting even if 50,000,000 sequences of six generations are randomly created.

Under ordinary voting, more than half of the sequences of six generations end up choosing alternative A all the time. Choosing alternative B once or less occupies more than 90%. Two-ballot voting and proxy voting improve the frequency of choice B to a statistically significant degree, but the successive selection of B is still far from being achieved. Kamijo et al. [9] employed face-to-face discussion as a way for group decision, and observed that the frequency of choice B improved from 28% to 60% if one of the three group members played the role of the representative for the subsequent generations. Their percentages are calculated as the percentage of groups that have chosen B among all groups of their five generations. If we calculate the same measure from Table 2, the percentages are 9.25%, 17.11%, and 14.66% under ordinary, two-ballot, and proxy voting, respectively. Voting does not seem appropriate for achieving sustainability in the ISDG even if proxy votes are introduced.

4.2 How to Use Each Vote

Next, we investigate how to use each type of vote under each voting rule. Table 3 shows the percentage of choice B made with each type of vote by all participants of each generation for all possible cases of choice histories of previous generations under each voting rule. For example, the value "33.33" in the upper left cell means that 33.33% of the individual decisions made by the 12 participants of the first generation under ordinary voting was to vote for alternative B while the remaining 66.67% was for alternative A. At the aggregate level, we can see over the six generations that, under proxy voting, the use of their own vote when participants are given two votes is more or less similar to the use of the vote when they are given one vote. This tendency is also found between the use of their own vote under two-ballot voting and the use of the vote under ordinary voting. On the other hand, although the frequency of proxy votes being cast for alternative B is far from 100%, which is the ideal level intended by the institution designer, and stays around 50%, it is higher than that of own votes in every generation under both two-ballot voting and proxy voting. These observations imply that the presence of proxy vote is the main factor for the difference in the frequency of choice B as a group decision among the three voting rules (Table 2). In fact, proxy votes occupy 0%, 50%, and 25% of all votes given to participants under ordinary voting, two-ballot voting, and proxy voting, respectively.

Table 3. Percentage of choice B by vote type and by generation (%)

Session name	Voting rule	Number of votes	Vote type	Generation					
				1st	2nd	3rd	4th	5th	6th
Ordinary /two -ballot	Ordinary	One	Unspecified	33.33	20.83	4.17	30.21	12.50	29.43
	Two -ballot	Two	Own	25.00	16.67	10.42	37.50	17.19	33.07
			Proxy	58.33	45.83	20.83	53.12	63.02	48.96
Proxy	Proxy	One	Unspecified	16.67	16.67	43.75	17.71	30.73	7.81
		Two	Own	16.67	16.67	35.42	16.67	37.50	6.77
			Proxy	25.00	62.50	50.00	54.17	40.10	50.00

Note: The percentage in each cell is calculated from the decision-making data of the 12 participants assigned to that cell for all the possible cases of choice histories of the previous generations.

4.3 Regression Analysis with Individual Data

Finally, we conduct a logistic regression analysis to identify the factors that induce choice B at the individual level. We divide our data by vote type, and run a regression for each data set. We have three types of votes as in Table 3, (i) unspecified votes given to each participant under ordinary voting and two of the three group members under proxy voting, (ii) own votes, and (iii) proxy votes, both of which are given to each participant under two-ballot voting and one of the three group members under proxy voting. We do not include the first generation because it has no previous generations in contrast to the other generations. The number of observations for each generation is the number of cases in the choice history of the previous generations (i.e., 2, 4, 8, 16, and 32 cases for the second to the sixth generations) times the number of participants for each type of vote (i.e., 24 subjects for every generation). The total of 1,488 observations are available for the regression of each type of vote.

The dependent variable is whether to vote for alternative B (1) or A (0). Explanatory variables consist of whether the vote was made under proxy voting (1) or the other two voting rules (0) (i.e., *proxy dummy*), the proportion (between 0 and 1) that alternative B was selected in previous generations (i.e., *proportion of choice B*), whether the participant is prosocial (1) or not (0) according to the SVO measure (i.e., *prosocial dummy*), whether the participant is female (1) or not (0) (i.e., *female dummy*), and dummy variables for each generation where the second generation is the baseline. In order to confirm whether the effects of the proportion of choice B and each participant's prosociality differ depending on generations, their interaction terms with generation dummies are also included. The random effect for each participant is introduced in the regressions to take into account the fact that a set of data are generated from each participant.

The proxy dummy is intended to examine the effect of asymmetry in the number of votes among group members. The proportion of choice B is intended to examine the effect of the decisions made by the previous generations on the decision of the current generation. The prosocial dummy and the female dummy are intended to examine the effect of each participant's characteristics on his or her decision. Although the effects of proxy dummy and female dummy are difficult to predict, the proportion of choice B and the prosocial dummy are expected to have positive effects on the probability of alternative B being chosen by each participant in voting.

Table 4 shows the estimation results of the random-effect logistic regressions. As predicted, the prosocial dummy has a positive and statistically significant effect on the probability of voting for B for every type of vote. The SVO measures prosociality towards an anonymous person who exists currently. This estimation result suggests that such prosociality could be also activated in a situation of successive group decisions.

Table 4. Estimation results of the random-effect logistic regressions

	Unspecified vote		Own vote		Proxy vote	
Explanatory Variables	Coef.	Std. err.	Coef.	Std. err.	Coef.	Std. err.
Proxy dummy	0.423	0.845	-0.197	0.892	-0.321	0.957
Proportion of choice B	0.772	1.263	4.729**	2.267	-0.000	1.013
% of choice B × 3rd gener. dum.	2.584	1.835	-2.195	2.553	0.601	1.498
% of choice B × 4th gener. dum.	2.419	1.698	-1.052	2.523	3.042**	1.452
% of choice B × 5th gener. dum.	1.564	1.524	-2.115	2.416	3.233**	1.267
% of choice B × 6th gener. dum.	3.110**	1.424	-1.514	2.346	2.428**	1.143
Prosocial dummy	5.725**	2.495	7.875***	2.868	7.246**	2.974
Prosocial dum. × 3rd gener. dum.	-0.280	3.222	-3.958	3.485	-1.510	3.549
Prosocial dum. × 4th gener. dum.	-3.649	2.991	-5.081	3.370	-4.949	3.562
Prosocial dum. × 5th gener. dum.	-2.196	2.940	-4.246	3.290	-6.178*	3.520
Prosocial dum. × 6th gener. dum.	-2.011	2.946	-4.176	3.325	-8.097**	3.590
Female dummy	0.994	0.862	0.984	0.906	-0.854	0.991
3rd generation dummy	-1.671	2.506	3.580	3.139	-3.880*	2.035
4th generation dummy	0.433	2.184	4.099	3.066	-1.575	2.074
5th generation dummy	-0.538	2.144	3.689	3.010	-1.130	2.032
6th generation dummy	-1.268	2.000	2.858	2.932	0.149	1.883
Constant	-6.763***	1.880	-10.600***	2.862	-0.563	1.562
Number of Observations	1,488		1,488		1,488	
Wald χ^2	71.72***		67.39***		63.21***	

Notes: The dependent variable is whether to vote for B (1) or A (0). The statistical significance at the 10%, 5%, and 1% levels are denoted by *, **, and ***, respectively.

However, the coefficients of interaction terms between prosocial dummy and generation dummies are negative for every type of vote. In particular, for proxy vote, they are statistically significant for the fifth and sixth generations, and their negative effects offset the positive effect of the prosocial dummy. On the other hand, for proxy vote, the proportion of choice B has significantly positive effects for the fourth generation and later. These observations imply that, for decision making on proxy vote, as the generations go forward, the influence of prosociality diminishes while how often sustainable choices have been made in the previous generations becomes important. The importance of the frequency of sustainable choice in the previous generations is also found for the sixth generation in the regression of unspecified vote. For own vote, the proportion of choice B has a positive and statistically significant effect while its interaction terms with generation dummies are not statistically significant.

The larger proportion of choice B by the previous generations can have the following three effects on the decision of the current generation. First, it might induce indirect reciprocity: participants might think that they should leave a larger pie for the subsequent generations because their previous generations did so for their generation. Second, it might have an income effect: since the larger proportion of choice B by the previous generations leaves a larger pie for the current generation, the current generation can earn a sufficiently large reward even if it chooses alternative B. Finally, it might form a custom: the larger proportion of choice B by the previous generations might form a custom of choosing B, and the current generation might merely follow the custom which the previous generations had followed. All these three effects work to enhance choice B. Our current society could be regarded to have been choosing the own-payoff maximizing alternative A successively. Our experimental result suggests that such successive own-payoff maximization leads to a higher frequency of own-payoff maximization by the subsequent generations.

Our results regarding the positive effects of the proportion of sustainable choice by the previous generations and each individual's prosociality on the probability of voting for the sustainable alternative are consistent with those of Shahen et al. [16]. They conducted an ISDG experiment with each generation being represented by one person, and observed that the larger proportion of unsustainable choice by previous generations led to a higher frequency of unsustainable choice by the current generation, and that prosocial participants were more likely to choose the sustainable alternative.

5. Discussion

Our result is in contrast to the observation of Hauser et al. [14] that the introduction of voting increases the frequency of sustainable choice dramatically in their intergenerational goods game (IGG). We think that the ISDG represents a more difficult situation for sustainability than their IGG as explained below.

In the IGG, each generation consists of five members, and each member extracts any number of units between 0 and 20 from a common pool of 100 units endowed to his or her generation. If the total number of units extracted by the five members does not exceed a predetermined threshold (50, 40, or 30 units), the size of common pool recovers to 100 units for the next generation. If it exceeds the threshold, the common pool is destroyed so that nothing is left for the next generation, which means the end of the game. In this setting, participants with any social preference would want to avoid the catastrophic outcome. They seem to be most satisfied if they achieve both the extraction of the common pool up to the threshold and the full recovery of the common pool for the next generation. In fact, Hauser et al. [14] observed in most five-person groups that a majority of members extracted 10 units or less, but that a minority extracted a larger number of units and hence the total number of units exceeded the threshold.

In the IGG with median voting, on the other hand, the number of units each member extracts is common to the five members of each generation and determined by voting among the five members. Each member votes for a number of units, and the median among the five proposals determines the number of units each member extracts. Under such median voting, Hauser et al. [14]

observed that the total number of units extracted by each generation fell within the threshold with an extremely high frequency. Since a majority extracted 10 units or less in the IGG, the median member should also vote for 10 units or less in the IGG with median voting. Voting is a device to reflect the preference of majority, and works well to prevent a minority from acting against the majority. Therefore, if the sustainable sequence of generations is preferred by a majority, it is achieved through voting.

In the ISDG, on the other hand, only two alternatives are available, the own-payoff maximizing alternative and the sustainable alternative. Even if participants want to increase their payoff by a small amount, there is no alternative between the two; they need to choose the own-payoff maximizing alternative. Furthermore, choosing it does not end the game; it merely decreases the common pool left for the next generation by 900 yen. Therefore, participants in the ISDG seem to be given a stronger incentive to choose the own-payoff maximizing alternative than in the IGG. In fact, a majority of our participants preferred the own-payoff maximizing alternative under ordinary voting. Two-ballot voting and proxy voting increased the sustainable choice, but it was to a small extent.

6. Conclusions

In this paper, we conducted a laboratory experiment with human subjects to examine the possibility of proxy vote on behalf of future generations improving the frequency of sustainable choice in the intergenerational sustainability dilemma game (ISDG). We observed that the ordinary one-person-one-vote rule resulted in a very low frequency of sustainable choice, and that the introduction of proxy votes enhanced the sustainable choice, but it did so only slightly. Our negative result for voting in achieving sustainability is in contrast to the positive result of Hauser et al. [14]. Our discussion about the difference in game structure between the ISDG and their intergenerational goods game (IGG) suggests that the ISDG represents a more difficult situation for sustainability than the IGG. A majority prefers the own-payoff maximizing alternative in the ISDG whereas a majority prefers a sustainable choice in the IGG. In principle, voting is a means for collective decision-making that reflects the preference of a majority.

The key to sustainability issues from the perspective of majoritarianism is that while the majority of the current generation and beyond, including future generations, prefers sustainable options even if they are costly for the current generation, the majority of the current generation does not. Therefore, for sustainable options to be chosen in today's society, it is necessary to either include future generations in the current decision-making process or change the preferences of the majority of the current generation in a direction that is compatible with future generations. The proxy vote we examined in this paper is intended to include future generations in the vote. However, since it is people of the current generation who cast proxy votes, their preferences need to be compatible with future generations for the proxy vote to succeed in selecting sustainable options. It is hoped that the introduction of proxy votes would direct voters' attention to the interest of future generations and result in the selection of sustainable options, but our experiment has shown that the proxy vote does not have a sufficiently large effect in the ISDG. As a future task, we must come up with a political institution that does not overly rely on, or rather brings out, the prosociality of the current generation towards future generations.

One of the things that could be thought of as activating prosociality towards future generations is to give the context of sustainability. In our experiment, we used words such as subsequent groups instead of future generations. However, if the proxy vote is introduced in the actual voting system of our society, it must be explained as the proxy vote for future generations instead of subsequent groups. It is another future task to examine the effect of the context of sustainability on current people's decisions regarding intergenerational issues.

Appendix A

This appendix provides an English translation of the Japanese instructions used in our experiment. The “attached table” in the instructions is Figure 1 of Kamijo et al. [9] with grid lines added.

Instructions

(1) Outline of the experiment

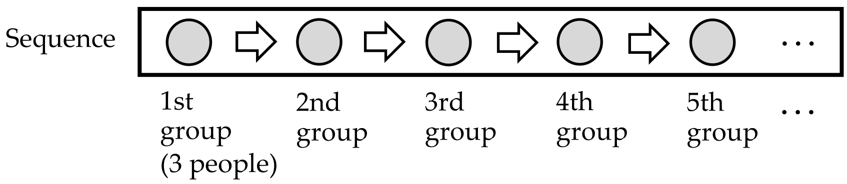
As an honorarium for participation in this experiment, 900 yen will be paid to each participant. We will pay this off after this experiment is over. Additional gratuities will be determined by the choice explained below.

In this experiment, participants in the laboratory will be randomly divided into groups of three. You will not be told who the other members of your group are.

Each group chooses between A and B. Depending on that choice, the gain will be determined. Please see the attached table. The numbers in this table are in hundreds. For example, 27 is 2,700 yen. If the first group chooses A, it gains 3,600 yen. If it chooses B, it gains 2,700 yen. Each group’s choice will be decided by voting. The additional gratuity you receive will be the amount of the gain chosen by your group divided equally by all the three members.

The figure below shows an overview of the experiment. Your group will be connected to other groups that are formed at other times. For example, suppose that your group is the third group in a sequence of groups. Then, the gains from A and B for your group will change in response to the choices made at the previous times by the first and second groups of the sequence to which your group belongs. Note that there will be no effect of the previous groups for the first group because it is the first group in its sequence. Depending on the choice of your group, the gains from A and B for the subsequent groups of your sequence will change.

Groups assembled at the same time in the laboratory will be given the same order in different sequences. Hence, the choices of other groups gathering in this laboratory now do not affect the choice of your group. It is the choices of the previous groups in the same sequence that will influence your group’s choice. The choice of your group will also affect the choices of the subsequent groups in the same sequence.



(2) How gains are determined

The gain for each group is determined as follows. If the first group chooses A, the gain for the second group will be reduced by 900 yen for both A and B. In other words, like the shaded part of the following table, the second group gains 2,700 yen from A and 1,800 yen from B. On the other hand, if the first group chooses B, the second group faces the same choice as the first group. In other words, the second group gains 3,600 yen from A and 2,700 yen from B.

1st group	2nd group
A 3,600 yen	A 2,700 yen
	B 1,800 yen
B 2,700 yen	A 3,600 yen
	B 2,700 yen

Next, let us consider the third group. Now, suppose that the first group has chosen A. Then, the second group faces the choice in the shaded part of the table above. The table below shows the gains for the third group that follow the shaded part of the table above. Here, if the second group chooses A, the gain from A for the third group decreases by 900 yen and becomes 1,800 yen, and the gain from B also decreases by 900 yen and becomes 900 yen. On the other hand, if the second group chooses B, the third group gains 2,700 yen from A and 1,800 yen from B.

2nd group	3rd group
A 2,700 yen	A 1,800 yen
	B 900 yen
B 1,800 yen	A 2,700 yen
	B 1,800 yen

As explained so far, if one group chooses A, the gain for the next group will be reduced by 900 yen for both A and B. On the other hand, if one group chooses B, the gains for the next group will be the same as the previous ones for both A and B.

Please refer carefully to the attached table. Raise your hand if you have any doubts. Then an experimenter will come to your assistance. During the experiment, conversations with others except experimenters are strictly prohibited.

(3) Decision-making by each group

You will be given a sheet of paper after the instructions, on which the gains from A and B for your group are written. These gains are determined by the choices of the previous groups although those for the first group are known to be 3,600 yen from A and 2,700 yen from B. If the gain will be negative as a result of your group's choice, you must pay it from your honorarium for participation in this experiment, 900 yen.

You will make voting decisions for two different experiments.

●Experiment X

[The following paragraph is presented in ordinary/two-ballot sessions.]

In Experiment X, all members of your group have one vote each. Group members are respectively asked to cast their votes for A or B. The alternative that receives the more votes will be the decision of your group.

[The following two paragraphs are presented in proxy sessions.]

In Experiment X, one of the three members of your group, except you, has two votes, while you and the remaining member have one vote each.

You and the remaining member are respectively asked to cast your votes for A or B. The member who has two votes is asked to cast one vote as "his or her vote" and another vote as a "proxy vote on behalf of the subsequent groups" who cannot participate in your group's vote. He or she is free to decide whether to cast each of the two votes for A or B. The alternative that receives the more votes will be the decision of your group. If a tie happens, a lottery will determine which of the two alternatives is chosen.

As explained so far, the gains from A and B for your group will change depending on the choices by the groups who participated in this experiment before you. There are multiple possible combinations for the choices of the previous groups. You will make voting decisions on all the cases that can arise.

For example, suppose that your group is the third group. Then, there are four possible cases for the choices of the previous groups, "the first group chose A and the second group chose A," "the first group chose A and the second group chose B," "the first group chose B and the second group chose A," and "the first group chose B and the second group chose B." Hence, the third group will make voting decisions on a total of four cases. Similarly, the number of cases on which voting decisions are made is one for the first group, two for the second group, eight for the fourth group, sixteen for the fifth group, and so on.

●Experiment Y

[The following two paragraphs are presented in ordinary/two-ballot sessions.]

In Experiment Y, all members of your group have two votes each. The other rules are the same as Experiment X.

You are asked to cast one vote as "your vote" and another vote as a "proxy vote on behalf of the subsequent groups" who cannot participate in your group's vote. You are free to decide whether to cast each of the two votes for A or B. The alternative that receives the more votes will be the decision of your group. If a tie happens, a lottery will determine which of the two alternatives is chosen.

[The following two paragraphs are presented in proxy sessions.]

In Experiment Y, out of the three members of your group, you have two votes while the other two members have one vote each.

You are asked to cast one vote as "your vote" and another vote as a "proxy vote on behalf of the subsequent groups" who cannot participate in your group's vote. You are free to decide whether to cast each of the two votes for A or B. The other two members are respectively asked to cast their votes for A or B. The alternative that receives the more votes will be the decision of your group. If a tie happens, a lottery will determine which of the two alternatives is chosen.

As in Experiment X, you will be asked to make voting decisions on all the cases that can arise.

When you make voting decisions, the two experiments are listed in random order. In other words, some participants make voting decisions in the order of "Experiment X → Experiment Y," while the other participants make voting decisions in the order of "Experiment Y → Experiment X."

You will find out where in a sequence of groups your group has been placed (i.e., first, second, and so on) on the form of paper handed out after the instructions.

(4) How to determine additional gratuities

Your additional gratuities will be determined in accordance with the following procedures.

[The following two steps are presented in ordinary/two-ballot sessions.]

[1] Either Experiment X or Experiment Y is randomly selected.

[2] The case that your group has faced is determined based on "the actual choices of the previous groups" in the selected experiment.

[The following two steps are presented in proxy sessions.]

[1] Out of the three members of your group, two members are assigned to Experiment X while one member is assigned to Experiment Y randomly.

[2] The case that your group has faced is determined based on "the actual choices of the previous groups."

[3] The votes of all the group members in that case will be counted, and the choice of your group is determined.

[4] The resulting gain is divided into three equal parts, and each part is given to each of your group members.

(5) Questionnaire

Once you have completed your voting decisions on all cases, you will receive a questionnaire from an experimenter and answer it.

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