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Accountability for future generations

Moinul Islam
Research Institute for Future Design, Kochi University of Technology
School of Economics and Management, Kochi University of Technology
Urban Institute, Kyushu University

Noriaki Hagimoto
School of Economics and Management, Kochi University of Technology

Raja R. Timilsina
Research Institute for Future Design, Kochi University of Technology
Asian Development Bank Institute

Koji Kotani
Research Institute for Future Design, Kochi University of Technology
School of Economics and Management, Kochi University of Technology
Urban Institute, Kyushu University
College of Business, Rikkyo University

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School of Economics and Management
Research Institute for Future Design
Kochi University of Technology

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Moinul Islam[*,†,‡] Noriaki Hagimoto[†] Raja R. Timilsina[*,§] Koji Kotani[*,†,‡,¶,‖]

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Abstract

Intergenerational sustainability (IS) is compromised because the current generation affects future generations, but the opposite is not true. This one-way nature tends to prevent the current generation from communicating with and taking accountability for their actions to future generations. While communication is known to mitigate some problems between parties, little is known about how intergenerational communication resolves some problems between the current and future generations. This research addresses how accountability among generations as a communication device promotes IS, hypothesizing that being accountable for future generations positively influences individuals in the current generation to take sustainable actions. We institute online intergenerational goods game (IGG) experiments via oTree with Python programming with two treatments, following Hauser et al. (2014) and Chen et al. (2016). In baseline IGG treatment, we prepare a sequence of generations, each consists of five individuals, and they are asked to choose their individual harvests where the resource is exhausted when the individual harvests' sum in the current generation exceeds some threshold, otherwise, the resource is replenished for the next generation. In intergenerational accountability (IA) treatment, individuals are additionally asked to be accountable by explaining the reasons of their harvest decisions and advice for future, passing the account to the next generation. We find that IA induces individuals to choose their harvests for being both intragenerationally and intergenerationally fair as well as for being intergenerationally sustainable.

Key Words: Intergenerational sustainability; Intergenerational accountability; Intergenerational goods game

[*]Research Institute for Future Design, Kochi University of Technology
[†]School of Economics and Management, Kochi University of Technology
[‡]Urban Institute, Kyushu University
[§]Asian Development Bank Institute
[¶]College of Business, Rikkyo University
[‖]Corresponding author, e-mail: kojikotani757@gmail.com

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1 Introduction

Achieving intergenerational sustainability (IS) is the most salient agenda for the existence of human civilization, and it is argued to be very challenging due to its one-way nature (Kamijo et al., 2017, Shahrier et al., 2017). The current generation affects future generations, but the opposite is not true, and the one-way nature tends to prevent the current generation from communicating with and taking accountability for their actions to future generations. The survival of human civilization is dependent on whether or not people can resolve the IS problems via enhancing cooperation across generations (Ehrlich et al., 2012, Steffen et al., 2015). To this end, it is essential to address intergenerational fairness regarding the quality of life between the current and future generations (Hunt and Fund, 2016). However, it is claimed that any economic and political institutions neither ensure intergenerational fairness nor sustainability. This research addresses how IS can be enhanced by introducing some institutions for communications among generations, conducting online intergenerational goods game (IGG) experiments developed by Hauser et al. (2014).

Several studies have used an experimental approach to examine individual and group behaviors as well as the decisions for IS considering different environments. Fischer et al. (2004) demonstrate that an existence of intergenerational links motivates an individual to exploit fewer resource in an intergenerational common pool resource experiment and enhances sustainability. Sherstyuk et al. (2016) analyze the level of difficulty for maintaining dynamic externalities over multiple generations by conducting climate change games. They find that controlling dynamic externalities is challenging under intergenerational settings because an individual make selfish decisions, as compared with non-intergenerational settings. To examine IS under group settings, Kamijo et al. (2017) design and implement the intergenerational sustainability dilemma game (ISDG) in a laboratory setting and show that introducing an agent for future generations named as an imaginary future generation (IFG) in a group decision process improves IS. Bosetti et al. (2022) focus on a channel to neutralizing negative intergenerational reciprocity. In an online experiment, authors identify that shifting decision makers' attention from the immediate past to the future is most effective in enhancing intergenerational beneficence decision.

A group of studies examines individual decisions for IS by employing some institutions with an experimental approach. Hauser et al. (2014) hypothesize that median voting is an institution that promotes IS, introducing a laboratory experiment in which subjects in the current generation can cooperate with future generations, called intergenerational goods games, i.e., IGGs. Authors identify that median voting promotes sustainability when a majority of individuals are prosocial. Lohse and Waichman (2020) conduct a replication IGG study in a laboratory with intragenerational punishment as an institution, identifying that the punishment is effective at sustaining the resource for multiple generations. Shahen et al. (2021) claim the necessity of an institution for inducing people to take a perspective of future generations as future ahead and back (FAB) mechanism, testing the effectiveness by implementing ISDG. They find that the FAB prevents individuals from choosing unsustainable actions, especially when IS is endangered. Koirala et al. (2021) institute a laboratory ISDG experiment of majority voting along with intragenerational deliberation as well as accountability. Authors show that accountability with majority voting enhances IS. Overall, IS is found to be largely affected by both environments and institutions.

Literature has identified how communications are effective or ineffective at resolving some problems. Crawford and Harris (2018) attempt to identify the impact of participation in group deliberations on individual preferences. Authors use a dictator game and a structural choice-revealed preference approach to measure individual preferences before and after face-to-face interactions in a group. They have identified that social interactions do change individual preferences. Koukoumelis et al. (2012) investigate how one way communication foster individuals cooperation. They use a linear public goods game with communication and notice that one-way communication significantly increases contributions to the public good. Cason et al. (2012) attempt to classify different types of communication that can change individual preferences to enhance or damage efficiency to resolve intragenerational problems. By using competitive coordination game, authors show that intra-group communication decreases while inter-group communication increase efficiency to resolve these problems. Timilsina et al. (2022) identify how intergenerational deliberation affects individual and collective decision for resolving intergenerational sustainability dilemma (ISD). By using an ISD game (ISDG) and a survey in urban an rural areas of a developing country, they do not recognize any impact of intergenerational deliberation for resolving ISD.

This study examine the impact of intergenerational accountability (IA) as a one-way communication device to facilitate connection within generations to among generations as well as from the current to the next generation in a sequence. We hypothesize that being accountable for future generations positively influences individuals in the current generation to take sustainable actions. By employing IGG suggested by Hauser et al. (2014), we implement an online experiment that identify the impact of IA to promotes IS. We specifically answer the following open questions: To become intragenerationally and intergenerationally fair and intergenerationally sustainable (i) Does IA induces individuals to choose their harvest decisions as a communication device? (ii) Do changes in individuals harvest decisions guide generations to achieve it? By answering these questions, our study identifies the potential of IA as an institution for enhancing IS.

2 Methods

2.1 Experimental procedures

Experiments are carried out online via oTree software which is based on the Python language (Chen et al., 2016). In total, 270 subjects participated in the experiments. One session consists of an intergenerational goods game (IGG), a social value orientation (SVO) game, a cognitive reflection test (CRT) and questionnaire surveys which comprised sociodemographic questions. We gather approximately 30 subjects and take about 45 minutes to complete one session. The subjects are recruited from the student subject pool of Kochi University of Technology (KUT), Kochi Prefectural University, Musashi University and Kyushu University. The online experiments are monitored via Zoom to secure the subjects' real-time participation.

One session includes sending out participant invitations and setting up a zoom meeting. At the beginning of each session, we verify a subject's identity, test internet connectivity and confirm browser compatibility to minimize distraction during the experiments. Subjects are asked to provide consent to participate in the experiments. Subjects can request clarification from the experimenters for a session. One treatment, baseline or IA, is randomly assigned to each session. After confirming the consent, the URL for the experiment was distributed to all subjects per session. Then, subjects read the instructions for IGG and answer quizzes for double-checking their understanding. We do not proceed to IGG unless the subjects correctly answer quizzes. Subjects fill up the SVO, the CRT and questionnaires after IGG. Finally, the subjects receive their payments with some experimental exchange rates according to their decisions. The payment for each subject is calculated as a summation of his/her earnings from the (i) showup fees 500 JPY, (ii) IGG with $1\text{point} = 50\,\text{JPY}$ ($\max = 1000\,\text{JPY}$) and (iii) SVO game, CRT and questionnaire survey (max = 1000 JPY). Each subject participated in only one session and received an average of 1950 JPY based on cumulative earnings. Figure 1 represents the flow chart of procedure for a subject to participate in the experiment.

[Figure 1 about here.]

IGG framework is a great simplification relative to real-world intergenerational cooperation. This study considers IGG as a preferable intergenerational game due to its fragile characteristics and recursive nature. In IGG, the selfishness of a subject can negatively affect subsequent generations. This behavior might lead a generation to the point of no return that abolishes access to the resource for the next generation. In contrast, a subject's unselfishness ensures the current generation's cooperation and benefits the succeeding generations. A mechanism that can positively impact resource conservation in such a fragile situation can be considered an effective treatment. The recursive nature of IGG facilitates the generation of the bootstrapping simulation data to validate the findings with the support of large-scale data.

2.2 Treatments

Two treatments were prepared: (1) baseline IGG and (2) intergenerational accountability (IA). We conducted 17 sessions for each treatment. Regarding baseline IGG treatment, we follow the basic design and procedure used by Hauser et al. (2014) for the purpose of replication and simplification to real-world intergenerational sustainability (IS) problems. This game utilizes basic features of public goods, common pool resources and threshold games. In IGG, five subjects randomly form a group and make decisions individually to determine their level of extraction from common pool resources. The groups formed by five subjects are referred to as generations in the experiments. A common pool resources of 100 units is endowed to the 1st generation per sequence, and each subject in the generation independently chooses the extraction level between 0 and 20 units from the resource pool. When the total extraction by a generation (subject harvests' sum in the generation) is equal to or below the threshold of $T = 50$, the resource pool is renewed to 100 units for the next generation. Otherwise, the resource pool is exhausted and the next generation in the same sequence cannot have any benefit of the resource pool, receiving zero payoff. In the experiments, the probability for the occurrence of the next generation is given by ρ and the probability of the generation ends is $1 - \rho$.

In baseline IGG treatment, we transfer resource pool across a sequence of generations with a discount factor of $\rho = 0.8$, i.e., an expected game length is five generations. In this way, we prepare a sequence of generations. As explained earlier, each generation consists of five subjects. Figure 2 and figure 3 show the processes of IGG in detail. The 1st generation is endowed with a resource pool of 100 points. Subjects are asked to choose their harvests between 0 to 20 points from the resource pool (figure 4). If the subjects in a group harvest a total of 50 points or less $T = 50$, the resource pool is replenished for the next generation, and then the next generation will have the opportunity to decide their harvests. In contrast, if the subjects in a group harvest 51 points or more, the resource pool is considered to be exhausted and the next generation receives no resources. After the resource-harvesting decision, the generation picks a computerized lottery out of a bag consisting of four white chips and one red chip. The game proceeds to the next generation in the same sequence if a white chip is picked. Otherwise, the sequence terminates.

[Figure 2 about here.]

[Figure 3 about here.]

[Figure 4 about here.]

A dominant strategy and a Nash equilibrium (NE) strategy in IGG for each subject choose extraction level to max 20 because it maximizes his/her payoff, irrespective of how other members in a generation make an extraction. All allocations in IGG are Pareto optimal intergenerationally because every allocation cannot be Pareto improved by any other feasible allocation. However, there exists a unique allocation that leads to sustainability and maximizes the sum of payoffs for all the generations (i.e., social welfare). The socially desirable allocation shall be when every generation keeps choosing ten and maintains sustainability by maximizing the sum of payoff for all generations by replenishing the resource pool. Each generation has to extract 50 units or less $T = 50$ to sustain resources over multiple generations. Thus, the socially efficient extraction of "fairness" is ten units per subject on average.

Firstly, we are interested in how voluntary cooperation emerges in multigenerational dilemmas like IGG. Next, we are interested in an institution that can facilitate the emergence of cooperation without any centralized enforcement or any punishment mechanism. In particular, we focus on an institution that does not require centralized enforcement since this type of enforcement may not be feasible all time and to be global or transnational in scope, and punishing others is also costly (Lohse and Waichman, 2020). Therefore, our focus is on identifying the mechanism for symmetric strategies that concentrate on subject harvests of 10 or fewer units as cooperators for sustaining the resources.

A new mechanism called "intergenerational accountability" (IA) is instituted as a treatment to improve IS. With the IA treatment, subjects asked to provide the reasons behind the decision as well as any advice to future generations that shall be passed to subsequent generations. We ensure that each subject account is passed to the next generation in the same sequence. It is hypothesize that IA treatment will be effective at maintaining IS in IGG through one-way communication from the current generation to subsequent generations by being accountable. Our idea is partly inspired by the previous literature, such as Schotter and Sopher (2003, 2006, 2007), Chaudhuri et al. (2006) and Chaudhuri et al. (2009). "Reasons" and "advice" are two important factors in accountability that makes it credible for social communication with self-governance. In this research, IGG represents sustainability problems, such as global climate change, with a long-run perspective of non-overlapping generations. No previous literature has systematically examined how reasons and advice effectively resolve sustainability problems under non-overlapping generations. At the same time, some studies mention that offering reasons and advice to the public and responding to them may induce citizens to manifest their commitment to justice (Ortmann and Gigerenzer, 1997, Rawls, 1999, Schedler et al., 1999, Hadfield and Macedo, 2012, Kogelmann and Stich, 2016, Caney, 2018).

Social value orientation (SVO) game and questionnaire

SVO is considered a good approximation of subject social preferences in relation to other people. SVO framework assumes that people have different motivations and goals for evaluating resource allocations between oneself and others. Additionally, SVOs are established to be stable for a long time (See, e.g., Van Lange et al., 2007, Brosig-Koch et al., 2011, Carlsson et al., 2014, Sutter et al., 2018). Thus, SVO helps to understand what types of people consider about future generations while making a decision under ISDG. SVO game with the "slider method" elicits the responses to six primary items from each subject and identifies the subject as either prosocial or proself (See, e.g., Murphy et al., 2011, for the details). The decisions for this SVO game are made with complete privacy as subjects are instructed not to communicate with each other. The decision maker and the other person will remain mutually anonymous while and after the decision is made. Such anonymity removes the potential influence of fear of reprisal, reciprocity and reputation concern. We use the slider method because it is easy and intuitive for subjects to understand even with a limited level of education.

We simplify the four categories of social preferences into two categories of prosocial and proself types: "altruist" and "prosocial" types are categorized as prosocial subjects, while "individualistic" and "competitive" types are categorized as "proself" subjects (Murphy et al., 2011). Figure 5 shows the six items on the slider measure that uses numbers to represent the outcomes for oneself and the other in a pair of persons where the other is unknown to the subject. Subjects are asked to make a choice among the six options for each item. Each subject chooses an allocation by marking a line at the point that defines his or her most preferred distribution between oneself and the other. The mean allocation for oneself $\overline{A}_s$ and the mean allocation for the other $\overline{A}_o$ are computed from all six items (See figure 5). 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 SVO is given by $\mathrm{SVO} = \arctan\frac{(\overline{A}_o)-50}{(\overline{A}_s)-50}$.

Depending on the values generated from the test, social preferences are categorized as follows: (i) altruist: SVO $> 57.15°$, (ii) prosocial: $22.45° <$ SVO $< 57.15°$, (iii) individualist: $-12.04° <$ SVO $< 22.45°$ and (iv) competitive: SVO $< -12.04°$. Respondents are informed that the units in this game are points, meaning that the more points they accumulate, the more real money they will earn. To compute the payoffs of the subjects, we collect the answer sheets from all subjects in a session and randomly make a pair. The payoff for each subject in SVO game is the summation of points from 6 selections by him- or herself as "you" and 6 selections by the partner as "other." We explain the payoff calculation with the exchange rate for the real money to subjects before starting SVO game. After the SVO game finishes, subjects proceed with answering the questionnaire surveys for their sociodemographic information. An exchange rate is applied to the points in the SVO game to determine the monetary reward and subjects have received a maximum of 1000 JPY and 900 JPY on an average. The SVO game with the slider method has been utilized to identify each subject as either prosocial or proself (Murphy et al., 2011). Figure 5 shows six slider measure items that give numbers to represent outcomes for oneself and the other in a pair of persons. Subjects are asked to choose among the six options for each item. Each subject chooses her allocation by marking a line at the point that defines her most preferred distribution between oneself and the other.

[Figure 5 about here.]

Cognitive Reflection Test (CRT)

Following Frederick (2005), this study uses a three-item CRT. This is a simple measure of one type of cognitive ability. The CRT score is considered to be correlated with impulsivity, performance in rational thinking tasks and inhibition of intuitive thinking (Campitelli and Gerrans, 2014, Frederick, 2005, Thomson and Oppenheimer, 2016, Toplak et al., 2014). Subjects who can correctly answer the CRT questions have a high probability of utilizing deliberate thinking processes. The notion that more intelligent people are more patient does not devalue or "discount" future rewards. Frederick (2005) identify that the CRT was generally more "patient", their decisions implied lower discount rates. For short-term choices between monetary rewards, the high CRT group was much more inclined to choose the later larger reward. However, temporal preferences were weakly related or unrelated to CRT scores for choices subject longer horizons. In the domain of risk preferences, there is no widely shared presumption about cognitive ability influences.

3 Results

Table 1 presents the definitions of the variables for subject level and generation level. Table 2 shows the summary statistics of the 270 subjects in this experiment. In total 115 subjects receive baseline and 155 subjects receive intergenerational accountability (IA) treatment. Our baseline data shows that approximately 57 % of the student subjects are cooperators. This finding is in line with Hauser et al. (2014) which identify that 68 % of non-student individuals are cooperators. The proportion of the prosocial subjects in baseline and IA are approximately 37 % and 54 %, respectively. With respect to cognitive reflection test (CRT), approximately 44 % and 36 % of subjects correct all questions. Figure 6(a) shows the frequency distributions of the subject harvests. The baseline frequency distribution implies that 30 % of subjects choose 10 points and 23 % subjects choose 20 points. On the other hand, IA frequency distribution shows that 52 % individuals choose 10 points and 18 % individuals choose 20 points. We draw the corresponding box plots in Figure 6(b) for baseline and IA. The medians are equal between baseline intergenerational goods game (IGG) and IA. However, the variations or variances are clearly different between them. We run a non-parametric variance test (Fligner-Killeen test) with the null hypothesis that the variances between baseline and IA are identical. The null hypothesis is rejected at 1 % significant level (Chi-squared = 6.9234, p-value = 0.009).

[Figure 6 about here.]

[Table 1 about here.]

[Table 2 about here.]

Table 3 summarizes the estimation results and the associated marginal probabilities from the three logistic regressions. The dependent variable in these regressions is the dummy variable that takes unity when a subject harvests 10 points, otherwise zero. We use this dummy variable as a dependent variable for the analysis based on the summary statistics, histograms and boxplots regarding subject harvests in IGG. Model 1 shows that the coefficient and the marginal probability of IA dummy is statistically significant at 1 % level. More specifically, the subjects in the IA treatment are approximately 22 % likely to take intergenerationally sustainable action than those in the baseline. The results can be interpreted that IA influences subjects to take intragenerationally and intergenerational fair as well as intergenerationally sustainable. Harvesting 10 points is the only one among all possible actions to be so.

[Table 3 about here.]

To check the robustness of our regression results, we include different explanatory variables in model 2 and 3 to demonstrate how subjects behave differently under the baseline IGG and IA. In model 2 we identify the impact of IA and next generation dummy on the subject harvest of 10 points. The impact of IA and the next generation dummy variable are statistically significant. We test the impact of the interaction of these variables and it is not statistically significant. Therefore, we do not include it in further analysis. Besides the variables in model 2, model 3 identifies the impact of the prosocial dummy variable, which is not statistically significant. The impact of the cognitive ability on the dependent variable is positive and statistically significant at 10 % level. The impacts of the female dummy and urban dummy are not statistically significant. Models 1, 2 and 3 consistently show that all the coefficients and the marginal probabilities of IA dummy are statistically significant.

To illustrate how subject harvests contribute to sustaining the generations, we conduct bootstrap simulation, which is a resampling method to approximate the probability of how many generations continue per sequence out of the samples we have. Figure 7 reports the bootstrap simulation results of 10 000 sequences created by randomly sampling five subjects out of the samples in the 1^{st} generation as well as the next generation to simulate how many generations sustain a resource per sequence. Approximately 16 % of the sequences in the baseline is simulated to sustain a resource up to the 2^{nd} generation. On the other hand, about 26 % of the sequences in IA is simulated to sustain a resource up to the 2^{nd} generation. Likewise, approximately 4 % of the sequences in baseline sustain a resource up to the 3^{rd} generation. About 10 % of the sequences in IA sustain a resource up to the 3^{rd} generation. The probability of generation continuation almost doubles in IA as compared to baseline. The bootstrap simulation results demonstrate that IA has enough impact on sustainability even at generational level.

[Figure 7 about here.]

Using the data generated from the bootstrap simulation, we run the generation level regression and report in table 4. We simulate 10 000 sequences for each treatment by utilizing the 1^{st} generation and the next generation information. We observe significant positive impact of IA on conserve resources at generation level. Model 1, 2 and 3 are used to check the robustness of IA impact on generation level outcome variable. The impact of IA is significantly positive in all three models. The results conclude that approximately 12 % generations sustain common pool resources for the next generation under partial IA, compared to the baseline treatment.

[Table 4 about here.]

In model 1 of table 4, we consider the basic independent variables, consisting of IA dummy, finding that the coefficient and marginal probabilities of the variable is statistically significant at 1 % level. More specifically, generations in IA treatment are 12.2 % more likely to choose sustainable harvest option than those in the baseline IGG treatment. IGG is highly fragile and one defector can make the generation unsustainable by harvesting all available resources. In such sensitive conditions, IA impact to increase the possibility of resource consrvation by 12 % is impressive. In model 2, we include the next generation dummy as well as interaction terms for IA treatment dummy and the next generation dummy. The estimation results of IA remain qualitatively the same as those in model 1. The coefficient and marginal probability of next generation dummy is positive and statistically significant at 1 % level. Therefore the next generation is 3.5 % more likely to choose sustainable resource harvest decision than the 1st generation.

The interaction term of IA treatment dummy and next generation dummy is statistically significant at the 1 % level with a negative sign in model 2. The marginal probability of the the interaction results imply that the first (next) generation of accountability treatment is likely to conserve resources by 12.3% (8.2%) as compared to the first generation in baseline (accountability) treatment. In addition, the next generation in baseline (accountability) treatment is likely to conserve resources by 8.8% (4.7%) as compared to the first (next) generation in baseline treatment. This results imply that accountability treatment have strong effect as generation proceed in a sequences from first to next generation. However, when sequence proceed to next generation irrespective to treatments, the difference of treatment impacts is going to be small. Therefore, intersequence comparison in next generation between treatments are tiny or insignificant. We apply model 3 including different specifications and other interaction terms as robustness checks, yielding qualitatively similar results to those in models 1 and 2 of table 4. Model 3 shows that generations that consist of full CRT score are not likely to conserve the resource. However, the dominance of female subjects in a generation ensures resource conservation.

To measure the impact of the treatment on the generation level and to test the robustness between individual and generation level results, we run the generation level regression by using bootstrap data. In an IGG game, a subject is randomly allocated to either the first or the non-first generation. In addition, a subject in the first generation and a subject in the non-first generation receive different sets of information in a sequence. We address these recursive nature of IGG and conduct a set of bootstrap simulations using the data generated by our participants to overcome the limited number of sequences generated from the observed subjects harvest data. We run the logistic regression based on the bootstrap simulation that generates the number of sustained generations in 10 000 sequences for each treatment. We also run the bootstrap simulattion for 100 000 and 1 000 000 generations to test the convergence of our results and identify the qualitatively same impacts of the treatments. Overall, this simulation further supports our results of the considerable increase in sustained generations.

The bootstrap simulation starts by randomly sampling a sequence of the generation that consists of five individuals and their harvests are summed up. The resource of this sequence is exhausted when the the sum of individual harvests in the current generation exceeds some threshold; otherwise, the resource is replenished for the second generation. To identify whether this resource pool will be transferred to the second generation in the same sequence or not, we implement a lottery with 80% probability of white chip to confirm the continuation of a generation. After the lottery, we randomly select five subjects from the non-first generations if the generation qualifies to reach the second generation. Whether the second generation subjects can make a harvest decision depends upon the type of resource pool they have received from the first generation. If the second generation receives an empty resource pool, they will not be able to make any harvest decisions and the sequence will end. In contrast, if the second generation receives a replenished resource pool, the third generation will be constructed and the previous steps will continue. The continuation of the generation in a sequence will not end until the lottery outcomes become a red chip (20% probability) or a generation replenished resource pool.

Intergenerational accountability (IA) tends to maintain intergenerational sustainability (IS), indicating that one-way communication from the current generation to future generations performs for several causes. The 1st possible cause is that IA activates the "pay-it-forward"[1] reciprocity that makes the current generation to anticipate about future generations (Ariely et al., 2009). Pay-it-forward reciprocity is considered to be responsible for large-scale cooperation in human societies. This leads people to cooperate with others for non-economic and non-reputational benefits. The 2nd possible cause why IA can perform is the "guilt-aversion" which states that people feel guilty if their behaviors fall short of others' expectations. In the guilt aversion hypothesis, people care about what others expect of them, feeling guilty if their behavior falls short of expectations. Economic literature suggest that people care about guilt aversion and it has theoretical implications for strategic behavior (Battigalli and Dufwenberg, 2007, Dana et al., 2007). The 3rd possible cause is that IA function as a social device to raise "empathy" and "sympathy" beyond self-interest motives across generations through a one-way communication channel (Haidt, 2004, Chen et al., 2019). Arrow et al. (2004) conclude that intergenerational fairness is difficult to achieve without having empathy and sympathy concern towards future generations. The sense of empathy and sympathy in the current generation about others is essential to changing subject and group behaviors in favor of future generations.

The unique feature of IA to resolve the challenges to achieve IS inherited in its decentralized characteristics. In past literature, median voting (Hauser et al., 2014), peer punishment (Lohse and Waichman, 2020) are suggested as institutions to enhance cooperation to ensure IS. These are great institutions that allows a majority of cooperators to restrain a minority of defectors and ensure IS. However, in reality, these institutions either require centralized enforcement or costly for one party to monitor their peer's behaviors for punishing and thus, end up being less effective or economic efficiency loss. In contrast, IA is a decentralized and nonenforcing mechanism that can be implemented irrespective of central enforcement. It simply depends on the critical thinking process of reasons and advice. Although it is not a very strong enforcement mechanism to prohibit the defectors from making selfish decisions, IA can be considered as a self-governance mechanism which is suggested by Ostrom et al. (1992). The success of median voting and peer punishment

[1]Humans often forward kindness received from others to strangers, a phenomenon called the upstream or pay-it-forward reciprocity (Horita et al., 2016).

mechanism hypothesizes the existence of the majority of prosocial people in society. The presence of prosocial people in group decision making may not be realistic in the context of different development stages of the countries. The increasing number of proself people in many developing economies is the reality, and leading these people to take the IS decision is critical. In this context, IA induces people to take IS decisions voluntarily irrespective of their prosocial or proself identity. Moreover, it does not require any group decision and performs at subject level.

4 Conclusion

This paper has explored how accountability among generations as a communication device promotes intergenerational sustainability (IS). We hypothesize that being accountable for future generations positively influences an individual in the current generation to take intergenerationally sustainable actions. This study institute online IGG experiments via oTree with Python programming to test the hypothesis. The findings show that intergenerational accountability (IA) induces an individual to choose the harvest for being both intragenerationally and intergenerationally fair as well as for being intergenerationally sustainable. Individuals are gradually becoming the primary stakeholders in each nation. Individual actions and decisions tend to considerably impact collective problems, such as climate change and intergenerational problems, irrespective of the central authorities' interventions. The current democratic system with only majority voting may not effectively maintain IS due to its dependence on centralized authorities. IA is a mechanism that virtually creates the network to report the reasons and advice of choices for subsequent generations. It can perform based on voluntary participation and without the central authorities' intervention or in a decentralized fashion. IA can be considered one possible institution that induces individuals to take intragenerationally and intergenerationally fair and intergenerationally sustainable actions voluntarily.

We note some limitations and future avenues of our study. Our sample is concentrated on the student subject pool of Japanese universities. Field experiments in the future should collect general individuals to address the external validity of our experimental results. This experiment might not give the chance to understand how IA induces individuals to choose intergenerational sustainable resource harvests. A qualitative and deliberative analysis will be beneficial to understand how reasons and advice induce individuals to reach a decision for intergenerationally sustainable actions. Follow-up research should be able to examine where the differences come from, considering psychology, culture and other relevant factors. These caveats notwithstanding, it is our belief that this paper is an important step in understanding individual behaviors in IGG and suggests a possible mechanism to enhance IS, such as IA.

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List of Figures

Figure 1: A flow chart of procedures for subjects to participate in one session

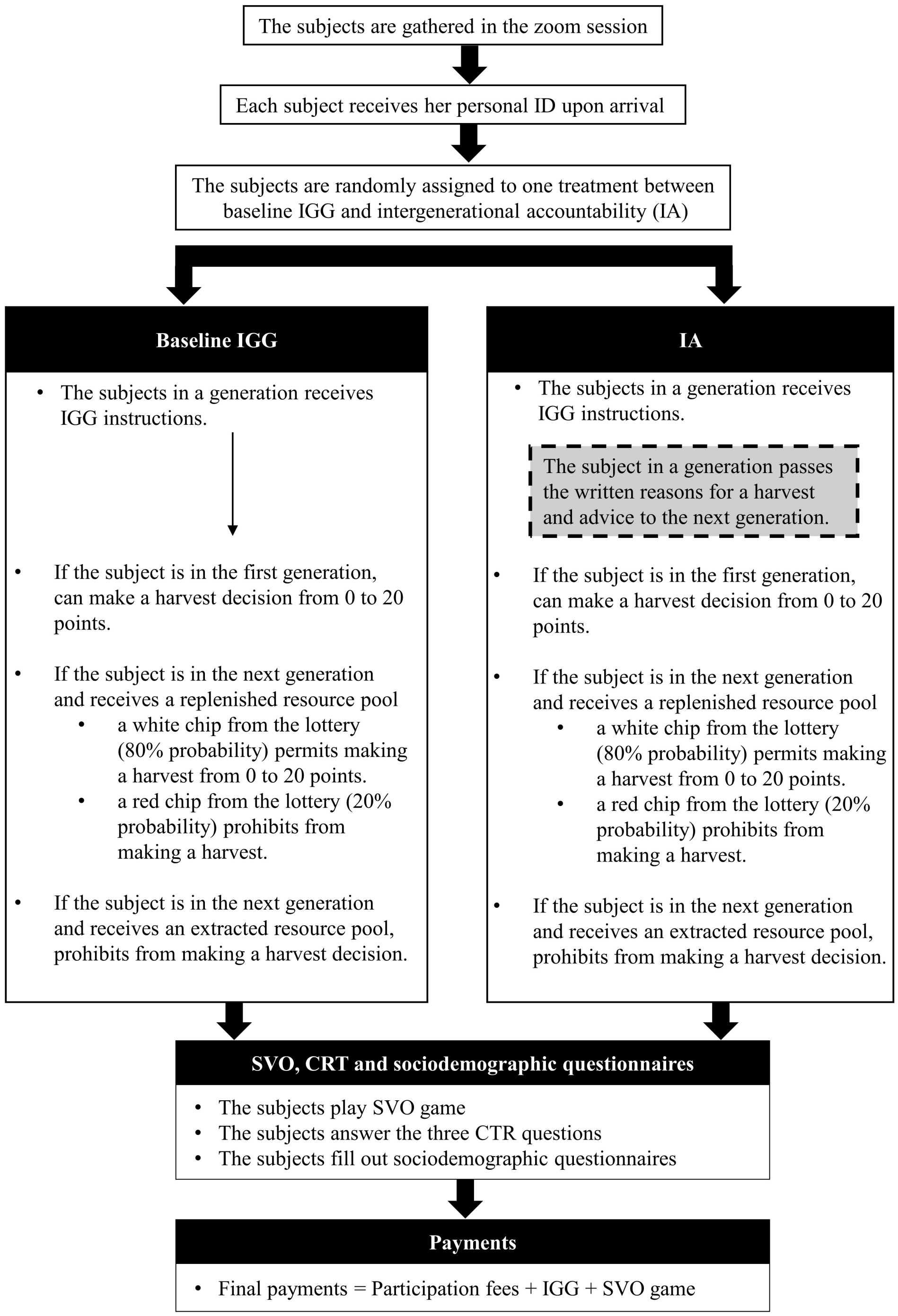


Figure 2: The experimental design

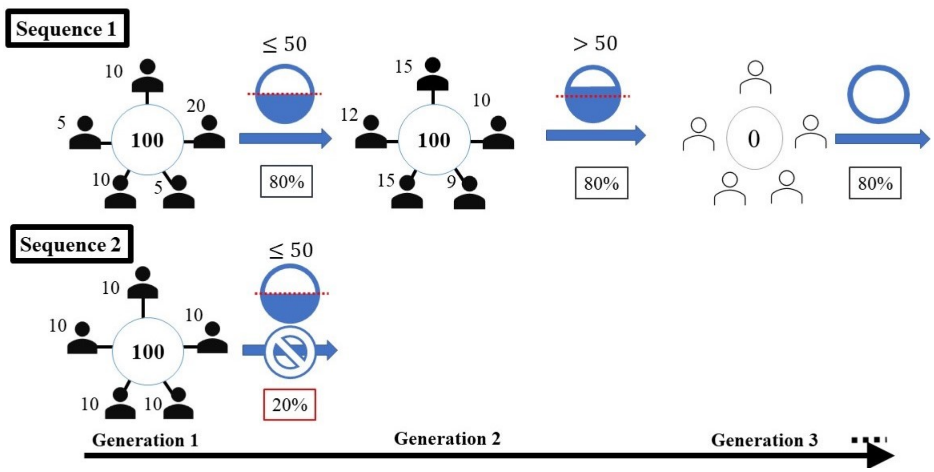


Figure 3: Procedure of the intergenerational goods game (IGG) per sequence in a session

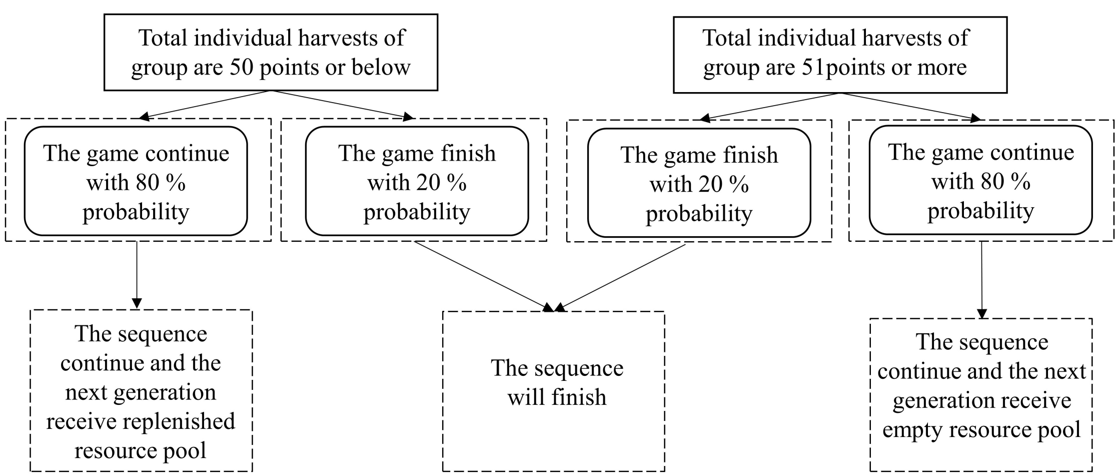
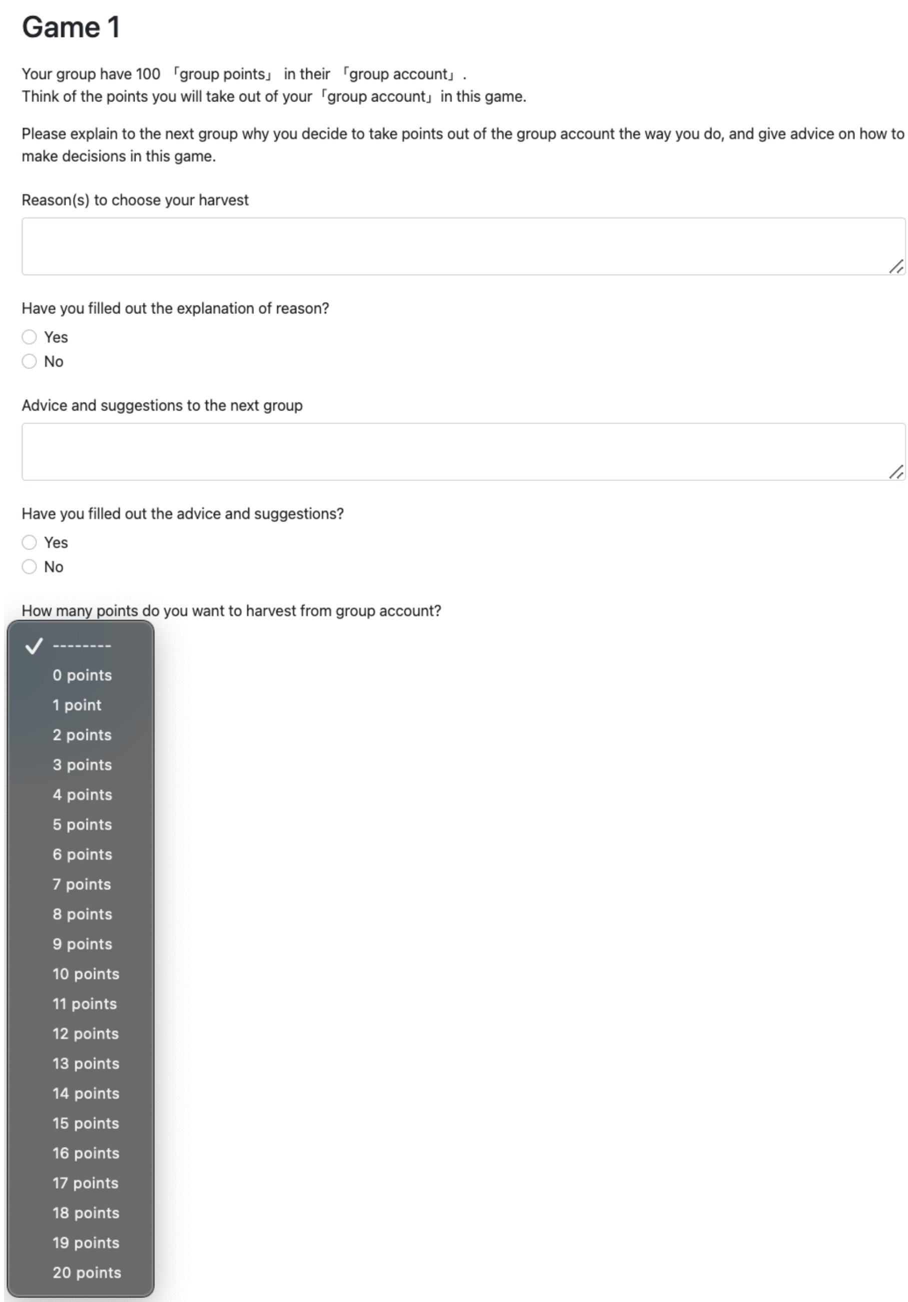


Figure 4: The decision-making screen for the 1st generation in IA treatment


Game 1

Your group have 100 「group points」 in their 「group account」.
Think of the points you will take out of your「group account」in this game.

Please explain to the next group why you decide to take points out of the group account the way you do, and give advice on how to make decisions in this game.

Reason(s) to choose your harvest

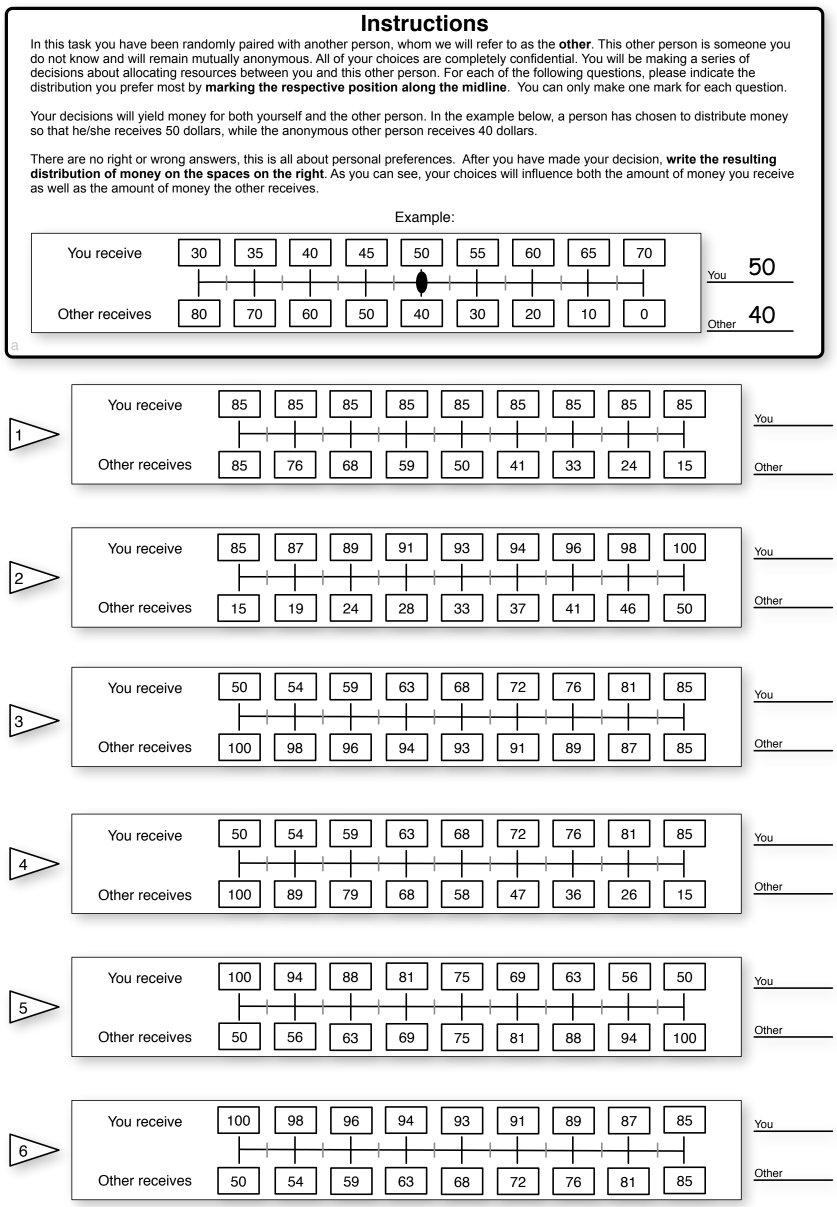
Have you filled out the explanation of reason?
Yes
No

Advice and suggestions to the next group

Have you filled out the advice and suggestions?
Yes
No

How many points do you want to harvest from group account?
----
0 points
1 point
2 points
3 points
4 points
5 points
6 points
7 points
8 points
9 points
10 points
11 points
12 points
13 points
14 points
15 points
16 points
17 points
18 points
19 points
20 points

Figure 5: Instructions of the slider method for measuring social value orientation (Murphy et al., 2011)



Instructions

In this task you have been randomly paired with another person, whom we will refer to as the **other**. This other person is someone you do not know and will remain mutually anonymous. All of your choices are completely confidential. You will be making a series of decisions about allocating resources between you and this other person. For each of the following questions, please indicate the distribution you prefer most by **marking the respective position along the midline**. You can only make one mark for each question.

Your decisions will yield money for both yourself and the other person. In the example below, a person has chosen to distribute money so that he/she receives 50 dollars, while the anonymous other person receives 40 dollars.

There are no right or wrong answers, this is all about personal preferences. After you have made your decision, **write the resulting distribution of money on the spaces on the right**. As you can see, your choices will influence both the amount of money you receive as well as the amount of money the other receives.

Example:

You receive	30	35	40	45	50	55	60	65	70
Other receives	80	70	60	50	40	30	20	10	0

You 50
Other 40

1

You receive	85	85	85	85	85	85	85	85	85
Other receives	85	76	68	59	50	41	33	24	15

You ____
Other ____

2

You receive	85	87	89	91	93	94	96	98	100
Other receives	15	19	24	28	33	37	41	46	50

You ____
Other ____

3

You receive	50	54	59	63	68	72	76	81	85
Other receives	100	98	96	94	93	91	89	87	85

You ____
Other ____

4

You receive	50	54	59	63	68	72	76	81	85
Other receives	100	89	79	68	58	47	36	26	15

You ____
Other ____

5

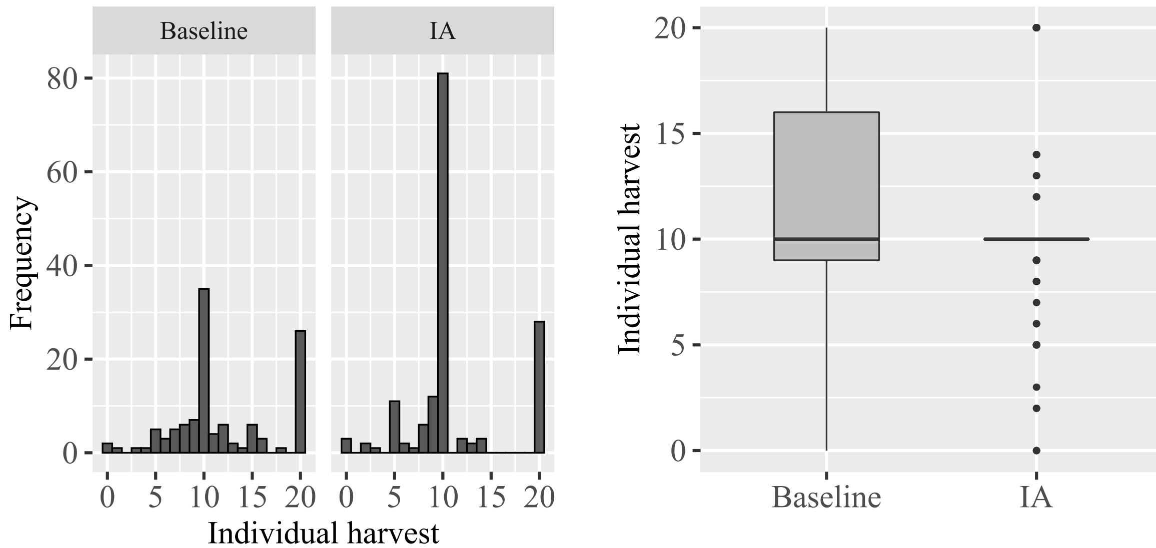
You receive	100	94	88	81	75	69	63	56	50
Other receives	50	56	63	69	75	81	88	94	100

You ____
Other ____

6

You receive	100	98	96	94	93	91	89	87	85
Other receives	50	54	59	63	68	72	76	81	85

You ____
Other ____

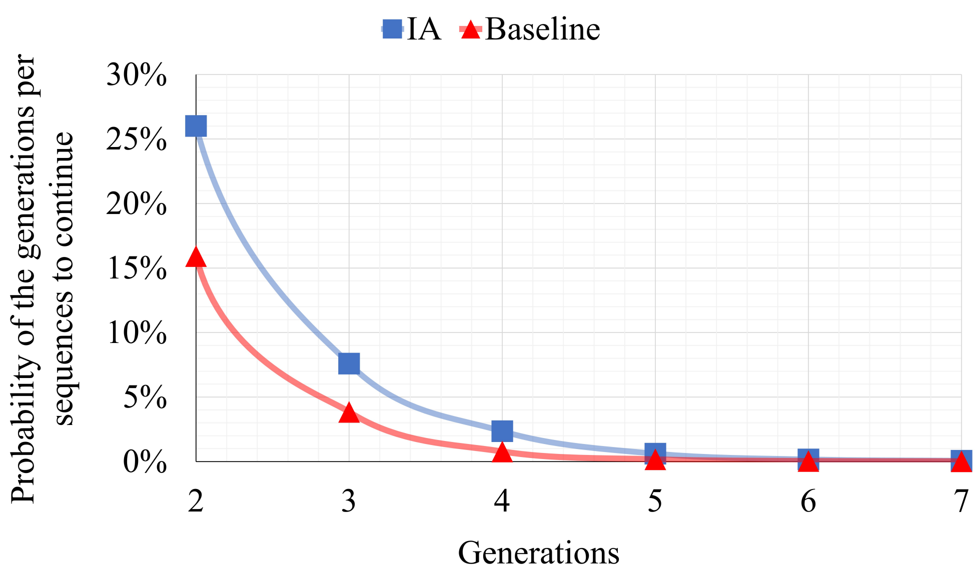


(a) Frequency distributions of the percentage of subject harvests from 0 to 20 points

(b) Boxplots of the choice of subject harvest in the basic IGG and IA treatments

Figure 6: The distribution of the choice of subject harvest in the baseline IGG and IA treatments

Figure 7: Number of generations that sustain a resource per sequence based on 10 000 bootstrap sequences



List of Tables

Table 1: Definitions of the variables

Variables	Definitions of the variables included in regressions
Variables at subject level	
Subject harvest	A variable that represents the subject harvest from the resource pool of 0 to 20 points.
Subject harvest 10 points	A dummy variable that takes 1 if the subject harvests 10 points; otherwise, 0.
Intergenerational accountability (IA)	A dummy variable that takes 1 if the subject is assigned to IA; otherwise, 0.
Prosocial	A dummy variable that takes 1 if the subject is identified as prosocial; otherwise, 0.
Next generation	A dummy variable that takes 1 if the subject is not in 1^{st} generation; otherwise, 0.
CRT full score	A dummy variable that takes 1 if the subject corrects all questions of CRT; otherwise, 0.
Female	A dummy variable that takes 1 if the subject is female; otherwise, 0.
Urban	A dummy variable that takes 1 if the subject lived in the urban area; otherwise, 0.
Variables at generation level	
Conserve resource	A dummy variable that takes 1 when a generation harvests less or equal to 50 points; otherwise, 0.
Intergenerational accountability (IA)	A dummy variable that takes 1 if the generaiton is assigned to IA; otherwise, 0.
Next generation	A dummy variable that takes 1 if the generation is not the 1^{st}; otherwise, 0.
No. of subjects with CRT full score	Sum of CRT scores among the members per generation.
No. of female subjects	A number of female subjects in each generation.

Table 2: Summary statistics

Variables	Baseline (115)					IA (155)				
	Mean	SD	Median	Min	Max	Mean	SD	Medain	Min	Max
Subject harvest	11.991	5.251	10	0	20	11.039	4.794	10	0	20
Subject harvest 10 points	0.304	0.462	1	0	1	0.523	0.501	1	0	1
Prosocial	0.374	0.486	0	0	1	0.536	0.500	1	0	1
Next generation	0.261	0.441	0	0	1	0.452	0.499	0	0	1
CRT full score	0.443	0.499	0	0	1	0.361	0.482	0	0	1
Female	0.391	0.490	0	0	1	0.374	0.485	0	0	1
Urban	0.139	0.348	0	0	1	0.277	0.449	0	0	1

Table 3: Regression coefficients and marginal probabilities of the independent variables in the subject level logit regressions

	Model 1		Model 2		Model 3	
	Coefficient	MP	Coefficient	MP	Coefficient	MP
IA (Base group = Non-IA)	0.917***	0.224***	0.811***	0.198***	0.839***	0.205***
	(0.259)	(0.063)	(0.265)	(0.065)	(0.275)	(0.067)
Next generation (Base group = First generation)			0.646**	0.158**	0.672**	0.164**
			(0.263)	(0.064)	(0.270)	(0.066)
Prosocial (Base group = Proself)					0.092	0.023
					(0.265)	(0.065)
CRT full score (Base group = Not CRT full score)					0.455*	0.111*
					(0.274)	(0.067)
Female (Base group = Male)					−0.200	−0.049
					(0.273)	(0.067)
Urban (Base group = Rural)					0.024	0.006
					(0.311)	(0.076)
Constant	−0.827***		−1.010***		−1.192***	
	(0.203)		(0.223)		(0.306)	
Number of observations	270		270		270	
Wald chi2	12.52		17.58		20.49	

***significant at 1 percent level
**significant at 5 percent level
*significant at 10 percent level
MP stands for marginal probability.
Robust standard errors are reported in the parenthesis.

Table 4: Regression coefficients and marginal probabilities of the independent variables in the generational level logit regressions

	Model 1		Model 2		Model 3	
	Coefficient	MP	Coefficient	MP	Coefficient	MP
IA (Base group = Non-IA)	0.610***	0.122***	0.802***	0.117***	0.715***	0.108***
	(0.030)	(0.006)	(0.059)	(0.004)	(0.157)	(0.017)
Next generation (Base group = First generation)			0.264***	0.035***	0.157***	0.017***
			(0.031)	(0.004)	(0.034)	(0.004)
IA × Next generation			−0.165***		−0.134***	
			(0.038)		(0.041)	
IA						
First generation				0.123***		0.117***
				(0.006)		(0.006)
Next generation				0.082***		0.072***
				(0.013)		(0.012)
Next generation						
Non-IA				0.088***		0.055***
				(0.011)		(0.011)
IA				0.047***		0.010
				(0.009)		(0.009)
Number of subjects with CRT full score					−0.070***	−0.014***
					(0.014)	(0.003)
Number of female subjects per generation					0.215***	0.043***
					(0.014)	(0.003)
Constant	−1.294***		−1.386***		−1.624***	
	(0.024)		(0.025)		(0.052)	
Number of observations	25 754		25 754		25 754	
Wald chi2	408.90		547.98		817.84	

***significant at 1 percent level
**significant at 5 percent level
*significant at 10 percent level
MP stands for marginal probability.
Clustered standard errors are reported in the parenthesis.
10 000 sequences per treatment by bootstrap simulation.