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When money is not enough: awareness of future generations drives sustainable development

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How can we encourage sustainable choices even though they yield scarce gains for the current generation? Monetary incentives and concerns for future generations are argued to have far-reaching effects on sustainable behaviours, they are at the backbone of current policy frameworks and climate change campaigns. Yet, there is a scarcity of causal evidence assessing the effectiveness of these interventions in overcoming the social dilemma at the core of sustainable choices. These theoretical arguments have been tested separately and with different samples, often using observational data and with a stronger focus on attitudinal rather than behavioural changes. Here, we jointly test these theoretical arguments and assess the impact of monetary incentives and intergenerational awareness on the emergence of sustainable behaviours in two large pre-registered between-subjects experiments ($N_1 = 1{,}167$; $N_2 = 1{,}093$) where participants played a discrete Common Pool Resource dilemma. Results show that being aware that there is a future generation which is affected by current decisions increases the chances to achieve sustainable development, while moderate monetary incentives alone do not accomplish such outcome. However, the combined presence of intergenerational awareness and monetary incentives is the most effective intervention to increase sustainable behaviours and achieve sustainable development.

Introduction

The excessive use of carbon resources for developmental purposes is at the core of anthropogenic climate change (Santer *et al.*, 2003; Nasa, 2021). As the emissions produced by the use of these resources surpass the carbon absorption capacity of the planet, the greenhouse gas concentration in the atmosphere increases, drastically changing the Earth's ecosystems and depleting natural resources—e.g. reduced water supplies, agricultural and forest damage (IPCC, 2013; USGCRP, 2017; Nasa, 2020; Wang *et al.*, 2020). Finding a way to promote sustainable development (i.e. development that meets the needs of the present without compromising the ability of future generations to meet their own needs, Brundtland, 1985; United Nations, 1987) is one of the focal points in public debates on climate change[1]: governments are pressured to implement policies favouring the environment and cleaner technologies (e.g. investments in low-carbon power sources—Kumar, 2018), while the general public is encouraged to make sustainable choices (e.g. reduce the consumption of red meat and dairy products or the purchase of diesel cars—USGCRP, 2017; Gaind, 2019; Schiermeier, 2019; IPCC, 2023). Yet, sustainable options are often costly to individuals and returns are only visible in the long-run or to future generations, making them unappealing or even unaffordable to parts of the population (Milinski *et al.*, 2006; Milinski *et al.*, 2008; Ponte *et al.*, 2017; Kline *et al.*, 2018). The dilemma that we face is therefore the following: given the necessity to promote

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sustainable development, how can we encourage individuals to consistently opt for sustainable options that yield scarce gains for the current generation?

Several mechanisms have been tested to encourage this behavioural shift towards sustainable options, including financial incentives, information-based interventions, social comparison messages, and appeal campaigns, among others (Nisa *et al.*, 2019; Vlasceanu *et al.*, 2024). In this paper, we test the causal impact of two distinct mechanisms on the emergence of sustainable behaviours, that is, financial incentives and intergenerational awareness, assessing the effectiveness of these interventions in overcoming the social dilemma at the core of such choices. To this end, we manipulate the presence of monetary incentives and participants' awareness of intergenerational transmission of resources. By doing so, we assess whether, and how, each of these interventions, alone as well as in combination, can encourage individuals to opt for the sustainable option.

Theoretical background

The conundrum of sustainable development is often formalized as a Common Pool Resource (CPR) dilemma (Gardner, Ostrom, and Walker, 1990; Kline *et al.*, 2018), where individuals can gain wealth through the appropriation of resources from a common pool, which has a certain replenishment rate (Ostrom, 1999; Walker *et al.*, 2000; Dietz, Ostrom, and Stern, 2003; Anderies *et al.*, 2011; Bernard *et al.*, 2013; Fennewald and Kievit-Kylar, 2013). Behavioural experimental research shows that individuals tend to rapidly exhaust resources in CPR dilemmas, favouring short-term over long-term gains (Janssen *et al.*, 2010; Bernard *et al.*, 2013; Ponte *et al.*, 2017; Kline *et al.*, 2018).

Incentive-based theoretical arguments (Khanna *et al.*, 2021), which rely on a rational model of human behaviour and are often followed in large-scale policy interventions (Cansino *et al.*, 2010), suggest that sustainable behaviours could be encouraged by providing monetary rewards when choosing green—e.g. via government funds to promote the purchase of electric cars, heat pumps, etc. (Lossin *et al.*, 2016; Berger, 2019): by increasing short-term gains for more environmentally friendly goods, individuals should be encouraged to make sustainable choices (Abrahamse *et al.*, 2005; Lossin *et al.*, 2016; Sudarshan, 2017). Effective incentives could allow a society to save enough resources for the next generation without requiring its population to share the same environmental goals or concerns, hence sustainable development would be achieved as an unintended by-product of an economic stimulus. However, monetary incentives can only partially offset the short-term advantages of unsustainable options and have several drawbacks in the long-run (Abrahamse *et al.*, 2005; Cairns, Newson, and Davis, 2010; Bolderdijk and Steg, 2015; White, Habib, and Hardisty, 2019). For instance, monetary incentives require a certain economic wealth, and they may be harder to employ as global warming produces increasing economic damages and depletes the planet's natural resources (IPCC, 2013; USGCRP, 2017; Nasa, 2020; Wang *et al.*, 2020; Kotz, Levermann, and Wenz, 2024). Further, once the incentive is removed, crowding out may occur and pro-environmental behaviours may disappear. This could even lead individuals to lose their reason to act sustainably, especially if the incentives were not combined with other factors tapping into individuals' intrinsic motivations—e.g. social norms, environmental awareness, social recognition, and social tipping (Bolderdijk *et al.*, 2012; Kerr *et al.*, 2019; Maca-Millán, Arias-Arévalo, and Restrepo-Plaza, 2021; Berger, Efferson, and Vogt, 2023). A way to mitigate this is to promote motivations that would support continued sustainable behaviour even when financial incentives are discontinued.

Concerns for the future generation have often been proposed as one of the main mechanisms to sustain the emergence of sustainable behaviours (Bogacki and Letmathe, 2021; Berkebile-Weinberg *et al.*, 2024) and have been widely employed in climate change campaigns (Bolsen and Shapiro, 2017; Bergquist *et al.*, 2023). This argument relies on the idea that while people incur short-term economic losses when choosing green, they are aware that they are contributing to the well-being of the next generation. This is generally linked to feelings of social responsibility and legacy concerns, generalized reciprocity, personal normative beliefs, and/or altruism which produce a psychological return for the individual (Chermak and Krause, 2002; Fischer, Irlenbusch, and Sadrieh, 2004; Wade-Benzoni and Tost, 2009; Hauser *et al.*, 2014; Lohse and Waichman, 2020). Following the affective-experiential framework, climate change campaigns strongly leverage on this mechanism (Bolsen and Shapiro, 2017), appealing to emotions such as guilt and fear in relation to future generations to reduce the psychological distance between individuals and the consequences of climate change—e.g. ACT on CO_2 campaign in the UK (Archives, 2010) and the Actions for a Healthier Planet developed by the United Nations (Nations, 2025). Previous research has examined how individuals navigate such collective action dilemmas under conditions of intergenerational resource transmission. Notably, Fischer *et al.* (2004) employed an intergenerational CPR with fast and slow rate of reproduction in a laboratory setting, where multiple generations of participants played the same game with the resources left from the previous generation of players. They showed how individuals' expectations of other participants' behaviours were too optimistic, which resulted in a fast depletion of the resources available. More recently, using an Intergenerational Goods Game across multiple generations, Hauser *et al.* (2014) found that a democratic voting system was necessary to prevent the overexploitation of the resources. In their game, participants had to harvest less than a fixed threshold for resources to be passed on to the next generation. When left unregulated, despite the high level of cooperation (68 per cent), only 4 of the 18 games reached the second generation, while all groups did not surpass the sustainability fixed threshold if democratic voting was implemented. Using a similar design, Lohse and Waichman (2020) found that peer punishment was another mechanism that could mitigate the overexploitation of the resources dominant in the unregulated condition, allowing the game to reach the last generation.

Taken together, these results indicate that, despite the high cooperation levels, the mere presence of intergenerational transmission may not be enough to favour a more sustainable management of the resources overall. Scholars have argued that the introduction of intergenerational transmission does not automatically reduce the psychological distance between present and future generations, and that this aspect should be specifically addressed to capitalize on intergenerational awareness. Along these lines, Kamijo *et al.* (2017) showed that, in a discrete intergenerational sustainability dilemma game, when psychological distance was reduced by including a representative of the future generation, participants had a stronger preference towards the sustainable option compared to the baseline. Similarly, Shahen, Kotani, and Saijo (2021) showed that asking participants to imagine themselves as members of a future generation before making their decision helps prevent unsustainable choices, especially in critical situations (e.g. when intergenerational sustainability is endangered). In other words, past work seems to suggest that the presence of intergenerational transmission alone entails considerable cooperation levels, but it requires to rely on other (unrelated or concomitant) mechanisms (e.g. peer punishment, voting systems, psychological distance) to achieve successful transmission of resources across generations.

It is important to note that in such prior behavioural research awareness of intergenerational transmission has rarely been the focus of experimental manipulation, leaving its impact, relative to a baseline condition in which individuals ignore future generations' challenges, unclear (Chermak and Krause, 2002; Wade-Benzoni and Tost, 2009; Hauser *et al.*, 2014; Kamijo *et al.*, 2017; Lohse and Waichman, 2020). That is, we still need to understand whether, and to what extent, mere awareness of a subsequent generation facing the same dilemma alters green behaviour compared to a condition without such awareness. This is important to evaluate if the cooperation levels observed in prior research are indeed linked to future generation concerns instead of potential confounders or specific sample characteristics. Further, there is a lack of research in the social dilemma literature investigating to what extent intergenerational awareness *and* monetary incentives for green choices effectively encourage individuals to engage in sustainable behaviours. These two mechanisms, crucial in current climate policies, may effectively support sustainability when combined, as each could help to address the limitations of the other. Indeed, while monetary incentives make the sustainable option financially viable, intergenerational awareness fosters intrinsic motivation to adopt the behaviour independent of external nudges, possibly limiting or avoiding crowding out effects (see Hypotheses). Finally, previous studies have mostly employed game formalizations where the green option was not clearly identifiable to participants. Yet, present-day policies aimed at supporting a more sustainable consumption have made green options more and more identifiable and accessible to the general public (e.g. eco-labelling), ultimately simplifying the sustainable development dilemma societies face nowadays (OECD, 2016; Berger, 2019; White *et al.*, 2019). Indeed, people are frequently presented with clearly labelled choices whose environmental impacts are explicitly highlighted (e.g. see Trainline, 2025).

To illustrate how a clearer identification of sustainable and unsustainable options relates to real-life environmental decisions and dilemma formalization, let us consider the case of meat shopping (see Figure 1 for a graphical representation of the paradigm). Livestock production contributes to 34 per cent of the green-house emissions (Crippa *et al.*, 2021). Switching to lower impact meat, such as chicken, together with a decreased meat intake, reduces the green-house emissions, while avoiding any animal-source food has the highest greenhouse gas mitigation potential. Each of these options has consequences on the planet: as the emissions produced surpasses the CO_2 absorption capacity of the planet, the Earth's ecosystem drastically changes, leading to the depletion of the natural resources (Smith *et al.*, 2019). Within this broader context, individuals have essentially three possibilities when meat shopping and they are made aware of the consequences of their decisions through extensive campaigns and labelling (Rimal, 2005; Taillie *et al.*, 2023; Change, 2025; De-loyde *et al.*, 2025). The three options are: buying red meat, which is

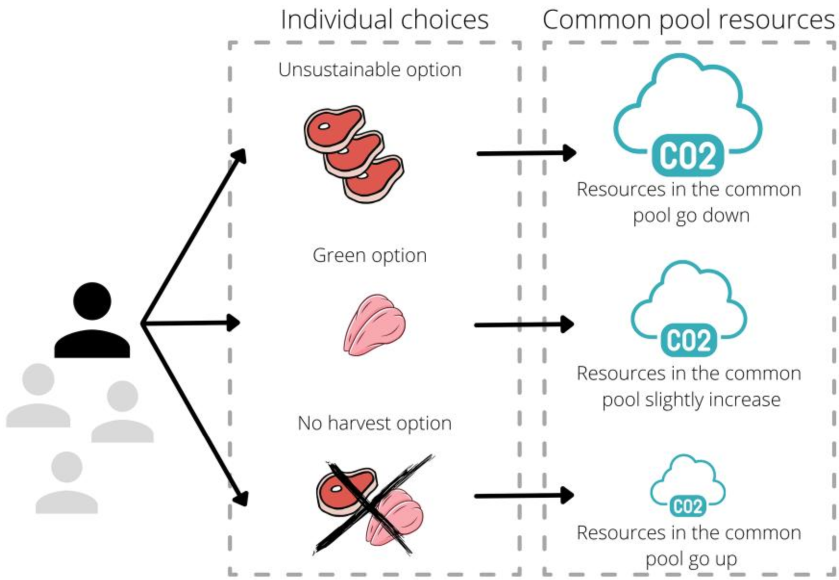

Figure 1 Discrete common pool resources (CPR) paradigm. Note. We employ a neutral language in the game, and the three options are presented as option A, B, and C. Participants were made aware of the consequences of each option on the environment, see SI, section S6

highly polluting; buying less meat and opting for white meat, which reduces individuals' choice set but is less polluting; or giving up meat, which involves an individual sacrifice but strongly reduces pollution caused by farming (Schiermeier, 2019). To better represent this scenario that individuals often face, in our paradigm, we separate the three choices clearly showing how each option affects the resources available in the environment, without labelling the options themselves: red meat corresponds to the unsustainable option (option *u*: harvesting 11 per cent of the available resources, decreasing of the overall resources in the environment for next round), white meat combined with the reduced meat intake corresponds to the green option (option *g*: harvesting 5 per cent of the available resources, slightly increasing the overall resources in the environment for next round), while avoiding any animal-source food corresponds to the no harvest option (option *n*: harvesting 0 per cent of the available resources, increasing the overall resources in the environment for next round, see Figure 1 and SI, S6).

Hypotheses

We argue that, when the consequences of each option have been clearly illustrated, sustainable development can be effectively supported by the combination of awareness of intergenerational transmission and monetary incentives. In the absence of intergenerational awareness, the unsustainable option will remain the most advantageous choice and people might not have strong enough motives to opt for the green option, even if it is monetarily incentivized. This lack of intrinsic motivations may result in the rapid exhaustion of the resources, as often observed in CPR games where resources are quickly depleted after the game begins (Janssen *et al.*, 2010). On the other hand, if there is awareness of intergenerational transmission of resources but no monetary incentives, people might lack the means to select the green option, even though they may be willing to do so. That is, even though individuals are motivated to act more sustainably, they may still be unwilling to forgo the earnings they would lose by choosing the sustainable option. This aligns with previous literature suggesting that, to promote a more sustainable use of resources, intergenerational transmission needs to be complemented by other mechanisms, such as peer punishment, voting, or the introduction of a representative of the future generation (Hauser *et al.*, 2014; Kamijo *et al.*, 2017; Lohse and Waichman, 2020). As a result, we hypothesize that only when both interventions are present, people will effectively select the green option and leave enough resources for the survival of the next generation—i.e. to achieve the sustainability threshold.

To test this argument, we employ a 2 × 2 between-subjects design where we manipulate the monetary incentives of the green option and the awareness of intergenerational transmission in a 10-round discrete CPR game (see Methods and SI for more details). We evaluate the impact of green option incentives (GI) and awareness of intergenerational transmission of resources (IT) on the emergence of sustainable development when the green option is clearly identifiable. In GI, participants could earn an additional monetary reward when choosing the green option (incentives = 33 per cent). In IT, participants learned that, if their remaining resources were above a fixed threshold (sustainability threshold = 20 resources), their remaining resources would be transferred to a new group of players who would play the same game after them (see Methods and SI for more details).

Following the theoretical argument outlined above, our hypotheses are the following:

H1. When the green option is incentivized and there is awareness of intergenerational transmission (IT&GI), people will be more likely to choose the green option than when the green option is not incentivized and/or there is no awareness of intergenerational transmission.

H2. When the green option is incentivized and there is awareness of intergenerational transmission (IT&GI), people will be more likely to achieve the sustainability threshold than when the green option is not incentivized and/or there is no awareness of intergenerational transmission.[2]

Methods

Participants

We ran two real-time online experiments via MTurk and Prolific. Study 1 involved 1,167 US participants (M_{age} = 40.07, SD = 11.84; 537 women) across 309 sessions. Study 2 involved 1,093 US participants (M_{age} = 36.22, SD = 12.95; 544 women) across 288 sessions (see Table 1 for demographics as well as SI and pre-registration for more details). Study 2 was designed as a direct replication of Study 1, differing only in the sample pool (MTurk for Study 1 and Prolific for Study 2); all aspects of the game design and data collection procedures were kept identical. The experiment was programmed in oTree, version 3.4.0 (Chen, Schonger, and Wickens, 2016). Data and pre-registration files are available on the Open Science Framework website (Study 1: https://osf.io/ybqt5/overview?view_only=ec0b12d6a1c7461ba7a48e48829579da, Study 2: https://osf.io/8s7kj/overview?view_only=a1f2dc7c10814175bc4dec1de414245b). This study was approved by the Ethics Committee of the Faculty of Social Sciences of the Vrije Universiteit Amsterdam (Study 1: 2022-12-18-857; Study 2: 2022-10-3-677). Informed consent was obtained from all participants.

Table 1 Descriptive statistics Study 1 and Study 2

	Study 1		**Study 2**	
	Mean	**Sd**	**Mean**	**Sd**
Ethnicity				
White	0.75	0.43	0.70	0.46
Black	0.12	0.32	0.08	0.28
Hispanic or Latino/a	0.04	0.20	0.10	0.30
Asian	0.07	0.26	0.09	0.29
Other	0.02	0.13	0.03	0.17
Education				
Less than high school (Grade 11 or less)	0.00	0.05	0.01	0.07
High school diploma (including GED)	0.09	0.28	0.12	0.33
Some college	0.16	0.37	0.21	0.41
Associate degree (2 years) or specialized technical training	0.10	0.30	0.09	0.29
Bachelor's degree	0.45	0.50	0.39	0.49
Some graduate training	0.02	0.15	0.02	0.14
Graduate/professional degree or higher	0.18	0.38	0.16	0.37
Gender				
Male	0.53	0.50	0.48	0.50
Female	0.47	0.50	0.50	0.50
Other	0.00	0.05	0.02	0.14
Age	40.07	11.84	36.22	12.95
Offspring	1.09	1.21	0.82	1.27

Offspring was an integer variable: 'How many children do you have?' (min Study 1 and Study 2 = 0, max Study 1 = 9, max Study 2 = 10).

Procedure

In both studies, we manipulated two factors in the experiment: GI and awareness of IT in a 2 (incentives vs no incentives for the green option) × 2 (awareness vs no awareness of intergenerational transmission) between-subjects design; see Table 2. Each session was randomly assigned to one of the treatments, and it included four participants.

Across the two studies, participants earned on average \$5.47 of bonus plus \$2.5 of showing up fee (Study 1) and \$5.56 of bonus plus \$2.95 of showing up fee (Study 2). Participants were informed that the maximum amount they could earn was \$11. This cap was introduced as a constraint in the experimental design on the participants' payoff determined from harvesting.

First, participants read the instructions and were asked relevant comprehension questions. Participants had no

Table 2 Experimental design

		Awareness of intergenerational transmission (IT)	
		No	**Yes**
Green option incentives (GI)	No	NGI&NIT Study 1: $N = 308$, sessions = 81 Study 2: $N = 251$, sessions = 65	IT Study 1: $N = 266$, sessions = 71 Study 2: $N = 241$, sessions = 64
	Yes	GI Study 1: $N = 286$, sessions = 75 Study 2: $N = 319$, sessions = 84	IT&GI Study 1: $N = 307$, sessions = 82 Study 2: $N = 282$, sessions = 75

means to communicate with one another, and their identity was kept anonymous throughout the entire duration of the experiment. Then, they played 10 rounds of a discrete version of the CPR game. The number of rounds was mentioned in the instructions, but it was not shown during the game to minimize the end-of-game effect. Finally, participants were presented a short questionnaire to gather socio-demographic information (see Figure 2 for more details and SI for the formalization of the game).

Study design

In the CPR game, participants started with a common pool of 100 resource units and had 3 discrete choices (a neutral language was used throughout the entire experiment): Option u, harvest 11 per cent of the common resources; Option g, harvest 5 per cent of the common resources; and Option n, harvest 0 per cent of the common resources.[3] While participants were not told through labelling which option was the sustainable one, they were informed about the consequences of each option on the environment. Participants were also informed about the replenishment rate of the pool (fixed rate = 1.3) and could see the impact of their choices on the common pool at the end of each round. The harvesting rates were calculated so that (i) the Nash equilibrium[4] of the game was to choose Option u, in line with the original CPR; (ii) if all participants chose Option g, the environment would grow of about 4 per cent; (iii) if all participants chose Option u, the environment would decrease of about 28 per cent (see SI for a full description of the game and its equilibria). The sustainability threshold (i.e. 20 resource units in the common pool) was calculated based on the definition of sustainable development, that is, an individual in the next generation should be able to earn at least one unit of resources when harvesting (choosing either option g or u; 5 per cent of 20 = 1). In IT, participants learned that, at the end of the game, their remaining resources would be transferred to a new group of players who would play their same game. Participants were also informed that, if at the end of round 10 the remaining resources were below the threshold, the new group would not be able to play the game and earn any monetary bonus from it. Also, participants were reminded about the threshold and were able to see whether they reached it or not at the end of each round.

Our treatment aims to create a proxy for intergenerational awareness by manipulating the very existence of intergenerational transmission. We adopted this approach because directly manipulating awareness is not feasible for practical and ethical reasons (e.g. we cannot alter participants' belief systems or their lack of awareness of a given issue). The underlying assumption of our treatment is that individuals who lack awareness of future generations' challenges would understand and play the CPR 'as if' no future generation existed. By removing the next generation, we create a condition in which participants make decisions without considering the challenges faced by future generations, while keeping the Nash equilibrium and the socially optimal choice constant across conditions (see SI). Compared to alternative approaches such as framing or perspective-taking, our proxy avoids some important pitfalls, including demand effects and emotional priming biases. However, it remains restrictive in how it captures the absence of awareness, since it represents a condition in which individuals behave as though future generations' needs are entirely irrelevant. This may not entirely reflect real-life situations if we expect that even the most unconcerned individuals retain some awareness of future generations' challenges (e.g., through family members). This possibility entails a limitation for the ecological validity of the study. Our findings should be interpreted with these considerations in mind.

In GI, participants could see, when making their choice, the additional monetary reward they would receive by

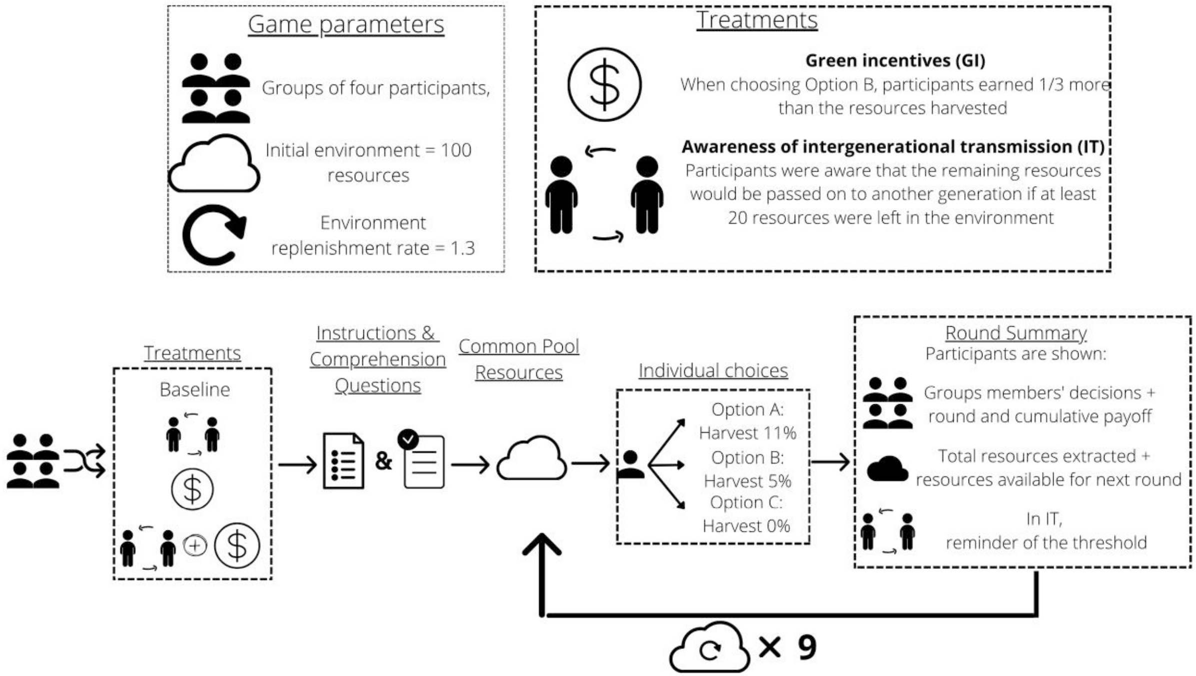

Figure 2 Structure of the experiment. **Note.** Participants were first arranged in groups of four and randomly assigned to a treatment. They then read the instructions and were asked a series of comprehension questions. Participants were required to answer correctly to these questions to proceed to the next stage. Participants played 10 rounds of a discrete Common Pool Resources Dilemma and at the end of each round they were shown the other group members' decisions, their own payoff, and the evolution of the environment following the group decisions. In IT, participants were also reminded about the threshold and were able to see whether they reached it or not at the end of each round

choosing Option g. Incentives were set so that participants would earn 1/3 more of the resources harvested (incentives = 33.3 per cent).[5]

Statistical analysis

To analyse our outcomes at the round-decision level (i.e. extraction choice), we employ multilevel linear probability models, estimated via maximum likelihood, with random intercepts for individuals and sessions to account for the lack of independence among observations (round-decisions nested in individuals nested in sessions). Heteroskedasticity-robust standard errors were applied at the highest level of the model hierarchy (i.e. sessions). To analyse our outcome at the session level (i.e. achievement of sustainability threshold), we use linear probability models with heteroskedasticity-robust standard errors. Results are robust to different modelling strategies (e.g. logistic and multilevel logistic regressions) and statistical controls (e.g. round, age, gender, education). Controls were included in our robustness checks to address potential imbalance in covariates across treatments and to increase the precision of the estimates. These analyses are reported in the SI. Statistical significance is set at the 5 per cent level (i.e. $\alpha = 0.05$) for two-sided tests.

Results

Panels A1-A2 and B1-B2 in Figure 3 illustrate, respectively, the predicted probability of each extraction choice and the predicted probability of achieving the sustainability threshold by treatment for Study 1 and Study 2 (see SI for analysis details, and robustness checks). Results show that participants in IT&GI were more likely to choose the green option than participants in virtually any other treatment (Study 1: $\beta_{IT\&GI-IT} = 0.072$, SE = 0.026, $P = 0.005$; $\beta_{IT\&GI-GI} = 0.051$, SE = 0.025, $P = 0.043$; $\beta_{IT\&GI-NIT\&NGI} = 0.181$, SE = 0.022, $P \leq 0.001$; Study 2: $\beta_{IT\&GI-IT} = 0.056$ SE = 0.028, $P = 0.042$; $\beta_{IT\&GI-GI} = 0.044$, SE = 0.028, $P = 0.117$; $\beta_{IT\&GI-NIT\&NGI} = 0.159$, SE = 0.027, $P \leq 0.001$; Figure 2A1 and A2), supporting H1. Considering the magnitude of the effects, the models indicate rather notable changes, as participants in IT&GI were approximately 18 (Study 1) and 16 (Study 2) percentage points more likely to select the green option compared to those in NIT&NGI. Evidence also indicates that there was no statistically significant difference in how IT and GI increased the likelihood of opting for the green choice (Study 1: $\beta_{(IT-NIT\&NGI)\text{-}(GI\text{-}NIT\&NGI)} = -0.021$, SE = 0.025, $P = 0.390$; Study 2: $\beta_{(IT-NIT\&NGI)\text{-}(GI\text{-}NIT\&NGI)} = -0.012$, SE = 0.029, $P = 0.674$ Figure 3A1 and A2). Thus, in our samples, awareness of intergenerational transmission and green option incentives yielded an analogous effect on the probability of choosing the green option, and the combination of these two elements had the strongest influence.

As visible in Figure 3B1 and B2, across both studies, participants in IT&GI were more likely to achieve the sustainability threshold than participants in GI or NIT&NGI (Study 1: $\beta_{IT\&GI-GI} = 0.234$, SE = 0.074, $P = 0.002$; $\beta_{IT\&GI-NIT\&NGI} = 0.250$, SE = 0.072, $P \leq 0.001$; Study 2: $\beta_{IT\&GI-GI} = 0.136$, SE = 0.067, $P = 0.044$; $\beta_{IT\&GI-NIT\&NGI} = 0.273$, SE = 0.076, $P \leq 0.001$). When considering the effect sizes, we can observe that sessions in IT&GI were approximately 25 (Study 1) and 28 (Study 2) percentage points more likely to achieve the threshold compared to those in NIT&NGI, indicating rather sizable changes in terms of magnitude. However, the likelihood to achieve the threshold in IT&GI was not statistically different from IT (Study 1: $\beta_{IT\&GI-IT} = 0.034$, SE = 0.069, $P = 0.624$; Study 2: $\beta_{IT\&GI-IT} = 0.061$, SE = 0.069, $P = 0.378$; Figure 3B1 and B2). This evidence partially supports H2.

The mere introduction of green option incentives did not increase the chances of survival of the next generation, since there was no statistically significant difference in the achievement of the sustainability threshold between GI and NIT&NGI (Study 1: $\beta_{GI-NIT\&NGI} = 0.016$, SE = 0.080, $P = 0.844$; Study 2: $\beta_{GI-NIT\&NGI} = 0.137$, SE = 0.080, $P = 0.090$; Figure 3B1 and B2). On the other hand, participants in IT were more inclined to opt for the no harvest option than participants in GI (Study 1: $\beta_{IT-GI} = 0.034$, SE = 0.014, $P = 0.015$; Study 2: $\beta_{IT-GI} = 0.034$, SE = 0.016, $P = 0.029$; Figure 3A1 and A2), and the introduction of intergenerational transmission alone did increase the chances of survival of the next generation (Study 1: $\beta_{IT-NIT\&NGI} = 0.216$, SE = 0.076, $P = 0.005$; Study 2: $\beta_{IT-NIT\&NGI} = 0.212$, SE = 0.082, $P = 0.010$; Figure 3B1 and B2). Further, when we examined the main and interaction effects of GI and IT on achievement of the sustainability threshold, we observed that GI had no statistically significant main effect on achieving the sustainability threshold (Study 1: $\beta_{GI} = 0.025$, SE = 0.053, $P = 0.641$; Study 2: $\beta_{GI} = 0.100$, SE = 0.053, $P = 0.061$), whereas IT had a statistically significant main effect in both studies (Study 1: $\beta_{IT} = 0.225$, SE = 0.053, $P < 0.001$; Study 2: $\beta_{IT} = 0.170$, SE = 0.052, $P = 0.001$). We found no evidence of non-additive effects in either study (Study 1: $\beta_{IT \times GI} = 0.018$, SE = 0.106, $P = 0.864$; Study 2: $\beta_{IT \times GI} = -0.076$, SE = 0.106, $P = 0.476$).

Figure 4 provides further insights on the dynamics at play by illustrating the predicted probability of each extraction choice by round and treatment. In line with previous findings, we observe an increase of resource

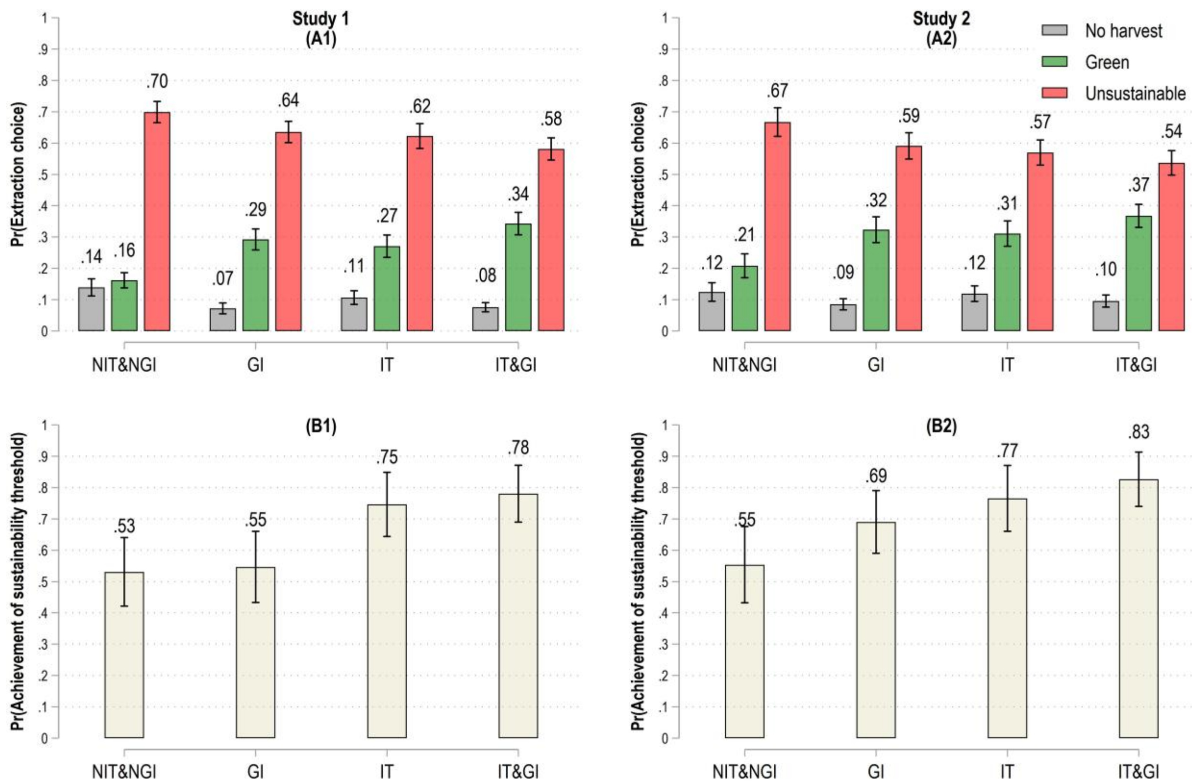

Figure 3 Extraction choices and achievement of sustainability threshold by treatment for Study 1 and Study 2. **Note.** Panels A1 and A2 show the predicted probability of each extraction choice by treatment with 95 per cent CIs based on multilevel linear probability models with round-decisions (Study 1: $N = 11{,}389$; Study 2: $N = 10{,}751$) nested in individuals (Study 1: $N = 1{,}167$; Study 2: $N = 1{,}093$) nested in sessions (Study 1: $N = 309$; Study 2: $N = 288$) and robust standard errors for Study 1 and Study 2, respectively. Panels B1 and B2 show the predicted probability of achieving the sustainability threshold by treatment with 95 per cent CIs based on a linear probability model with sessions as unit of analysis (Study 1: $N = 309$; Study 2: $N = 288$) and robust standard errors for Study 1 and Study 2, respectively. Results are robust to different modelling strategies (i.e. multilevel logistic regression) and statistical controls (results are presented without controls, see SI for results with controls). We set statistical significance at the 5 per cent level (i.e. $\alpha = 0.05$) for two-sided tests

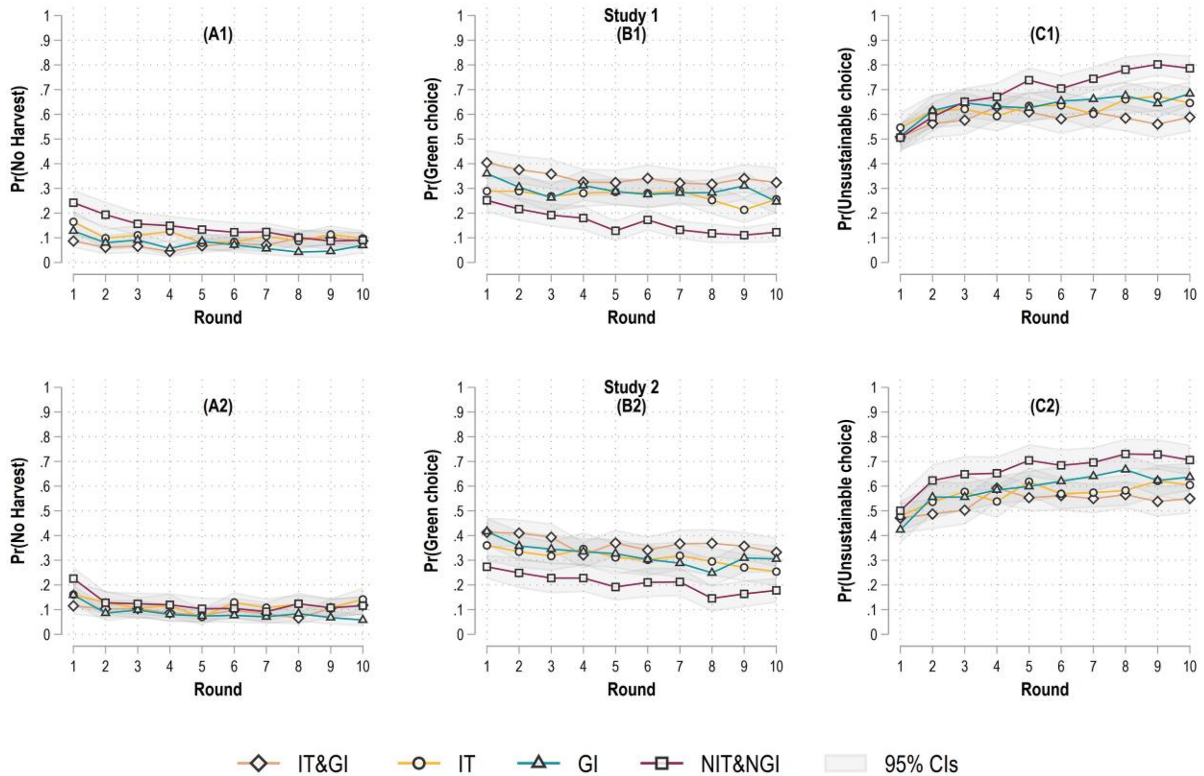

Figure 4 Extraction choices by round and treatment for Study 1 and Study 2. **Note.** Panels A1-A2, B1-B2, and C1-C2 show the predicted probability of choosing no harvest (0 per cent harvest), green (5 per cent harvest), and unsustainable (11 per cent harvest) by treatment and round, with 95 per cent CIs based on multilevel linear probability models with round-decisions (Study 1: $N = 11{,}389$; Study 2: $N = 10{,}751$) nested in individuals (Study 1: $N = 1{,}167$; Study 2: $N = 1{,}093$) nested in sessions (Study 1: $N = 309$; Study 2: $N = 288$) and robust standard errors. Results are robust to different modelling strategies (i.e. multilevel logistic regression) and statistical controls (see SI for detailed results)

extraction across treatments over rounds. Participants in NIT&NGI, contrary to other treatments, displayed a distinct exploitative strategy. They opted more frequently for the no harvest option in the initial rounds than any other treatment (Figure 4A1 and A2), favouring a growth of the resources in the common pool, and then overwhelmingly switched to the unsustainable option (Figure 4C1 and C2), quickly exhausting the available resources.

Discussion

Our study jointly tests two theoretical arguments at the core of current environmental policy interventions and campaigns, addressing a lack of causal evidence in the literature. We evaluate the causal effect of monetary incentives and intergenerational awareness on sustainable behaviours and assess their impact on individuals' ability to overcome the sustainable development dilemma our society is currently facing. To do so, we conducted two pre-registered large-scale between-subjects experiments, where participants simultaneously played a discrete CPR dilemma in which the sustainable option is clearly identifiable—mimicking more closely the space of choices available to individuals nowadays. Importantly, participants were informed about the sustainability implications of each decision not through labels, but through explicit information detailing the environmental impact associated with each option.

On the one hand, our results indicate that the simple introduction of awareness of intergenerational transmission leads participants to make more sustainable choices for the next generation. This substantially increases the likelihood of achieving the sustainability threshold, regardless of the presence of green option incentives. In other words, once concerns for future generations are triggered, individuals seem to change their beliefs on what ought to be done to overcome the sustainable development dilemma and act accordingly. This resonates with recent findings reported by Vlasceanu *et al.* (2024) showing that, across 63 countries, interventions prompting individuals to relate to future generations are effective in shaping people's attitudes, such as support of pro-environmental policies, beliefs in climate change, and willingness to share climate change information. Taken together with our results, this body of evidence illustrates the relevance of intergenerational awareness in shaping sustainable behaviours in relation to the social dilemma at the core of sustainable development as well as real-life attitudes. A switch in personal normative beliefs and social norms may be one of the core mechanisms underlying the reported effect (Szekely *et al.*, 2021). Future research could measure participants' empirical expectations and normative beliefs at the end of each round to gain a clearer understanding of the patterns that emerged in our experiment (see Figure 4) and the factors driving their development (see Decision mode presented in Truelove *et al.* (2014)). Understanding what underlying mechanisms are responsible for this behavioural shift is crucial to design effective climate policies, and exploring the potential psychological (e.g. personal normative beliefs, altruism) and social (e.g. generalized reciprocity, social responsibility, social norms) roots of such mechanisms is an important step in this direction. Finally, further studies should also investigate how intergenerational awareness triggers observed attitudinal and behavioural responses in individuals, while comparing its effectiveness to other interventions such as social comparison and nudges (Nisa *et al.*, 2019).

Our results are possibly contingent on some key game parameters, such as the replenishment rate of the common pool and the values set for the sustainability threshold, which allowed for an ample use of environmental resources. Previous research set a much harsher threshold, typically at half of the available resources in the environment (or within a narrow range around that level), thereby creating conditions that were particularly difficult to meet. This demanding threshold may help explain why prior studies found that groups relying solely on intergenerational transmission often failed to survive beyond the initial rounds (Hauser *et al.*, 2014; Lohse and Waichman, 2020; Balmford, Marino, and Hauser, 2024). While such stringent thresholds may capture more critical climate scenarios, they do not necessarily reflect the dilemma faced by individuals in our society (yet). Researchers could explore the interdependency between the different levels of the sustainability threshold and its achievement, considering more severe environmental conditions—i.e. replenishment rate, (Fischer *et al.*, 2004) and different sustainability thresholds, which may be more fitting to formalize real-life situations in the near future and help assess how individuals might behave under different scenarios.

Further, it is important to note that our proxy for intergenerational awareness relies on the assumption that individuals who lack awareness of future generations' challenges would approach the sustainable development dilemma 'as if' no future generation existed. This could indeed be the case for individuals who genuinely lack intergenerational awareness, but it could also be argued that even those with very limited awareness are likely to retain at least some sense of future generations' challenges—for example, through family members or their own offspring.[6] From this point of view, our experimental setup may be overly restrictive in representing individuals' intergenerational unawareness. As a result, differences from the baseline condition observable in real-life contexts may be less noticeable, meaning that these effects could be less pronounced than those detected in our experimental setting. Future studies could implement alternative manipulations of intergenerational awareness that allow for a minimal level of awareness within this dilemma to test the robustness of our results.

On the other hand, moderate green option incentives alone increase the likelihood of choosing green but are not sufficient to create an environment where enough resources are endogenously saved to ensure the survival of the next generation. Green incentives are an appealing option because they could facilitate the achievement of sustainability goals without needing the population to acknowledge their importance or urgency. That is, even though individuals do not realize that the survival of the next generation depends on their decisions, they may be able to achieve such goal unintentionally with the appropriate push in the right direction, bypassing altogether the sustainability dilemma society is currently facing. Our results, however, indicate that a moderate level of green incentives does not produce such outcome. More substantial economic investments could be more effective in this sense, but their feasibility should be carefully evaluated in future studies. Indeed, while large economic incentives can change the nature of the social dilemma at hand, it is crucial to consider the feasibility of this approach across a variety of consumption domains and for different economic systems, taking into account the increasing economic damages produced by global warming.

Finally, in line with our hypotheses, results indicate that the combined presence of intergenerational awareness and moderate green option incentives is the most effective way to increase the likelihood of choosing green and achieve sustainable development. Our findings point out the importance of a mix of different types of incentives to enable groups to more consistently overcome the sustainability dilemma. Therefore, future policies designed to promote sustainable development should consider a multifaceted approach to sway individuals' behaviours as effectively and efficiently as possible.

Notes

1. While the current manuscript examines the issue by focusing on individual-level contributions, it is worth emphasizing the critical role of governments in fighting climate change. See Turnhout (2024) for a critique that calls for redirecting research attention towards a government-centred lens.
2. Please note that H2 refers to a group-level behaviour.
3. All values were rounded to two decimal places, this was applied consistently across all calculations.
4. The Nash equilibrium is a strategy profile in which every player's chosen decision maximizes their payoff given the choices made by the others (Osborne and Rubinstein, 1994). This is often interpreted as the rational strategy that optimizes an individual's payoff.
5. In our paradigm, the incentives were set at one-third of the resources harvested when choosing the green option, which corresponds to 1.67 per cent of the total resources available in the environment. Hence, when choosing the green option in GI, participants earned 6.67 per cent of the total resources while harvesting only 5 per cent from the environment. By contrast, participants who chose the unsustainable option earned 11 per cent of the available resources, reflecting a 4.33 per cent surplus relative to the incentivized green option.
6. We examined the role of offspring in option selection; however, no significant patterns were observed (see SI for details).

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Supplementary data

Supplementary data are available at *ESR* online.

Author contribution

M.T and S.L.I conceptualized the study. M.T. programmed the experiment and collected data. S.L.I. analyzed the data. S.L.I and M.T. wrote the first draft of the manuscript. M.T. and S.L.I reviewed and edited the manuscript.

Martina Testori (Conceptualization, Funding acquisition, Methodology, Writing—original draft, Writing—review & editing [equal], Investigation, Project administration, Software [lead]), and Sergio Lo Iacono (Conceptualization, Funding acquisition, Methodology, Writing—original draft, Writing—review & editing [equal], Data curation, Formal analysis, Visualization [lead], Project administration [supporting]).

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Competing interests

The authors declare no competing interests.

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Data availability

All data, analysis, and pre-registration files are available on the Open Science Framework website (Study 1: https://osf.io/ybqt5/overview?view_only=ec0b12d6a1c7461ba7a48e48829579da, Study 2: https://osf.io/8s7kj/overview?view_only=a1f2dc7c10814175bc4dec1de414245b).

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