Inconsistent allocations of harms versus benefits may exacerbate environmental inequality

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We report five studies that examine preferences for the allocation of environmental harms and benefits. In all studies, participants were presented with scenarios in which an existing environmental inequality between two otherwise similar communities could either be decreased or increased through various allocation decisions. Our results demonstrate that despite well-established preferences toward equal outcomes, people express weaker preferences for options that increase equality when considering the allocation of environmental harms (e.g., building new polluting facilities) than when considering the allocation of environmental benefits (e.g., applying pollution-reducing technologies). We argue that this effect emerges from fairness considerations rooted in a psychological incompatibility between the allocation of harms, which is seen as an inherently unfair action, and equality, which is a basic fairness principle. Since the allocation of harms is an inevitable part of operations of both governments and businesses, our results suggest that where possible, parties interested in increasing environmental equality may benefit from framing such proposals as bestowing relative benefits instead of imposing relative harms.

allocation decisions | environmental justice | harms vs. benefits | fairness | inequality

In recent years, issues related to inequality have received widespread attention in the media, politics, and academic research. In general, this discussion has tended to focus on economic issues, such as income and taxation (1–5). In contrast, inequalities in environmental conditions, such as differences in air or water quality, receive less attention. Although there is certainly natural variation in environmental conditions, many forms of environmental inequality arise from the decisions that people make regarding environmental resources, pollution, and conservation (6, 7). Such decisions, in turn, can have far-reaching consequences for people's health and well-being (6–9). Consider, for example, decisions such as where to place the Keystone Pipeline (10) or where to first improve water quality for the affected residents of Flint, Michigan (11). In such cases, officials and the broader public need to make difficult decisions about where to potentially worsen environmental conditions by allocating an environmental harm (e.g., an oil pipeline) or where to improve conditions by allocating an environmental benefit (e.g., water treatment).

The present research identifies an asymmetry in people's preferences regarding such decisions. Specifically, people express weaker preferences for options that increase equality when considering the allocation of environmental harms than when considering the allocation of environmental benefits.

To illustrate this phenomenon, consider the case of noise pollution from air traffic at Chicago's O'Hare International Airport. The noise pollution level that different communities face depends not only on their proximity to the airport but also on which particular runway is used (12). For example, departures from runway 28R mostly affect residents of Wood Dale, while departures from runway 22L mostly affect residents of Elmhurst. In 2016, O'Hare sought to add new late-night takeoffs and

landings, and officials had to decide which of the two runways would handle the new flights. The residents of Wood Dale (who were affected by ∼30% of nighttime traffic) argued that they were already disproportionately suffering, while the residents in Elmhurst (who were affected by ∼7% of nighttime traffic) argued that the additional flights would dramatically decrease their quality of life.

Although one of the two communities ultimately had to incur some environmental harm in the form of increased noise pollution, the allocation of that harm to either community does not seem particularly fair. Indeed, in a pilot study we posed exactly this scenario to 100 participants who were divided on whether they thought the increase in noise pollution should be allocated to Wood Dale (38%) or Elmhurst (62%; for details, see the *SI Appendix*).

Now consider an alternative scenario involving the same two communities. Imagine, however, that instead of adding new flights, O'Hare was canceling flights, and officials now needed to decide whether to reduce traffic in the nosier Wood Dale, or the less noisy Elmhurst. When a different group of 100 participants read about this scenario, a large majority (86%) thought the decrease in air traffic should be allocated to the worse-off Wood Dale, while only 14% thought it should be allocated to Elmhurst. In other words, while people generally preferred options that increased environmental equality, that preference differed by more than 20% when participants were asked to reason about the allocation of benefits (reductions in pollution) versus the allocation of harms (increases in pollution). The present studies investigate this seeming inconsistency in people's preferences.

Significance

Local environmental conditions, such as air and water quality, are shaped, in part, by how societies allocate environmental harms and benefits. Since environmental conditions have long-lasting impacts on people's lives, understanding the psychology behind such allocation decisions is critical. Across studies, we demonstrate that people are less likely to support decisions that increase environmental equality when considering the allocation of environmental harms (vs. benefits). Our findings suggest that careful attention to the way that the allocation of environmental harms is presented to the public could change the support for decisions that address environmental inequality.

A great deal of research has examined people's conceptions of allocation fairness and has identified a number of different principles that come into play (13–27). For instance, in the example of O'Hare Airport, officials may try to balance the noise pollution across the different communities, so that all residents bear the burden equally (20). This would lead officials to benefit the less advantaged Wood Dale when reducing air traffic, and harm the more advantaged Elmhurst when increasing air traffic. Alternatively, officials may believe that the best approach is to concentrate the noise as much as possible. This would lead officials to reduce noise pollution for the already better-off Elmhurst, while adding further pollution to the noisier Wood Dale. Regardless of which approach officials choose, a key feature of both of them is symmetry; that is, if they choose to improve conditions for one location when bestowing benefits, they should choose to worsen conditions for the other location when allocating harms.

In the current studies, however, we show that people are significantly less likely to prefer options that increase environmental equality when allocating harms than when allocating benefits. We propose that this effect results from a fundamental incompatibility between equality, which is a basic fairness principle, and allocating harms, which is seen as an inherently unfair action (28–30). We suggest that people do not perceive harms as a means of achieving fairness, and therefore are reluctant to support using harms as means for achieving greater equality. Across five experiments (and two additional studies reported in the *SI Appendix*), we provide empirical evidence for this phenomenon and show that differences in allocation preferences across harms versus benefits are explained by perceptions of fairness.

Results

In study 1, participants were presented with a scenario about two similar communities that varied in their current water quality levels (2 vs. 3, on a five level water quality index). In this study (and all other studies), the populations of the towns were said to be the same, and differences along any other dimension (e.g., wealth, jobs, etc.) were not mentioned. In the harms condition, participants were told that the current budget mandated the closure of a water treatment plant and asked where state officials should close it. In the benefits condition, participants were told that the current budget only allowed building one new water treatment plant and asked where state officials should open it.

Participants were told that closing or opening a water treatment plant would lead to a one-unit change on the water quality index for residents of that town. Thus, in the benefits condition, participants could choose to increase environmental equality by building the plant in the town with worse water quality, while in the harms condition, participants could choose to increase environmental equality by shutting down the plant in the town with better water quality.

We observed that in the benefits condition, nearly all participants (92%) chose to increase equality by building the treatment plant in the town with worse water quality. However, in the harms condition, only 73% of participants chose to increase equality by closing the plant in the town with better water quality $[X^2(1, 268) = 16.54; P < 0.000]$. That is, we find a significantly lower preference for equality when allocating environmental harms then when allocating benefits. To test for robustness, we replicated this experiment with two additional scenarios about solid waste management and air pollution (*SI Appendix*).

In study 2, we repeated our study 1 design with a nationally representative sample of US residents. In addition, we also included "I prefer not to answer" as a third response option. Our reasoning was that if people are reluctant to use harms as a means of achieving environmental equality, then significantly more people should choose the opt-out option in the harms condition compared with the benefits condition. Consistent with this prediction, participants preferred different allocations across

harms vs. benefits, $[X^2(2, 1,129) = 55.99; P < 0.000]$. Specifically, in the benefit condition, 74% of participants chose to increase equality and only 5% chose to opt out. In contrast, in the harm condition, 56% of participants chose to increase equality, while 17% chose to opt out of the decision.

Data on political orientation and environmental attitudes were also collected from the nationally representative sample. We found that liberal respondents reported stronger support of environmental issues (M = 5.99; SD = 1.27) compared with conservative respondents [M = 4.92; SD = 1.52; $t(696) = -10.13$; $P < 0.000$]. However, neither political orientation nor environmental attitudes moderated the asymmetry between the allocation of harms versus benefits (*SI Appendix*).

In study 3, we examined whether the observed effect is due to participants' reluctance to personally cause a harm (and avoid potential blame) or, instead, a more general incompatibility between fairness perceptions and the allocation of harms. The design of study 3 was similar to the previous studies, in that participants were told about two similar-sized communities that differed in air pollution levels (*SI Appendix*). However, rather than asking participants to actively choose between different allocation options (giving them a sense of agency over the outcome), we asked them to indicate their support for a policy decision that had already been made and to rate how fair they thought that policy was (using 7-point Likert scales).

Overall, participants indicated greater support for decisions that increased environmental equality [$F(1, 338) = 110.6$; $P < 0.000$]. However, we also observed a significant interaction between the type of resource (harms vs. benefits) and the outcome (more vs. less equal) on policy support [$F(1, 338) = 23.8$; $P < 0.000$; Fig. 1]. Specifically, support for the option that increased equality was higher when people evaluated the allocation of benefits [$M_{More\ equality} = 5.86$ (SD = 1.26) vs. $M_{Less\ equality} = 3.06$; (SD = 1.74); $t(169) = -12.0$, $P < 0.000$] than when people evaluated the allocation of harms [$M_{More\ equality} = 3.99$ (SD = 1.82) vs. $M_{Less\ equality} = 2.96$ (SD = 1.83); $t(169) = -3.6$, $P < 0.000$]. Judgments of fairness were aligned with the ratings of
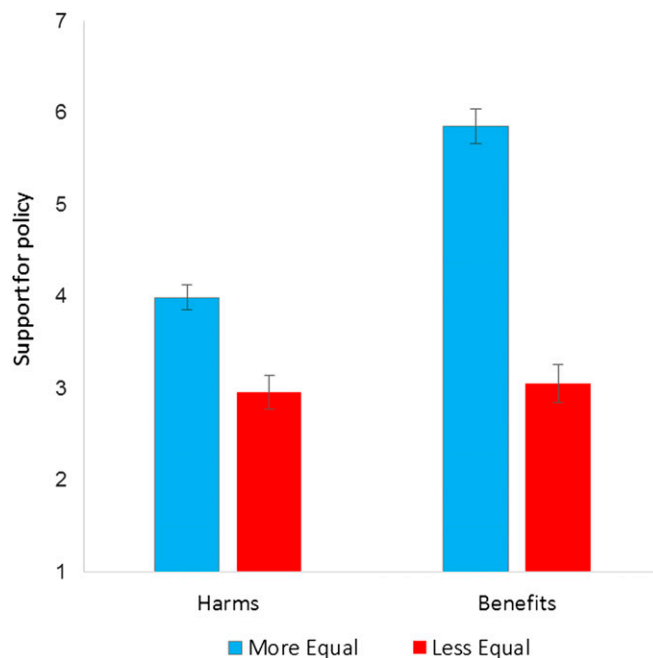

Fig. 1. Study 3 results. Support for policy by resource allocated (benefits vs. harms) and policy decision outcome (more equal vs. less equal). Error bars represent SE.

policy support (*SI Appendix*), and a mediation analysis indicates that perceptions of fairness accounts for the effects on policy support (indirect effect = 1.16; SD = 0.30; 95% CI, 0.60 to 1.77).

The goal of study 4 was to test whether the inconsistency in allocation preferences for harms versus benefits has behavioral consequences. We also examined whether the effect generalized to cases in which the harm resulted from the behaviors of individuals, rather than a large polluting facility. Specifically, in the harms condition, participants were told about a proposal to build a new apartment complex in one of two environmentally sensitive areas. In the benefits condition, participants read about a proposed clean-up effort involving the same two areas. In all cases, participants could choose among increasing equality, decreasing equality, preferring not to choose, or stating they had no preference (*SI Appendix*). In addition to indicating which set of outcomes they preferred (similar to our previous studies), participants were given a $1.00 bonus and were asked if they would like to donate to an environmental charity that supported the outcome they selected (by either sponsoring the clean-up or preventing the construction of the apartment complex). As seen in Fig. 2, the same inconsistency between harms and benefits was observed [X^2(3, 415) = 65.87; $P <$ 0.000]. Moreover, participants donated $35.95 in total to the more equal outcome in the benefits condition compared with only $14.50 in the harms condition. Thus, this effect may hold consequences for public support of various policies, as well as people's decision to fund various conservation efforts.

In study 5, we examined whether framing the exact same environmental policy decision as either a benefit or a harm could increase people's preferences for policies which enhance equality. Using the scenario of an oil spill, we framed the same outcome as a harm (40 out of 60 miles of coastline will be destroyed) or as a benefit (20 out of 60 miles of coastline will be saved). Parallel to the design used in study 1, we presented participants with two coastal areas that were similar except for their current pollution levels and asked them to indicate which of the two should be allowed to be partially destroyed (harms) versus partially saved (benefits). Consistent with the previous studies, while 75% of participants in the benefits framing condition chose the program that would increase equality, only 62% in the harms framing condition chose the program that would increase equality [X^2(270) = 5.73; $P = 0.017$]. That is, simply framing the oil spill in terms of miles of coastline saved (vs. destroyed) significantly increased participants' preference for outcomes that increased environmental equality.

Discussion

The allocation of environmental harms and benefits is an integral part of operations for governments and businesses alike. These decisions directly impact local environmental conditions, which in turn have important consequences for people's health and well-being (6–9). We find that despite an overall preference for equal outcomes, people express weaker preferences for options that increase environmental equality when reasoning about the allocation of environmental harms (e.g., where to place a polluting industrial facility) than when reasoning about the allocation of environmental benefits (e.g., where to apply pollution controlling technologies).

On the surface, this phenomenon appears to share features with Prospect Theory, which posits that subjectively, potential losses loom larger than potential gains (22). However, closer consideration suggests that Prospect Theory's explanatory value in this context depends on one's assumptions about where the two locations initially lie on the gain/loss value function. In all but one case, Prospect Theory predicts symmetry in the allocation of harms and benefits, contrary to our findings. The one exception is under the assumption that the reference point (on the gain/loss function) is the better-off location and the worse-off location is in the loss domain. Only in this case does Prospect Theory predict the asymmetric allocation of harms and benefits in the manner that we find here. It is unclear whether participants themselves hold this particular assumption when evaluating such scenarios. Moreover, Prospect Theory itself does not make any predictions regarding people's fairness judgments (study 3), nor does it predict greater endorsement of the no-choice option in the harm conditions (studies 2 and 4). Therefore, while Prospect Theory can be used to interpret some of the results identified here, its application is selective and difficult to anticipate a priori.

While we acknowledge that there are many factors that lead to environmental inequality, we wanted to test whether environmental inequalities could emerge solely based on the asymmetry identified here. As a simple illustration, we ran a series of Monte Carlo simulations (10^4) looking at the impact that such tabula rasa allocation preferences might have. In each simulation, we allocated environmental harms or benefits between two communities in 10 sequential rounds, randomly selecting from the distribution of choices revealed in study 1 (*SI Appendix*). The simulation results suggest that even when completely detached from other considerations, differences in allocation decisions for harms versus benefits can by themselves lead to environmental inequalities 22% of the time.
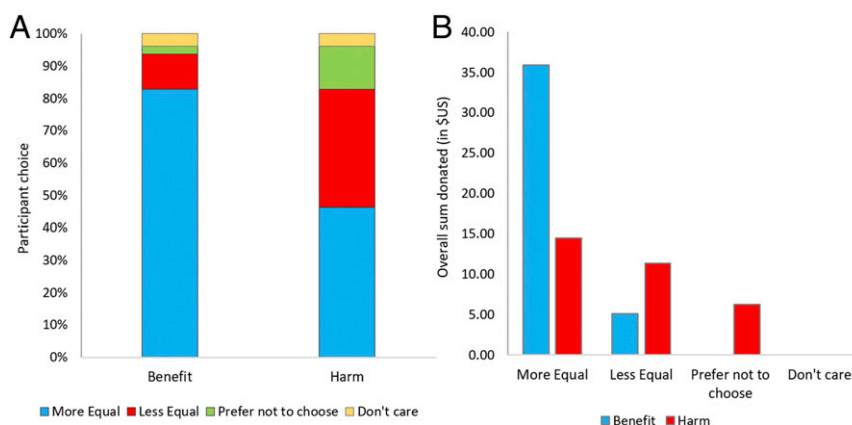

Fig. 2. Study 4 results. (*A*) Allocation decision by resource type (benefits vs. harms). (*B*) Overall sum donated by allocation decision and resource type (benefits vs. harms).

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Since environmental conditions have long-lasting impacts on people's lives, it is important to gain a better understanding of how people reason about the allocation of environmental harms and benefits. The current research provides insights on how environmental harms can be presented to the broader public in ways that remedy, rather than exacerbate, environmental inequalities.

Materials and Methods

For all studies reported, written consent was obtained from participants prior to participation, and approval to conduct the studies was granted by the Human Subjects Committee IRB at Yale University.

Participants: Main Text Studies. Participants were drawn from two samples. These included 1,602 US-based MTurk workers and 1,229 participants drawn from a nationally representative sample recruited via the research firm ROI. The MTurk participants in studies 1, 3, and 5 were paid $0.50 each, participants in study 4 were paid $1.50 each, and the participants from ROI were paid $3.50 each. The participants from the ROI sample matched US population demographics (*SI Appendix*).

In the MTurk samples, responses were restricted to workers who had an approval rate of 90% or higher (N_{Study1} = 401; N_{Study3} = 453; N_{Study4} = 440; N_{Study5} = 308). Across these studies, a total of 19% of the responses were excluded for failing QA questions (*SI Appendix*) or based on repeating GPS locations (i.e., duplicate latitude and longitude coordinates recorded by the Qualtrics software), leaving a total of 1,295 eligible participants overall (female = 43.3%; M_{age} = 36.6; SD_{age} = 11.1). To confirm that these exclusions did not significantly bias results, we repeated all analysis, using all completed survey responses. Across all studies, including additional studies reported in the *SI Appendix*, the findings remained significant and in line with those reported in the main text when all responses were included in the analysis.

Study 1. A total of 268 eligible participants (Female = 51.1%; M_{age} = 37.3; SD_{age} = 11.1) were randomly assigned to one of two between-subject resource conditions (harms vs. benefits). Participants were told that their state would be shutting down (harms) or opening (benefits) a water treatment plant in one of two similar towns: A or B. Participants were then asked to indicate whether they thought the plant should be shut down/opened in town A or town B (binary choice). Shutting down the plant in the town with better water quality and opening the plant in the town with worse water quality were coded as more equal outcomes, since both reduced differences between the two communities (i.e., towns A and B would both end up as 3/5 on the water quality scale). Similarly, shutting down a plant in the town with worse water quality and opening a plant in the town with better water quality were coded as less equal outcomes.

Study 2. A total of 1,129 eligible participants comprising a representative sample of the US adult population (*SI Appendix*) were randomly assigned to one of two between-subject resource conditions (harms vs. benefits). Participants read the same scenario as in the previous study and were asked to indicate in which of the two towns (A or B, presented in alternating order) they thought a water treatment plant should be shut down (harms) or opened (benefits). In addition to a binary choice between A and B, all participants had the option to not express a preference and choose a third option "I prefer not to answer." Participants of this study were also asked to indicate the degree to which they agreed with a series of environmental statements presented in random order on 9-point Likert-type scales [ranging from 1 = strongly disagree to 9 = strongly agree; adapted from Makov and Newman (31)]. Items formed a reliable scale (alpha = 0.84) and were averaged to produce a single measure of environmental attitudes.

Study 3. A total of 342 eligible participants (M_{age} = 37.6; SD = 11.1; 45.3% female) were randomly assigned to one of four conditions in a 2 resource conditions (harms vs. benefits) × 2 outcome (more equal vs. less equal) design. All participants began by reading information on air pollution, its associated health risks, and the air pollution scale (*SI Appendix*). Next, participants read that their state would either install a new power plant that increased air pollution (harms) or install air scrubbers that reduced air pollution from a power plant (benefits) in one of two towns: A or B. As in previous studies, one community had higher baseline air pollution levels (7/10) compared with the other (3/10). Participants were told how the power plant (scrubbers) would affect air pollution and the number of pollution-related deaths in each area. In the more equal outcome conditions, participants read that policy makers had decided that the power plant (scrubbers) would be installed near the town with fewer (more)

pollution related-deaths. In the less equal outcome conditions, participants read that policy makers had decided that the power plant (scrubbers) would be installed near the town with more (fewer) pollution-related deaths.

Participants were then asked to indicate how much they agreed with the decision, as well as rate how fair they thought it was on 7-point Likert scales (ranging from 1 = strongly disagree to 7 = strongly agree, and 1 = extremely unfair to 7 = extremely fair).

Study 4. A total of 415 eligible participants (M_{age} = 36.5; SD = 11.1; 39.5% female) were randomly assigned to one of two between-subjects resource conditions (harms vs. benefits). Half the participants assigned to the harms condition read that property developers were considering in which of two environmentally sensitive areas (A or B) they will build a new apartment complex, which would add pollution and harm the local environment. The other half of the participants, assigned to the benefits condition, read that conservationists were considering in which of the two areas they should organize a clean-up operation, which will reduce pollution and help the local environment. As in previous studies, baseline environmental conditions in one area were better (medium) than in the other (poor). Participants were asked to indicate where they thought the new apartment complex (clean-up effort) should take place, and responses were coded as more or less equal following the same procedure used in previous studies. In addition to choosing either areas A or B, participants also had the option to opt out of the decision ("I prefer not to answer") or state that they did not have a preference ("I don't care"). Participants were informed that they had received a $1 bonus for their participation, and were asked whether they would like to donate to an environmental charity that supported the outcome they preferred. Participants were then asked to state how much money (in $US) they are willing to donate using a slider bar, ranging from $0 to $1.

Study 5. A total of 270 eligible participants (M_{age} = 34.6; SD = 10.9; 39.3% female) were randomly assigned to one of two between-subjects, resource-type conditions (harms vs. benefits). Participants read a short paragraph asking them to "imagine that the US was currently experiencing a large oil spill expected to damage 60 miles of coastline in the Gulf of Mexico." Participants then read that two programs to combat the oil spill had been proposed, and how each program would affect the coastal areas of communities A and B. Participants were asked to indicate which of the two programs they would favor. Similar to the previous studies, community A had higher baseline costal pollution levels (4/5) compared with community B (3/5). For participants in the harms condition, the impacts of programs 1 and 2 were described in terms of miles of coastline devastated. For participants assigned to the benefits condition, the result of programs 1 and 2 were described in terms of miles of coastline saved.

Monte Carlo Simulation. We simulated allocations of harms and benefits between two similar areas, using Monte Carlo simulations, as follows: In each simulation, both areas began with a pollution level of zero. Then, we ran 10 sequential rounds in which either a harm or a benefit (randomly selected) was allocated to one of the two areas. Based on the results of our first study (study 1) when areas had different pollution levels, 73% of the time harms were allocated to the less polluted area and 91% of the time benefits were allocated to the more polluted area. When both areas were equally polluted (i.e., they had the same pollution grade), the harm or benefit were randomly allocated to one of the two. This process was repeated 10^4 times. Finally, we counted how many simulations ended with the two areas having different pollution grades and divided that number by the total number of simulations to derive the percentage of simulations in which environmental inequality emerged. The code use for simulations is presented in the *SI Appendix*.

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