# Uncertainty about the impact of social decisions increases prosocial behavior

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**Uncertainty about how our choices will affect others infuses social life. Past research suggests uncertainty has a negative effect on prosocial behavior[1–12] by enabling people to adopt self-serving narratives about their actions[1,13]. We show that uncertainty does not always promote selfishness. We introduce a distinction between two types of uncertainty that have opposite effects on prosocial behavior. Previous work focused on *outcome uncertainty*: uncertainty about whether or not a decision will lead to a particular outcome. But as soon as people's decisions might have negative consequences for others, there is also *impact uncertainty*: uncertainty about how badly others' well-being will be impacted by the negative outcome. Consistent with past research[1–12], we found decreased prosocial behavior under outcome uncertainty. In contrast, prosocial behavior was increased under impact uncertainty in incentivized economic decisions and hypothetical decisions about infectious disease threats. Perceptions of social norms paralleled the behavioral effects. The effect of impact uncertainty on prosocial behavior did not depend on the individuation of others or the mere mention of harm, and was stronger when impact uncertainty was made more salient. Our findings offer insights into communicating uncertainty, especially in contexts where prosocial behavior is paramount, such as responding to infectious disease threats.**

We constantly face decisions that might have consequences for others, and when our decisions do affect others we can never be certain about how they will react[14–16]. For instance, when there is uncertainty about whether a self-serving action will lead to a potentially negative outcome for others[1] – even when there is just a small chance that it will[4] – people are much more likely to act selfish than when uncertainty is absent. Similarly, if people are uncertain about whether their behavior will deplete a common resource, they are more likely to overharvest[10,11]. Such decreases in prosociality might occur because uncertainty enables people to adopt self-serving narratives that allow them to behave selfishly while maintaining a positive self-image[17,18]. Consistent with this idea, when decision outcomes are uncertain people optimistically underestimate the chance that self-serving behavior will cause negative outcomes for others, making self-serving behavior appear more appropriate to oneself[1,13,19,20]. Perceptions of social norms – shared beliefs about what people should do in a given situation – mirror these results: self-interested behavior when outcomes are uncertain not only appears appropriate to oneself, but also to others[21].

We propose that past research on uncertainty and prosocial behavior has overlooked the possibility that there are different types of uncertainty that may have distinct effects on prosocial behavior. Previous work has focused on what we will call *outcome uncertainty*: "the psychological state in which a decision maker lacks knowledge about what outcome will follow from what choice"[22]. In the context of social decision-making, most past studies have induced uncertainty about whether or not a decision will lead to a negative outcome for others (Fig. 1a). A person might lack knowledge about whether or not, for instance, she will infect another co-worker if she goes to work while sick with the flu, or if a donation will actually reach the people in need. But outcome uncertainty is only one type of uncertainty present in social interactions. As soon as people's decisions might have consequences for others, they may also lack knowledge about how others' well-being will be impacted by the outcomes of those decisions (Fig. 1b). For example, a person might lack knowledge about how badly the flu will impact a co-worker's well-being, or how much a donation will actually improve the welfare of another person. This type of uncertainty, which we will call *impact uncertainty,* is uncertainty related to how much the well-being of others will be affected by a particular outcome.

Outcome and impact uncertainty may arise in relation to the same event (e.g., infecting another person with the flu), but they correspond to different aspects of this event. Outcome uncertainty occurs when a decision-maker lacks knowledge about whether an event (e.g., infecting another person) will occur following a particular choice (e.g. going to work while sick), and as such bears on the decision-maker's causal responsibility for the outcome. In contrast, impact uncertainty occurs when a decision-maker lacks knowledge

about how an event (e.g., infecting another person) will impact the well-being of another person (e.g., how badly they will suffer from the infection), and thus relates to the welfare of another person. These two dimensions may respectively contribute to assessments of responsibility and harm magnitude, which independently influence moral judgments[24]. We note that the conceptual distinction between "outcomes" and "impact" does not correspond with constructs in standard decision theory[23]; while outcome uncertainty indexes uncertainty about states of the world, impact uncertainty indexes uncertainty about subjective utilities over those states. To support our proposition that outcome and impact uncertainty relate to different assessments that might arise in relation to the same event, we demonstrated that laypeople can reliably distinguish between them in real-world scenarios (see Supplementary Methods).

In contrast to outcome uncertainty, little is known about how impact uncertainty affects social behavior. This is surprising because impact uncertainty is omnipresent in social interactions: people often lack knowledge about how badly others will be impacted by the outcomes of their decisions, in large part because other people's subjective experiences are often inaccessible[14,15].

Previous research has investigated how people predict the preferences of others, such as preferences about birthday presents[25], possessions[26], financial or romantic advice[27–31], and forgiveness[32]. This work demonstrates that people often struggle to accurately predict the impact of outcomes on others, even for very close others on important matters such as end of life care for a terminally ill spouse[33]. Moreover, people are at least partially aware of the lack of insight they have into how others will be impacted by an outcome, with the resulting uncertainty inducing stress and anxiety while making decisions for others, and thereafter doubt and guilt over the decisions made[34,35]. However, it remains unclear how the experience of impact uncertainty affects prosocial behavior.

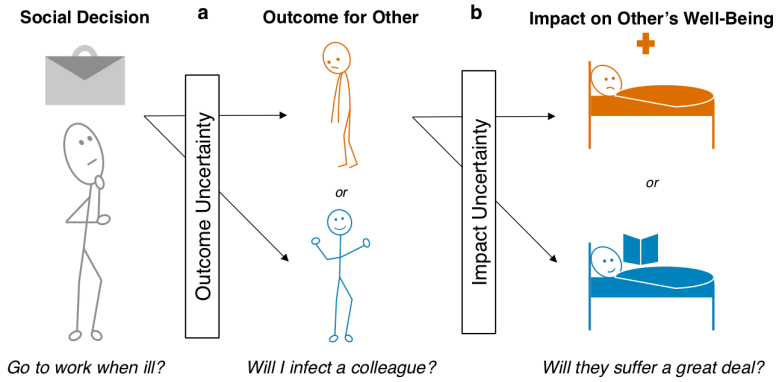


*Figure 1.* A decision might cause a potentially negative outcome for another person, and the negative outcome may have a negligible or large impact on their well-being. (a) *Outcome uncertainty* is uncertainty about whether or not a decision will cause a negative outcome for another person. In the depicted example, the decision to go to work when feeling ill might or might not lead to infecting a colleague. (b) *Impact uncertainty* is uncertainty about how badly the other person's well-being will be impacted by the negative outcome. In the depicted example, infecting a colleague with a disease might cause them a great deal of suffering, or the infection might have only a mild effect.

If impact uncertainty activates self-serving narratives in a similar way to outcome uncertainty, then people may similarly exploit impact uncertainty to justify self-serving behavior. For example, when deciding whether to share money with a stranger whose income level is unknown, people might optimistically assume the stranger is rich and thus would benefit little from generosity, creating a self-serving justification for being stingy. However, a recent study suggests that impact uncertainty may increase rather than decrease prosociality, perhaps by activating a different set of narratives around protecting

others' welfare[36]. Participants in this study chose between different amounts of money in exchange for different numbers of electric shocks delivered to either themselves or an anonymous other person. Strikingly, most people were more averse to harming others than themselves. There was no outcome uncertainty in this experiment, but many participants explained their behavior by appealing to impact uncertainty (e.g., "I knew what I could handle but I was less sure about the other person and didn't want to be cruel"), and behavioral indices of uncertainty predicted prosocial behavior[36]. This suggests impact uncertainty may induce precautionary social preferences, where people prefer to avoid the worst-case scenario.

Thus, impact uncertainty might activate different narratives than outcome uncertainty, and consequently have different effects on prosocial behavior. While outcome uncertainty introduces optimistic and self-serving narratives that mitigate personal responsibility, impact uncertainty may lead people to think more about protecting the welfare of potentially vulnerable others, and thereby increase prosocial behavior. To test these hypotheses, we independently manipulated impact uncertainty and outcome uncertainty within modified Dictator Games (Studies 1-3) and infectious disease scenarios (Study 6). In order to test if it is indeed *impact uncertainty* that drives the observed effects, we examined if simply mentioning the negative *impact* (Study 4), or any type of *uncertainty* about the other person (Study 5) produce similar results. Finally, we tested if people are reluctant to contemplate the harm they might cause to others (Study 7) and if this reluctance can be overcome by making impact uncertainty salient.

To manipulate impact uncertainty, we varied the information participants received about the people potentially affected by their decisions. Specifically, in the studies that involved Dictator Games, we varied the information participants received about the income level of the Receiver they were paired with (Fig. 2a-c). All participants in the experimental conditions learned that some of the Receivers are "near the bottom of the income scale" and "are very dependent on the money they earn to help supplement their income to pay for food and shelter" while others are "at the top of the income scale" and would use the money "to earn a bit of extra spending money, e.g., to use for entertainment." In the *impact uncertainty* condition, participants were then told "The Receiver might rank near the top of the income scale, or they might rank near the bottom, or somewhere in the middle."

Our main goal was to test if people exploit impact uncertainty just like outcome uncertainty and use it to license selfishness, or if instead impact uncertainty promotes prosocial behavior. We included two different conditions in our experiments to test these competing hypotheses, a *certain-rich* and a *certain-poor* condition. In the certain-rich condition, we told participants that "The Receiver ranks near the top of the income scale." If participants exploit impact uncertainty to justify self-serving behavior and optimistically assume their Receiver is rich, prosocial behavior in the impact uncertainty condition should match prosocial behavior in the certain-rich condition. In the *certain-poor* condition, we told participants that "The Receiver ranks near the bottom of the income scale". If participants adopt precautionary preferences under impact uncertainty – as we suggest – then behavior in the impact uncertainty condition should match behavior in the certain-poor condition.

We also included a *control* condition in which participants did not receive any information about income in general or their Receiver's income in particular. This control condition mirrors how previous research has implemented Dictator Games[37] allowing us to examine if the introduction of impact uncertainty increases or decreases prosocial decision-making in comparison to the standard used in decades of research. Furthermore, in everyday life, impact uncertainty is most often implicitly present but not explicitly mentioned, similar to our control condition. Hence, this control condition allows us also to observe if impact uncertainty increases prosociality compared to the conditions encountered in everyday life.

To manipulate outcome uncertainty in the Dictator Games, we replicated the methods of a previous study investigating how outcome uncertainty affects prosocial behavior[1]. Participants played either a standard binary Dictator Game (Fig. 2d), where a self-serving choice led deterministically to a worse outcome for the Receiver (no outcome uncertainty), or

a Hidden Information Game, where a self-serving choice led probabilistically to a worse outcome for the Receiver (outcome uncertainty; Fig. 2e) but participants had the chance to reveal the outcome of the self-serving option beforehand at no cost.

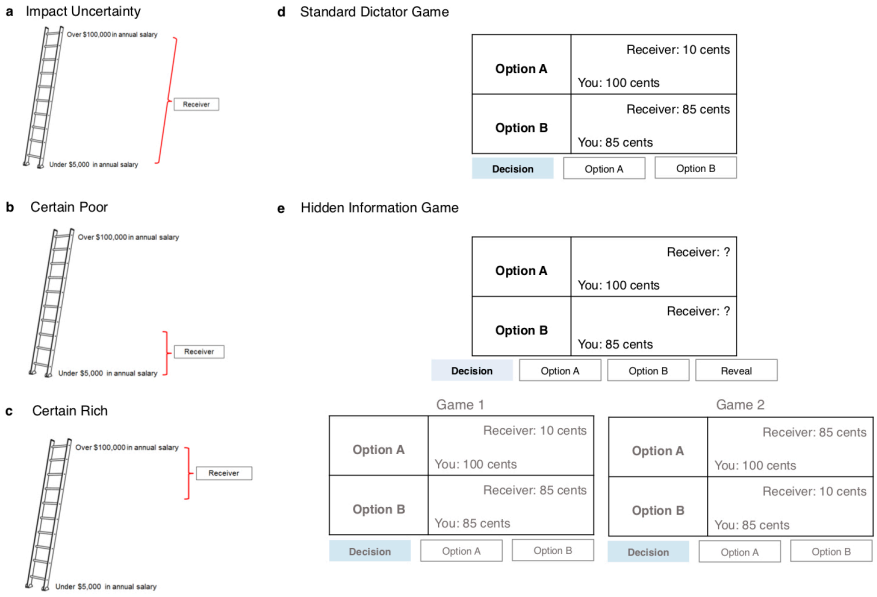


*Figure 2.* Depiction of uncertainty manipulations across experimental conditions. (a) Participants in the impact uncertainty condition learned that with equal chances, the Receiver could be either poor, rich, or somewhere in between. (b) Participants in the certain-poor condition learned that the Receiver was poor. (c) Participants in the certain-rich condition learned that the Receiver was rich. d) Participants in the outcome certainty condition played a standard binary Dictator Game e) Participants in the outcome uncertainty condition played a Hidden Information Game. A virtual coin flip decided on whether Game 1 or Game 2 would be played. In Game 1, Option A would result in 10 cents for the Receiver, but in Game 2 in 85 cents. In Game 1, Option B would results in 85 cents for the Receiver, but in Game 2 in 10 cents for the Receiver. Participants had the chance to reveal which game was played before making the decision.

We used generalized linear models to test the main effects of outcome uncertainty, impact uncertainty, and their interaction on prosocial decisions. Thereafter, we tested the simple effects of outcome uncertainty and impact uncertainty with chi-square tests in order to determine how the conditions affected the distribution of prosocial behaviors in our samples. The model predicted decision type (self-serving or prosocial) with separate regressors for outcome uncertainty (type of Dictator Game: standard, hidden information), impact uncertainty (Receiver information: uncertain, certain-poor, certain-rich, control), and the interaction between outcome and impact uncertainty. As the dependent variable in the Standard Dictator Game, we coded whether participants chose the prosocial option (Figure 2d, Option B). In the Hidden Dictator Game, we coded whether participants chose the reveal option and subsequently took the prosocial option (Fig. 2e Game 1, Option B, and Fig. 2e, Game 2, Option A). We found main effects of outcome uncertainty ($\chi^2(1, N = 832) = 117.84$, $p < .001$, Cohen's $d = 0.81$) and impact uncertainty ($\chi^2(3, N = 832) = 29.33$, $p < .001$, Cohen's $d = 0.38$), but no interaction ($\chi^2(3, N = 832) = 2.99$, $p = .39$). Consistent with previous research[1–3,5,6,38], outcome uncertainty reduced prosocial behavior (Fig. 3a). All of our observed effects remained significant when controlling for participants' income level (see Supplementary Notes).

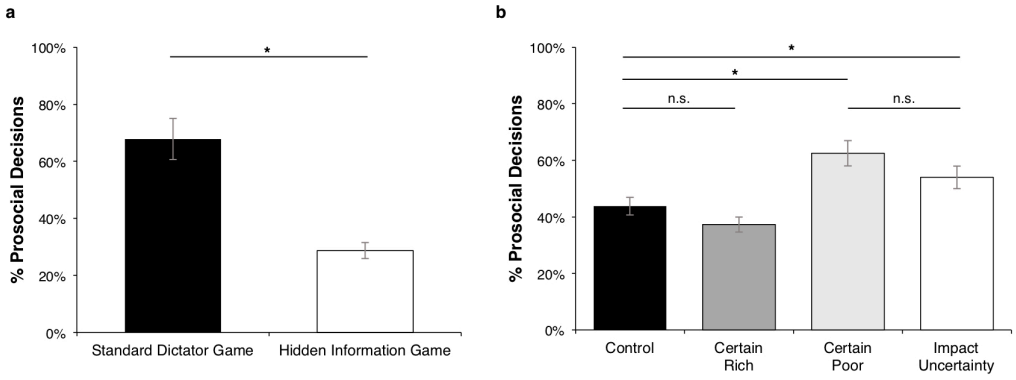


*Figure 3.* a) Percentage of prosocial decisions for the Standard Dictator Game and the Hidden Information Game in Study 1 (N = 833). b) Percentage of prosocial decisions for the four Receiver information conditions: control condition, certain-rich, certain-poor, and impact uncertainty condition in Study 1 (N = 833). Error bars represent standard errors. *$p < 0.01$, n.s. = not significant.

We next examined the effect of impact uncertainty on prosocial behavior. First, we confirmed that participants were sensitive to the income level of Receivers by comparing the proportion of prosocial choices when the Receiver had a low income (certain-poor condition) versus high income (certain-rich condition). Indeed, participants in the certain-rich condition were less prosocial than those in the certain-poor condition ($\chi^2(3, N = 417) = 26.43$, $p < .001$). To investigate whether this difference was driven by increased generosity toward low-income Receivers or by decreased generosity toward high-income Receivers, we compared each of these conditions with the control condition where participants received no information about the income level of the Receivers. As found in previous work[39–41], participants in the certain-poor condition were significantly more prosocial than those in the control condition ($\chi^2(1, N = 418) = 14.67$, $p = .001$, Cramer's $V = .19$). Meanwhile, participants in the certain-rich condition were not significantly less prosocial than those in the control condition, ($\chi^2(1, N = 419) = 1.81$, $p = .18$, Cramer's $V = .06$). This suggests the difference in prosociality between the certain-rich and certain-poor conditions was driven by increased generosity towards low-income Receivers.

To test our main prediction that impact uncertainty increases prosocial behavior, we compared the uncertainty condition with each of the other three conditions. Participants were significantly more prosocial in the uncertainty condition relative to the certain-rich condition ($\chi^2(1, N = 416) = 14.64$, $p = .001$, Cramer's $V = .19$). These results speak against a self-serving exploitation of impact uncertainty, which would predict that participants assume the Receiver in the uncertain condition is rich and thus behave similarly in the uncertain and certain-rich conditions. In contrast, the proportion of prosocial choices in the uncertain condition was not significantly different from that in the certain-poor condition ($\chi^2(1, N = 415) = 1.80$, $p = .18$, Cramer's $V = .06$). These results suggest that participants in the uncertainty condition erred on the side of caution rather than exploiting uncertainty about the impact on the Receiver for their own benefit. Finally, participants in the uncertainty condition were significantly more prosocial than in the control condition ($\chi^2$ (1, $N = 417$) = 6.23, $p = .01$, Cramer's $V = .12$), suggesting that explicitly mentioning impact uncertainty increases its effect on prosocial behavior.

One potential alternative explanation for our findings is that participants believed that the average MTurk participant was low-income. If so, it would be sensible to assume in the uncertainty condition that the Receiver is likely to be low-income, and behave accordingly. We ruled out this explanation in two ways. First, we repeated our analysis of impact uncertainty controlling for participants' beliefs about the average income level of Receivers. The effects of impact uncertainty on prosocial behavior remained significant when controlling for these beliefs, and participants' beliefs about the average income level of Receivers did

not interact with any of our observed effects (see Supplementary Notes). Second, we conducted a new experiment in which we explicitly controlled participants' beliefs about the income level of the Receiver (Study 2). In this study, participants in the impact uncertainty condition were instructed: "We pre-selected three Receivers: a high-income Receiver, a low-income Receiver, and a middle-income Receiver. You will be paired with ONE of these Receivers at random." Using this belief manipulation, we fully replicated the effects of both outcome and impact uncertainty in Study 2 (see Supplementary Notes).

In a third study, we showed that the opposing effects of outcome and impact uncertainty on prosocial behavior are paralleled at the level of beliefs about social norms, measured via an incentivized coordination game (see Supplementary Notes). Since general beliefs about social norms are independent from specific beliefs about a particular social interaction (including beliefs about the income of the Receiver), the fact that participants believe that others think selfish behavior is wrong when facing impact uncertainty, but acceptable when facing outcome uncertainty, lends further support to our claim that impact and outcome uncertainty activate distinct narratives about the appropriateness of self-serving behavior.

One might wonder, however, if impact uncertainty is indeed necessary to increase prosocial behavior, or if simply mentioning relative income or the worst possible case is sufficient to produce similar results. In Study 4, we tested if just mentioning the possibility of the Receiver being poor, rather than introducing uncertainty about it, is sufficient to increase prosocial behavior. In this study the control condition explicitly mentioned that online participants come from all walks of life, some "are poor (meaning their income is below the poverty threshold) and are very dependent on the money they earn on Prolific to help supplement their income to pay for food and shelter". We induced impact uncertainty by informing participants that the Receiver might be either poor or rich with a probability of 50% each (Supplementary Methods for details). Again, we found that participants in the impact uncertainty condition behaved more prosocially than participants in the control condition, ($\chi^2$ (1, $N$ = 401) = 5.72, $p$ = .018, Cramer's $V$ = .12), and just as prosocially as participants in the certain-poor condition, ($\chi^2$(1, $N$ = 400) = 0.035, $p$ = .852, Cramer's $V$ = .009), suggesting that it is indeed uncertainty about the impact of one's decision that drives the increase in prosocial behavior.

Study 4 also investigated the question of what level of impact uncertainty may be necessary to enhance prosocial behavior. In the studies reported so far, participants either faced moderate (33% chance of Receiver being poor), or relatively high (50% chance of Receiver being poor) levels of impact uncertainty. In both cases, participants acted more prosocially relative to the control condition. In Study 4 we included a low impact uncertainty condition, in which participants learned that their Receiver might be poor with 10% chance, or rich with a 90% chance. The low impact uncertainty condition was not significantly different from the control condition, $p$ = .284, leaving open the question of the lowest possible threshold required to elicit impact uncertainty's effect on prosocial behavior.

Study 4 also included measures of cognitive and affective empathy (QCAE)[42] and wise reasoning[43] to investigate whether impact uncertainty's prosocial effect depends on individual differences. While we found significant main effects of cognitive and affective empathy, as well as wise reasoning, on prosocial behavior, the conditional effect of *impact uncertainty* remained significant when we controlled for these individual differences. However, exploratory analyses suggested that the effects of impact uncertainty on prosocial behavior may be partially mediated by cognitive empathy (see Supplementary Methods for details and further exploratory analyses).

We next turned to a potential alternative explanation for our findings: one might argue that it is not necessarily uncertainty about the *impact* of the outcomes on another person that drives the increase in prosociality, but rather that uncertainty about any individuating aspect of the Receiver might be sufficient. Indeed, previous work has shown that individuation of others increases prosocial behavior towards them[44–46]. Thus, reading that the Receiver "might be rich, poor, or something in between" in our instructions may have induced participants to think about the Receiver as an individual, resulting in increased prosocial

behavior under impact uncertainty. If this was the case, then we should observe increased prosociality under uncertainty even when the dimension participants are uncertain about is irrelevant to the potential harm caused by the outcomes. For instance, it might be sufficient to induce uncertainty about whether or not the Receiver is extroverted or introverted.

To test this alternative hypothesis, we provided participants with different information about the Receiver's extroversion (Study 5). Participants randomly assigned to the uncertain condition read that the Receiver "could be extroverted, introverted, or somewhere in between". In the certain-extrovert and certain-introvert conditions, participants read that the Receiver is extroverted or introverted respectively, while participants in the control condition did not receive any additional information about the Receiver. We did not find a significant difference in prosocial decisions across conditions ($\chi^2(3, N = 862) = .94$, $p = .82$). Thus, participants made as many prosocial choices under impact uncertainty (73%) as they did when being certain about the Receiver's intro-/extroversion (both conditions 72%), or when they did not learn any information about the Receiver at all (69%). Taken together, our results show that the increase in prosocial behavior in our experiments was due to uncertainty about the negative impact of one's actions on others as opposed to simply mentioning negative impact (Study 4) or inducing any kind of uncertainty about the other person (Study 5).

Next, we examined if the effects of impact uncertainty are restricted to economic decisions by testing if we can replicate the results using hypothetical medical decisions concerning the threat of infectious disease. We chose infectious disease since fighting the threat of them depends on behaviors with social consequences (e.g., vaccinations, hygiene, or isolation). In Study 6, participants were asked to imagine the following scenario: "Eight days after you arrived back from a lovely Safari trip to Tanzania, Africa, you feel unwell: feverish and dizzy. You go to the doctor and learn that you have the African Flu. The doctor warns you that African Flu is contagious: people you come into contact with may get infected. [The following sentence differed across condition, see below and Supplementary Methods]. However, you still feel able to work and you really want to go to the office for finishing a project that is important for your career." (Supplementary Methods for complete instructions). Participants were then asked to indicate how likely they were to stay home (prosocial intention).

We manipulated impact uncertainty by varying the information participants received about the vulnerability of people they might infect at work. Participants in the impact uncertainty condition read that if they would go to work, there was a chance they would infect a young co-worker, for whom the African Flu would be unproblematic, but also a chance they would infect an old co-worker, for whom the African Flu would be dangerous. This impact uncertainty condition was compared to a worst-case condition, in which participants learned that if they would go to work they would infect an old co-worker, and to a control condition in which they did not receive additional information about the vulnerability of their co-workers. We found that participants in the impact uncertainty and the *worst-case* condition were significantly more likely to stay home compared with participants in the control condition ($U = 60.75$, $p = .004$, $\eta^2 = .075$; $U = 90.653$, $p < .001$, $\eta^2 = .075$). Again, we found no difference in prosocial intention under impact uncertainty compared to the worst-case condition ($p = .343$); under impact uncertainty people formed similar intentions to protect others as when the worst case was certain.

Our findings suggest that under impact uncertainty, people consider the potential harmful impact of their actions on others, leading them to err on the side of caution. Yet, people are often reluctant to consider how others could be harmed by their decisions[43]. It may be that the effects of impact uncertainty rely on overcoming a reluctance to consider harming others, and are only induced if the possibility of others' suffering is made salient to a degree at which people can no longer neglect this possibility when forming a decision. We tested this in a final study, by manipulating the salience of the uncertainty information. We manipulated salience by repeating information, which is one of the most effective ways to increase the salience of information[47] and the likelihood that people attend to this information[48,49].

We included three conditions where the income of the Receiver was uncertain, a fact that was made salient to different degrees. In the control condition, participants did not receive any information about the Receiver's income. In the low salience condition, participants were told that "MTurkers come from all walks of life", additionally mentioning that some "are very dependent on the money they earn on MTurk to help supplement their income" while others "use MTurk as a way to earn a bit of extra spending money". Then, we told them that "We pre-selected three Receivers: a high-income Receiver, a low-income Receiver, and a middle-income Receiver. You will be paired with ONE of these Receivers at random." In the high salience condition – which matched our previous impact uncertainty manipulations – participants received the same information, but we additionally highlighted impact uncertainty by telling participants "The Receiver might rank near the top of the income scale, or they might rank near the bottom, or somewhere in the middle." We found a significant difference in the proportion of prosocial decisions across conditions ($\chi^2(2, N = 468) = 6.02$, $p = .049$, Cramer's $V = .11$). Paired comparisons showed that participants in the high salience condition were more prosocial than participants in the low salience condition ($\chi^2(1, N = 314) = 5.15$, $p = .023$, Cramer's $V = .13$) and the control condition ($\chi^2(1, N = 311) = 4.39$, $p = .036$, Cramer's $V = .12$), which did not differ from one another ($p = .86$).

To summarize, we show that uncertainty does not always decrease prosocial behavior; instead, the type of uncertainty matters. Replicating previous findings[1–3,6,13,38,50], we found that outcome uncertainty – uncertainty about the outcomes of decisions – made people behave more selfishly. However, impact uncertainty about how an outcome will impact another person's well-being increased prosocial behavior, in economic and health domains. Examining closer the effect of impact uncertainty on prosociality, we show that for the increase in prosociality to occur, simply mentioning negative outcomes or inducing uncertainty about aspects of the other person unrelated to the negative outcome is not sufficient to increase prosociality. Rather, it seems that uncertainty relating to the impact of negative outcomes on others is needed to increase prosociality in our studies. Finally, we show that impact uncertainty is only effective when it is salient, thereby potentially overcoming people's reluctance to contemplating the harm they might cause.

Recent theoretical work highlights the power of stories (or narratives) people tell themselves (and others) to justify self-serving behavior[17]. Applied to our findings and supported by Study 3, this framework suggests that outcome uncertainty activates self-focused narratives that enable people to tell themselves that it is very unlikely that a negative outcome for the other person will occur, allowing them to reap the benefits of self-interested actions without feeling selfish[17]. Such self-focused narratives decrease prosociality by downplaying the potential social costs of self-interested actions. In contrast, our findings suggest that impact uncertainty activates other-focused narratives that include potential social costs, leading participants to adopt behaviors that preserve others' welfare. Notably, such other-focused narratives might also cater for self-image concerns (e.g., "only a horrible person would risk infecting a vulnerable other"). Future work, perhaps combining qualitative with quantitative methods, might more directly investigate the content of the narratives motivating people's social behavior and use these insights to explain how uncertainty encourages (or discourages) prosocial behavior.

Another important avenue for future research is to examine how other situational features factor into impact uncertainty's effect on prosociality. We find, for instance, that effect sizes for high and moderate levels of impact uncertainty (50% and 33% chance of negative impact) are similar, whereas the effect size for low impact uncertainty (10% chance of negative impact) is substantially lower. Based on this observation, we tentatively propose that representations of the expected harmfulness of one's decision's impact on others could be described as a convex function that is increasingly steep under impact uncertainty: above a certain level, impact uncertainty uniformly affects prosocial behavior such that people choose whatever option minimizes harm to others. One might speculate that this threshold level depends on further features of the situation. For example, people might be more prone to minimize harm and act prosocially if the harm is physical versus non-physical. People might be willing to maximize their personal outcomes under a 1% chance that another

person receives 75 cents less, but people might not be willing to maximize their personal outcomes if there is a 1% chance that they could endanger a pregnant women and the unborn child with an infectious disease.

Our findings highlight the potential for using impact uncertainty to nudge people towards prosociality. For instance, we found that participants facing impact uncertainty reported they would be more willing to adopt behavior that would help containing the threat of infectious disease, highlighting the relevance of our findings for addressing global threats. While the communication of such global threats often emphasizes outcome uncertainty (e.g., "What Are the Chances of a Devastating Pandemic Occurring in the Next 50 Years?"[51]), impact uncertainty is rarely communicated. Our work suggests, however, that when communicating uncertainty, policy makers, public health officials, and others should consider which type of uncertainty they intend to communicate. Since outcome uncertainty biases people towards self-interested behavior, highlighting impact uncertainty instead may lead to more prosocial decision-making.

## Methods

All studies were approved by the University of Oxford's Central University Research Ethics Committee (Approval number: MSD-IDREC-C1-2014-005) and participants in each study gave their informed consent beforehand.

### *Study 1*

***Participants.*** We determined sample size using G-Power 3.1[52] (See SI methods). A total of 833 participants were recruited via Amazon's Mechanical Turk (AMT or MTurk). AMT provides reliable participants who are ethnically and socioeconomically more diverse than university-recruited participants[53,54]. We paid participants in line with US minimum wage.

***Procedure.*** Participants were instructed that their decision determined the exact monetary amount themselves and a Receiver would obtain. The experiment did not involve deception as a corresponding number of Receivers was randomly recruited from unrelated studies on MTurk and paid according to participants' choices. We manipulated *outcome* and *impact uncertainty* as between-subject factors with two and for levels respectively.

To manipulate outcome uncertainty, each participant was randomly assigned to one of two conditions - Standard Dictator Game (outcome certainty) or Hidden Information Game (outcome uncertainty, see Fig.2, d & e). The standard Dictator Game (Fig.2, d) mirrored the baseline game in Dana and colleagues[1]. Here, participants were presented with two options, A and B. Option A – the self-serving option – meant that the Decider would receive 100 cents, and the Receiver would get 10 cents. Option B – the prosocial option – meant that the Decider would get 85 cents and the Receiver would get 85 cents. The Hidden Information Game was adapted form the uncertainty treatment in Dana and colleagues[1]. Participants first saw a game table that only specified the outcomes for the Decider (i.e., themselves), but not for the Receiver. If choosing Option A, participants would get 100 cents, if choosing Option B, participants would get 85 cents. The Receiver's outcome would depend on a virtual coin-flip, determining whether Game 1 or Game 2 would be played. In Game 1, Option A would result in 10 cents for the Receiver, but in Game 2 in 85 cents. In Game 1, Option B would results in 85 cents for the Receiver, but in Game 2 in 10 cents for the Receiver. Participants learned that they could reveal which Game was played before making their decision at no cost. Hence, participants could choose Option A (the self-serving option), Option B, or reveal which game was being played before making their decision. If participants chose to reveal the game, they saw which game was played, and were then prompted to choose between Option A and B.

To manipulate impact uncertainty, each participant except those in the control condition read the following description of the Receivers: "MTurkers come from all walks of

life, with different educational backgrounds and income levels. Some MTurkers, for instance, rank near the bottom of the income scale, and are very dependent on the money they earn on MTurk to help supplement their income to pay for food and shelter. Others rank in the middle-to-high end of the income scale, and use MTurk as a way to earn a bit of extra spending money, e.g. to use for entertainment." Participants then were randomly assigned to one of four conditions: impact uncertainty, certain-poor, certain-rich, and control condition. Participants in the impact uncertainty condition read that "The Receiver might rank near the top of the income scale, or they might rank near the bottom, or somewhere in the middle." Participants in the certain-poor condition read that: "The Receiver ranks near the bottom of the income scale." Participants in the certain-rich condition learned that: "The Receiver ranks near the top of the income scale." Participants in the control condition did not receive any information about the Receiver.

***Study 2***

***Participants.*** A total of 1,320 participants were recruited via Prolific, a crowdsourcing platform to recruit participants online (prolific.ac) similar to AMT. Sample size was determined using effect size estimates from Study 1 and aimed at replicating findings with a power of .80.

***Procedure.*** The procedure was the same as in Study 1, but we manipulated impact uncertainty differently in order to control for participants' beliefs about Receivers' income. This time, participants in the uncertain condition read: "We pre-selected three Receivers: a high-income Receiver, a low-income Receiver, and a middle-income Receiver. You will be paired with ONE of these Receivers at random. Thus, the Receiver you are paired with might rank near the top of the income scale, or they might rank near the bottom, or somewhere in the middle."

***Study 3***

***Participants.*** A total of 742 participants were recruited via AMT.

***Procedure.*** To examine perceived social norms about the options presented in Studies 1-2, we used a mixed design with impact uncertainty as within-subjects factor (certain poor, certain rich, impact uncertainty) and outcome uncertainty (standard Dictator Game, Hidden Information Game) as between-subjects factor. All participants played an incentivized coordination game[21]. In this game, they were presented with the same instructions that participants saw in Studies 1-2, but instead of deciding themselves between Options A and B, they were asked to indicate how "socially appropriate" or "socially inappropriate" each of these options were (for details see SI methods).

***Study 4***

***Participants.*** A total of 807 participants were recruited via Prolific.

***Procedure.*** We used a between-subjects design with an independent variable of four levels, high impact uncertainty, low impact uncertainty, certain poor, and control. The procedure was the same as in Study 1 with the Standard Dictator Game, but this time all participants – including those in the control condition – read the following general information about Receivers: "Prolific Workers come from all walks of life, with different educational backgrounds and income levels. Some Prolific Workers, for instance, are poor (meaning their income is below the poverty threshold) and are very dependent on the money they earn on Prolific to help supplement their income to pay for food and shelter. Other Prolific Workers have a high income, and use Prolific as a way to earn a bit of extra spending money, e.g. to use for entertainment". Deciders in the high impact uncertainty condition were then told that there was a 50% chance that their Receiver was poor, and a 50% chance that they were rich. In Studies 1-3, we had told Deciders that their Receiver may be poor, or rich, or somewhere with a 33% probability each. We now used only the two extremes (i.e., poor and rich) with a 50% split, because it is not intuitive what the norm for behavior towards a

middle-income Receiver should be and in fact this aspect is not relevant to our research question. Participants in the low impact uncertainty condition were told that there was a 10% chance their Receiver was poor and a 90% chance their Receiver was rich. The certain poor condition was the same as in Study 1. After participants made their decision in the Dictator Game, they answered questions about their demographics and completed individual differences measures. These included a measure of cognitive and affective empathy with well-established psychometric properties, QCAE[42] and a measure of wise reasoning[43].

***Study 5***

***Participants.*** A total of 862 participants were recruited via AMT.

***Procedure***. In a between-subjects design, participants learned that we pre-selected three types of Receivers – an extroverted Receiver, an introverted Receiver, and a Receiver who ranks in the middle – and that they would be randomly paired with one of them. Mirroring the impact uncertainty manipulation used in Studies 1-2, participants in the certain-extrovert condition learned that the Receiver was extroverted, participants in the certain-introvert condition learned that the Receiver was introverted, and participants in the control condition did not receive any information about the Receiver. Thereafter, all participants played the Standard Dictator Game (Figure 2d).

***Study 6***

***Participants.*** A total of 903 participants was recruited via AMT.

***Procedure.*** We used a 3 (*uncertainty*: impact uncertainty vs worst-case certainty vs control) by 2 (*possibility*: implicit vs explicit) between-subjects design to replicate our previous finding's robustness using a scenario-based paradigm and to investigate whether impact uncertainty shifts people's representation of possible outcomes for others towards the worst-case possibility. Manipulations for the uncertainty conditions were based on a fictive scenario set in the context of infectious disease. The implicit versus explicit possibility manipulation was based on a paradigm introduced recently[55] (see SI notes). The introductory text for the infectious disease scenario was the same across all conditions and read "Eight days after you arrived back from a lovely Safari trip to Tanzania, Africa, you feel unwell: feverish and dizzy. You go to the doctor and learn that you have the African Flu. The doctor warns you that African Flu is contagious: people you come into contact with may get infected [This middle part differed across conditions, see below]. However, you still feel able to work and you really want to go to the office for finishing a project that is important for your career". The scenario middle-part differed across uncertainty conditions: in the impact uncertainty condition, participants learned there "is a chance that you would infect co-workers who are healthy people for whom the African Flu is unproblematic (e.g., a young person) so that they would only barely suffer. But there is also a chance that you would infect co-workers who are vulnerable people (e.g., an old person) for whom the African Flu is very dangerous so that they would suffer severely". In the worst-case certainty condition, participants learned that most co-workers were vulnerable and hence that if they would go to work, they were most likely to infect a vulnerable person. Participants in the control condition did not receive any information related to the vulnerability of their co-workers. Participants then made two possibility judgments (possibility that co-workers are vulnerable; possibility to infect co-workers) presented in random order either under time pressure (implicit condition), or without time limit (explicit condition; see SI methods for exemplary instructions). Following their possibility judgment, participants proceeded to indicate whether they would go to work in the scenario they had read, or not, on a 7-point Likert scale from "definitely not" to "definitely".

***Study 7***

***Participants.*** A total of 468 participants were recruited via Prolific.

***Procedure***. We used a between-subjects design. In the low salience condition, participants read that we had pre-selected one high income, one middle income, and one low income Receiver, and that they would be randomly paired with one of these three Receivers. In the high salience condition, participants were additionally told: "The Receiver might rank near the top of the income scale, or they might rank near the bottom, or somewhere in the middle." In the control condition, participants did not receive any information about the Receiver's income before making their decisions. Thereafter, all participants played the Standard Dictator Game (Figure 2d).

## Data availability

The data that support the findings of this study are available from the corresponding authors upon reasonable request.

## Code availability

The computer code that supports the findings of this study is available from the corresponding authors upon reasonable request.

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**Author contributions**

A.K and M.J.C. developed the research concept. A.K., M.J.C., and A.-M.N. designed the studies. Testing and data collection were performed by A.K and A.-M.N. A.K. performed the data analysis and interpretation in collaboration with A.-M.N. and M.J.C. A.K, A.-M.N. and M.J.C. drafted the manuscript and all other authors provided critical revisions. All authors approved the final version of the manuscript for submission.

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The authors declare no competing interests.

**Supplementary Methods**

*Power calculations*

For Study 1, we used effect size estimates from related work by Dana and colleagues[1], and determined that a sample size of 800 participants would be required to achieve a power of .90. For Study 2, we used effect size estimates from our Study 1, and determined that we would need a sample of 1300 to replicate our findings with a power of .80. For Study 3, we used effect size estimates from Krupka and Weber[2] and determined that we would need a sample of 750 participants to achieve a power of .80. For Study 4, we sampled 800 participants based on the expectation that a sample of 200 participants per condition allow us to achieve the necessary power to detect small to medium ($d$ = .3). Post-hoc power calculations confirmed that we achieved a power equal or greater than .84 in our logistic regression models. For Study 5, we used average effect size estimates from Study 1 and 2, and determined that we would need 850 participants to achieve a power of .90. We assumed a small effect size ($d$ = .2) for the scenario-based Study 6 and determined we would need a sample of 900 to achieve a power of .80. Finally, for Study 7, we used we used average effect size estimates from Study 1 and 2, and determined that we would need a sample of 450 participants for a power of .80.

*Attrition Rates*

A recent paper[3] showed that online studies might violate the assumption of random assignment: sometimes participants drop out of one condition more often than from another. Since our conditions were brief, and did not differ in length, it appears unlikely that this would have affected our study. In Study 1, we had an attrition rate of 1.8%, in Study 2 of 1.4%, in Study 3 of 2.9%, in Study 4 of 1.7%, in Study 5 of 0.6%, in Study 6 of 3.2% and in Study 7 of 1.5%. Hence, attrition rates cannot explain the reported differences between conditions in our studies.

*Definition Study*

We wanted to test whether a naïve audience can easily distinguish between the two types of uncertainty in realistic examples. For this, we recruited a total of 70 participants were recruited via Amazon's Mechanical Turk (AMT). Participants first were presented with the definitions of both types of uncertainty used in the revised manuscript. The definitions were presented on separate pages. The first definition referring to outcome uncertainty read that this type is about "not knowing whether or not a negative outcome will occur", while the definition for impact uncertainty read that here uncertainty is about "not knowing how a negative outcome will impact another person". Both definitions were followed by two

examples including the flu scenario (for outcome uncertainty: “a sick worker might wonder whether or not he will infect a co-worker if he goes to work”; impact uncertainty: “a worker might wonder how bad an infection would be for their co-worker”) and a graphic illustration of it.

On the subsequent page, participants had to answer a simple comprehension check about the respective types of uncertainty. Thereafter they were presented with an outcome and impact uncertainty case of three different real-world scenarios (yielding six versions) in a randomized order. Participants were asked to imagine themselves in these scenarios. One scenario asked them to imagine they are running a company and deciding whether to fire an employee (outcome uncertainty “You are uncertain about whether or not this employee will find a new job soon.”; impact uncertainty: “You are uncertain about how bad it will be for this employee if they do not find a new job soon.”). Another scenario asked them to imagine themselves as a tour guide deciding whether to take tourists to a volcanic island, for which scientists issued an eruption warning (outcome uncertainty: “You are uncertain about whether or not the volcano will erupt.”; impact uncertainty: “You are uncertain about how badly a volcano eruption would injure any tourists on your excursion.”). A third scenario asked them to imagine deciding whether to send a present for one’s best friend’s birthday at the last minute (outcome uncertainty: “You are uncertain about whether or not your present will arrive on time.”; impact uncertainty: “You are uncertain about how bad it would be for your friend if the present would not arrive on time.”). For each scenario, participants were then asked to indicate it was example of outcome or impact uncertainty, or whether they were not sure.

We found that the three scenarios exemplifying outcome uncertainty were correctly identified as such by 98 (firing an employee), 97 (leading tourists to volcano) and 94 (sending present to friend) percent of participants. The three scenarios exemplifying impact uncertainty were correctly identified as such by 97 (firing an employee), 94 (leading tourists to volcano), and 94 (sending present to friend) percent of participants. Only two participants indicated they were not sure for two of the scenarios. These results suggest that the difference between outcome and impact uncertainty is sufficiently intuitive for a naïve audience to reliably distinguish between these two types across various real-world examples.

*Study 3*

***Procedure***. Participants were introduced to the Dictator Game setup used in Studies 1-2 and instructed that they would be asked to predict how the other participants in their experiment evaluated the social appropriateness of the different possible choices available to the Decider. Socially appropriate behavior was defined as “consistent with moral or proper social behavior,” “behavior that most people agree is the ‘correct’ or ‘ethical’ thing to do”[2].

Participants then worked on an unrelated example situation. Thereafter, they learned that, at the end of the study, we would randomly select one of the Decider's choices. If the participant had given the response most frequently given by the other participants, then the participant would receive an additional 30 cents.

*Study 4*

***Procedure***. Different to the impact uncertainty manipulation used in Studies 1-3, instructions for this condition in Study 4 informed Deciders that their Receiver could be poor, or rich, with a 50% probability each. We introduced this modification to provide another test for the robustness of impact uncertainty's effect, and because the binary case is more intuitive. Note that for the binary case, uncertainty is maximal at the 50/50 chance distribution, whereas it is maximal at the 33/33/33 distribution for the previously used poor/middle-income/rich segmentation.

*Study 6*

***Procedure (implicit/explicit manipulation)***. The implicit versus explicit possibility manipulation was based on a paradigm introduced recently by Phillips and Cushman[4], in which participants have to judge whether a given even event is possible or not either under time pressure (implicit possibility judgement), or without time pressure (explicit possibility judgement). To ensure participants have internalized the required responses for possible (pressing the [ f ] key) versus impossible (pressing the [ j ] key) judgments, they went through a training phase of 20 trials during which the words "possible" and "impossible" appeared each 10 times in a random order and participants had to press the adequate key. Participants who performed below 60 percent accuracy on these training trials were excluded from all analyses. Exemplary instructions for the implicit condition read "Please answer as quickly and accurately as you possibly can. Remember that you will only have about 1 second to respond to each event". Conversely, participants in the explicit condition read "Please take your time and carefully reflect on these questions. Make sure you do not answer too quickly or carelessly".

**Supplementary Notes**

*Additional results*

*Study 1*

We examined the effects of outcome and impact uncertainty on prosocial decision-making, using modified Dictator Games. Consistent with previous studies using this paradigm, when looking at those participants who revealed the game and faced the same pay-off as participants in the Standard Dictator Game (Figure 2d, Game 1), we found that more than 90% chose the prosocial option, suggesting that revealing the pay-off structure was prosocially motivated. When examining the participants who revealed the game and faced a pay-off in which the self-serving option coincides with the prosocial option (Figure 2b, Game 2), we found that all participants chose the self-serving / prosocial option.

Our results suggest that participants under impact uncertainty (i.e., in the uncertain condition) erred on the side of caution and assumed the worst possible impact outcome for the Receiver. One might suspect that the income of the participants could have driven the differences in self-interest between the different impact uncertainty conditions. We tested this possibility in a Generalized Linear Model with decision as a binary dependent variable and the information conditions, participants' income level, and the interaction between conditions and participants' income level as independent variables. We did not find a significant interaction between information condition and participants income level ($\chi^2(3, N = 800) = 3.23$, $p = .36$), indicating that the effect of information condition did not depend on participants' income level. We then examined the main effects for the impact uncertainty manipulation and income on prosocial decisions. This analysis revealed that participants with higher incomes were more prosocial ($\chi^2(1, N = 800) = 4.53$, $p = .03$), but the main effect of impact uncertainty remained significant ($\chi^2(3, N = 800) = 33.39$, $p < .001$), when controlling for income. Impact uncertainty affected participants' choices regardless of their own income level.

An alternative explanation is that participants in the uncertain condition assumed that most other participants on AMT – the platform we used to recruit participants – are in fact in the lowest income bracket, making it appropriate for them to choose relatively prosocial. To rule out this possibility we asked a subset of participants ($N = 414$), at the very end of the study, to estimate how many out of 100 workers on AMT would be in the highest income bracket, middle bracket, and lowest income bracket. One average, these participants believed that about 10 workers would be in the highest income bracket (Mi$N = 0$, Max = 72; S$D = 13.32$), that about 40 workers would be in the medium income bracket (Mi$N = 0$, Max = 100; S$D = 17.87$), and that about 50 workers would be in the low income bracket (Mi$N = 0$, Max = 100; S$D = 22.87$). We then repeated the same control analysis as for income level to

rule out the possibility that the impact uncertainty effects were driven by participants' estimated proportion of AMT workers in the lowest income bracket. We did not find a significant interaction between impact uncertainty condition and the estimated proportion of AMT workers in the lowest income bracket ($\chi^2(3, N = 414) = 1.08$, $p = .78$). When subsequently examining the main effects, we found no significant effect of the estimated proportion of AMT workers in the lowest income bracket on self-serving choices ($\chi^2(1, N = 414) = 0.08$, $p = .77$), but the main effect of impact uncertainty on prosociality remained significant ($\chi^2(3, N = 414) = 18.25$, $p < .001$).

Similarly, for the estimated proportion of the AMT workers in the highest income bracket, we found neither a significant interaction effect with impact uncertainty ($\chi^2( (3, N = 414) = 1.08$, $p = .77$), nor main effect for the estimated proportion ($\chi^2(1, N = 414) = 0.13$, $p = .72$), but the main effect of impact uncertainty on prosociality remained significant ($\chi^2(3, N = 414) = 18.16$, $p < .001$) when controlling for the estimated proportion of AMT workers in the highest income bracket. Taken together, these results indicate that the observed effect of impact uncertainty on prosocial behavior was not merely a reflection of an assumption that most AMT workers are in the lowest income bracket.

*Study 2*

We examined the independent and interactive effects of outcome and impact uncertainty on prosocial decision-making in a Generalized Linear Model predicting decision type (self-serving or prosocial) with separate regressors for outcome uncertainty (type of Dictator Game: Standard, Hidden Information), impact uncertainty (Receiver information: uncertain, certain-poor, certain-rich, control), and the interaction between outcome and impact uncertainty. We found a main effect of outcome uncertainty ($\chi^2(1, N = 1193) = 129.078$, $p < .001$), a main effect of impact uncertainty ($\chi^2(3, N = 1193) = 28.34$, $p < .001$), but no interaction effect ($\chi^2(3, N = 1193) = 2.45$, $p = .48$).

We next examined the effect of outcome uncertainty on prosociality more closely. In line with previous research , under outcome uncertainty (Hidden Information Game) participants behaved less prosocial than under outcome certainty (Standard Dictator Game) ($\chi^2(3, N = 1193) = 133.92$, $p < .001$, Cramer's $V = .33$). About a third of participants in the Hidden Information Game chose the prosocial option compared to more than two thirds of participants in the Standard Dictator Game. These percentages resemble the findings of previous laboratory studies[1].

Then, we examined the effect of impact uncertainty on prosociality. We first confirmed that participants in both studies were sensitive to the income level of Receivers by comparing the proportion of prosocial choices when the Receiver had a low income (certain-poor

condition) versus high income (certain-rich condition). Participants in the certain-rich condition were less prosocial than those in the certain-poor condition ($\chi^2(1, N = 591) = 21.87$, $p < .001$, Cramer's $V = .19$). To investigate whether this difference was driven by increased generosity toward low-income Receivers or by decreased generosity toward high-income Receivers, we compared each of these conditions with the control condition where participants received no information about the income level of the Receivers. Participants in the certain-poor condition were significantly more prosocial than those in the control condition ($\chi^2(1, N = 595) = 14.54$, $p < .001$, Cramer's $V = .16$). Meanwhile, participants in the certain-rich condition were not significantly less prosocial than those in the control condition, ($\chi^2(1, N = 596) = .79$, $p = .37$, Cramer's $V = .037$). This suggests that the difference in prosociality between the certain-rich and certain-poor conditions was driven by increased generosity toward low-income Receivers.

To test our main prediction that impact uncertainty increases prosocial behavior, we compared the uncertain condition with each of the other three conditions. Participants were significantly more prosocial in the impact uncertainty conditions relative to the certain-rich conditions ($\chi^2(1, N = 598) = 8.63$, $p = .004$, Cramer's $V = .12$). These results speak against a self-serving exploitation of impact uncertainty. In contrast, the proportion of prosocial choices in the uncertain conditions was not significantly different from that in the certain-poor condition ($\chi^2(1, N = 597) = 3.19$, $p = .07$, Cramer's $V = .06$). And finally, participants in the impact uncertainty condition were significantly more prosocial than in the control condition ($\chi^2(1, N = 602) = 4.26$, $p = .04$, Cramer's $V = .08$). These results suggest that participants in the uncertain condition erred on the side of caution rather than exploiting uncertainty about the income level of the Receiver.

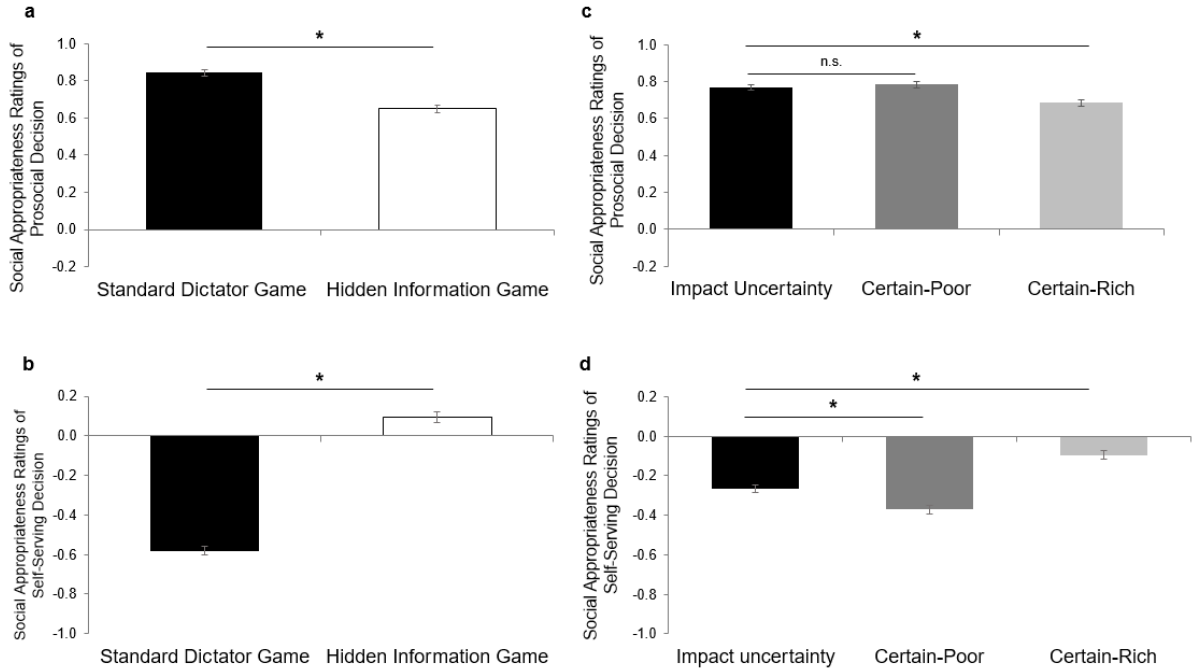
Again, we did not find a significant interaction between information condition and participants income level ($\chi^2(3, N = 1193) = 3.03$, $p = .35$), indicating that the effect of information condition did not depend on participants' income level. We then examined the main effects for the impact uncertainty manipulation and income on prosocial decisions. This analysis revealed that participants' incomes did not affect the results ($\chi^2(1, N = 1193) = 0.70$, $p = .43$), and the main effect of impact uncertainty remained significant ($\chi^2(3, N = 1193) = 26.10$, $p < .001$), when controlling for income. Impact uncertainty affected participants' choices regardless of their own income level.

*Study 3*

We replicated the opposing effects of outcome and impact uncertainty on prosociality by examining their distinct effects on social norms, using an incentivized coordination game[2] and the Dictator Games used in Study 1 and 2. The effects of both types of uncertainty on social norms mirrored those on behavior (Supplementary Figure 1). Under outcome

uncertainty, the self-serving choice was perceived as less socially appropriate when the Receiver's outcome was certain, relative to when it was uncertain, ($p < .001$, $\eta^2 partial = .32$). Furthermore, the prosocial choice was perceived as less socially appropriate when the Receiver's outcome was uncertain, relative to when it was certain, ($p < .001$, $\eta^2 partial = .06$). Under impact uncertainty, participants perceived the self-serving choice to be less socially appropriate in the uncertainty condition than in the certain-rich condition, ($p < .001$, $\eta^2 partial = .09$), but more socially appropriate in the uncertain condition than in the certain-poor condition, ($p < .001$, $\eta^2 partial = .04$). When examining the appropriateness evaluations of the prosocial choice, we found that participants perceived the prosocial choice to be more socially appropriate in the uncertain condition than in the certain-rich condition, ($p < .001$, $\eta^2 partial = .04$), and as equally socially appropriate in the uncertain condition as in the certain-poor condition, ($p = .27$, $\eta^2 partial = .002$).

**Supplementary Figure 1.** Social appropriateness ratings of the prosocial (a) and self-serving decision (b) in the Standard Dictator Game and the Hidden Information Game. Social appropriateness ratings of the prosocial (c) and self-serving decision (d) for three Receiver information conditions: uncertain, certain-poor, and certain-rich. Error bars represent standard errors. *$p < .05$, n.s. = not significant.




*Study 4*

Four participants failed the attention check and were excluded from all analyses, resulting in an overall sample of $N = 803$. Again, we did not observe a significant interaction between the conditional variable and participants' income on prosocial behavior ($p = .131$).

We next investigated the role of individual differences in empathy and wise reasoning for impact uncertainty's effect on prosociality. Mean scores on the cognitive and affective empathy subscales (Cronbach's alpha .915 and .833) differed significantly, $t(802) = 9.85$, $p < .001$, hence the subscales were not pooled. There were no interactions between either empathy subscale and the conditional variable ($p$s ≥ .481). Prosocial behavior was predicted by both cognitive ($\chi^2(1, N = 803) = 22.28$, $p < .001$) and affective empathy ($\chi^2(1, N = 803) = 14.45$, $p < .001$). Even though empathy is often conceptualized as trait[5], our manipulation might have affected participants' empathic mindset, which might then have mediated impact uncertainty's effect on prosociality. For instance, introducing impact uncertainty might give people a push towards considering others' perspectives, hence facilitating their ability to empathize with others. While there was no conditional effect on affective empathy ($p = .274$), cognitive empathy scores were indeed affected by the conditional manipulation, $F(3, 799) = 3.44$, $p = .016$, $\eta^2 = 0.03$. Bonferroni-corrected pairwise comparisons specified that this effect was driven by cognitive empathy scores being significantly higher under high impact uncertainty compared to the control condition, $p = .017$. Breaking cognitive empathy further down into its components[6], the conditional effect was significant only for the "perspective taking" component ($F(3, 799) = 3.98$, $p = .008$, $\eta^2 = 0.02$) but not the "online simulation" component ($p = .178$). To test the mediational hypothesis, we used Hayes' PROCESS tool in SPSS[7]. A bootstrap estimation with 5,000 samples[8] indicated the indirect effect was

significant, $b = .02$, $SE = .01$, 95% CI = .001, .042. As the conditional effect on prosociality remained significant ($b = .20$, $SE = .09$, $p = .019$) after controlling for perspective taking as mediator ($b = .44$, $SE = .15$, $p = .004$), the results support a partial mediation of impact uncertainty's effect on prosociality via perspective taking.

Next, we tested whether wise reasoning also mediated the conditional effect on prosociality. Wise reasoning subscales were substantially correlated ($r \geq .460$, all $p < .001$) and thus we used their mean score for subsequent analyses[9]. Logistic regression analysis showed a significant main effect of wise reasoning on prosocial decisions ($b = .35$, $SE = .112$, $p = .003$), controlling for which the conditional effects of high impact uncertainty and certain poor remained significant ($b = .618$, $SE = .272$, $p = .023$; $b = .622$, $SE = .270$, $p = .021$). There was no interaction between the conditional and wise reasoning variables, $p = .311$. Neither the mean score, nor any of the wise reasoning subscales (range Cronbach's alpha = .756 to .863) were influenced by the conditional variable (mean score: $p = .227$; subscales: $p$s = .057 – $p = .887$; sum score: $p = .227$). When we tested the mediational pathway including the wise reasoning subscale that was the only one close to statistical significance for the conditional effect ("application of an outsider's vantage point", $p = .057$), the indirect effect was not significant ($b = .001$, $SE = .007$, 95% CI = -.011, .019).

*Study 6*

14 participants performed below the 60 percent accuracy cutoff and were excluded from all analyses, leaving a total sample of $N = 889$ ($n_{\text{impact uncertainty}} = 295$, $n_{\text{worst-case}} = 297$, $n_{\text{control}} = 297$). Since there was no interaction between the uncertainty and the explicit/implicit manipulations on prosocial intention ($p = .801$), we examined the two conditional effects separately. In addition to the conditional effect of uncertainty reported in our main manuscript, we found that participants who made implicit possibility judgments were less inclined to indicate they would go to work than those who made explicit possibility judgments, $U = 5.369$, $p = .021$, $\eta^2 = .749$. Logistic regression models showed there was also no interaction between the uncertainty and the explicit/implicit manipulations on possibility judgments (possibility to infect: $p = .226$; possibility of vulnerable co-worker: $p = .115$) so that we again separately examined the two conditional effects on the two possibility judgments. Note that 72 participants in the *implicit* conditions missed to make their possibility judgments on time, thus the following analyses are based on a total sample of $N = 817$. While the uncertainty manipulation did not affect possibility ratings about infecting a co-worker at all ($p$s ≥ .357), participants under *impact uncertainty* were significantly more inclined to judge it impossible to infect a vulnerable co-worker ($b = -1.010$, $SE = .402$, $p = .012$) and we observed the same trend for participants in the *worst-case certainty condition* ($b = -.706$, $SE = .419$, $p = .092$). For both possibility decisions (i.e., infection and vulnerability), participants

in the *implicit* conditions significantly more often judged the given outcome “impossible” compared to the *explicit* conditions (infect co-worker: $b = -.710$, $SE = .312$, $p = .023$; infect vulnerable co-worker: $b = -.880$, $SE = .307$, $p = .004$).

*Study 7*

We did not find a significant interaction between information condition and participants income level ($\chi^2(3, N = 466) = 1.19$, $p = .55$), indicating that the effect of information condition did not depend on participants' income level. We then examined the main effects for the impact uncertainty manipulation and income on prosocial decisions. This analysis revealed that participants' incomes did not affect the results ($\chi^2(1, N = 466) = 1.86$, $p = .17$), and the main effect of impact uncertainty remained significant ($\chi^2(3, N = 466) = 5.94$, $p = .05$), when controlling for income. Impact uncertainty affected participants' choices regardless of their own income level.

*Effect Size Comparisons*

We compared effect sizes across participants presented with low (10% chance of negative impact, Study 4), moderate (33% chance of negative impact, Studies 1 and 2), and high (50% chance of negative impact, Study 4) levels of impact uncertainty. The lowest effect size was observed for low uncertainty at Fisher's $Z_r = 0.05$, 95% CI [-0.04, 0.15]. Effect sizes for moderate impact uncertainty were larger, Fisher's $Z_r = 0.12$ and 0.08, 95% CIs [0.03, 0.22 and 0.01, 0.16], and similar to effect size observed for high impact uncertainty, Fisher's $Z_r = 0.12$, 95% CI [0.02, 0.22].

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