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Moral Hindsight

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Abstract: How are judgments in moral dilemmas affected by uncertainty, as opposed to certainty? We tested the predictions of a consequentialist and deontological account using a hindsight paradigm. The key result is a hindsight effect in moral judgment. Participants in *foresight,* for whom the occurrence of negative side effects was uncertain, judged actions to be morally more permissible than participants in *hindsight,* who knew that negative side effects occurred. Conversely, when *hindsight* participants knew that no negative side effects occurred, they judged actions to be more permissible than participants in *foresight*. The second finding was a classical hindsight effect in probability estimates and a systematic relation between moral judgments and probability estimates. Importantly, while the hindsight effect in probability estimates was always present, a corresponding hindsight effect in moral judgments was only observed among "consequentialist" participants who indicated a cost-benefit trade-off as most important for their moral evaluation.

Keywords: moral judgment, hindsight effect, moral dilemma, uncertainty, consequentialism, deontological theories

Despite ongoing efforts, hunger crises still regularly occur all over the world. From 2014 to 2016, about 795 million people worldwide were undernourished, almost all of them in developing countries (FAO, IFAD, & WFP, 2015). Climate change has been projected to put a further 175 million people at risk in these countries by 2080 (Brown et al., 2015). Is it morally permissible for a government to cultivate new genetically modified (GM) crops that could ensure food availability and reduce malnutrition, even if it is uncertain whether they may cause side effects like severe allergies and the destruction of ecosystems and food chains (Herrera-Estrella & Alvarez-Morales, 2001)?

Uncertainty is a key feature of most situations in which moral judgments and decisions are made. Sometimes reliable risk estimates exist which can inform moral considerations, such as tests showing how likely a new crop survives under extreme conditions. But oftentimes no reliable data are available, for instance about the long-term effects of genetically modified crops, and uncertainty prevails. Certainty only exists in hindsight.

In stark contrast to the ubiquity of uncertainty in real-world situations, research on moral judgments has predominantly focused on situations of certainty, such as the famous "trolley dilemma" (Foot, 1967; for a review, see Waldmann, Nagel, & Wiegmann, 2012). Is it morally permissible to push an innocent person in front of a trolley in order to save the lives of five other people on the tracks? Should we treat a mother with uterine cancer when the treatment will kill her unborn baby, although not treating her will result in the death of both? Uncertainty is removed deliberately in these dilemmas, where all consequences are presented as certain (Gigerenzer, 2010). Moreover, using dilemmas with certainty can result in a mismatch with the beliefs and experience people bring to the task. For instance, Greene et al. (2009) found that participants evaluated moral responsibility differently if they indicated that they believed the action would not be successful, even when its success was instructed as being certain. Exclusively studying situations of certainty may thus limit the value of both descriptive and normative moral theories for understanding moral judgment in real-world situations, in which different degrees of uncertainty prevail (Meder, Le Lec, & Osman, 2013; Volz & Gigerenzer, 2012).

The role of uncertainty is also crucial when people morally evaluate decisions that have been made by others. Oftentimes such judgments take place in hindsight, when the course of events has unfolded and the outcomes of a decision are known (e.g., assessment of wrong medical diagnoses or fatal shootings by the police). In such situations, moral evaluations should be based on what was known to the decision maker when the action was taken. Yet, hindsight research shows that people have a strong tendency to believe that an event was more predictable than they thought beforehand once they know the outcome ("I knew it all along") (for a review, see Hawkins & Hastie, 1990). That people are unable to disregard outcome information not available to the decision maker creates serious problems, for instance, in the retrospective analysis of legal liability and medical errors (Henriksen & Kaplan, 2003). A similar problem arises for the moral evaluation of

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decisions if moral judgments change in hindsight based on information that was not available at the time of the decision: moral considerations that are supposed to guide actions will not safeguard against later moral condemnation.

For the present paper, we adopted the classical *hindsight paradigm* (Fischhoff, 1975) and tested the predictions of two types of moral theories on how judgments should vary under uncertainty (before the outcomes of a decision are known) and certainty (after the outcomes of a decision are known). The first types are consequentialist theories,[1] which derive moral judgments from a trade-off between the benefits and harms of an option, weighted by their probabilities. Since both consequences and their probability are crucial to these models, they predict that moral judgments should be affected by the (un)certainty of consequences (cf. Shenhav & Greene, 2010). The second types are deontological theories, which specify moral rules based on aspects of an action beyond its consequences (for a review, see Waldmann et al., 2012). Moral judgments based on such rules should thus be less affected by the uncertainty or certainty of consequences.

We manipulated knowledge about the occurrence of negative consequences of an action in moral dilemmas, such as the destruction of ecosystems and food chains that may result as side effect from growing GM corn. The study compared moral judgments of people in *foresight*, when it was uncertain whether the negative side effects will occur, with judgments in *hindsight*, when participants knew that the negative side effect did occur (*hindsight bad*) or did not occur (*hindsight good*). Thus, the only difference between the three conditions was the status of the negative side effect, which was uncertain, known to have occurred, or known not to have occurred. To test whether differences in moral judgments depend on a hindsight effect in probability estimates, we elicited participants' subjective estimates about the likelihood of the negative side effects. Because people are known to apply different models of moral judgment (e.g., Greene, Nystrom, Engell, Darley, & Cohen, 2004; Greene, Sommerville, Nystrom, Darley, & Cohen, 2001; Mikhail, 2007), we asked participants to select the most important reason for their moral judgment in a questionnaire as an indicator for the kind of model they rely on.

Moral Judgments in Foresight and Hindsight

Research on hindsight effects has demonstrated, across a variety of tasks and domains, that people adjust judgments and evaluations (e.g., probability estimates, confidence ratings, numerical estimates) in the direction of already known outcomes, even when explicitly instructed to ignore them (e.g., Christensen-Szalanski & Willham, 1991; Fischhoff, 1975; Guilbault, Bryant, Brockway, & Posavac, 2004; Hell, Gigerenzer, Gauggel, Mall, & Müller, 1988; Hoffrage & Pohl, 2003; for a hindsight effect in perception of business ethics, see Sligo & Stirton, 1998). For instance, Dawson et al. (1988) compared physicians' probability judgments for different diagnoses in foresight versus hindsight. In the foresight condition, physicians were asked to assign probability estimates to possible diagnoses of a deceased patient *before* the true diagnosis was announced. Their judgments were compared to a hindsight condition in which another group of physicians made the very same judgments *after* they learned about the true diagnosis. Although subjects in the hindsight condition were instructed to ignore the true diagnosis and make judgments as if they did not know it, their mean probability estimates for the correct diagnosis were exaggerated compared to subjects in the foresight condition.

Theoretical explanations of hindsight effects suggest that outcome knowledge can affect the knowledge base; the selection, evaluation, and integration of evidence; or even change the underlying mental model, making hindsight effects a by-product of general learning mechanisms that are adaptive within the uncertain environments in which people function (Hawkins & Hastie, 1990). Different from a situation in which people simply learn from outcomes, hindsight effects occur when people falsely believe that they would have estimated an outcome to be as likely in foresight without knowing that it occurred. Given the inability of people to disregard outcome information in their probability judgments, we expect that participants will show a hindsight effect when estimating the probability that an action leads to negative side effects: compared to *foresight*, probability estimates should be higher in *hindsight bad* when negative side effects occurred and lower in *hindsight good* when they did not occur (Figure 1), even if people are asked to ignore this information.

For moral judgments, consequentialist and deontological theories make diverging predictions across foresight and hindsight, depending on whether probability information is relevant to the judgment (Figure 1). First, consequentialist models take into account both consequences and their probabilities. While consequentialism is originally a normative view of morality (Scheffler, 1988), it has also been used as a descriptive theory (e.g., Greene, Morelli, Lowenberg, Nystrom, & Cohen, 2008; Koenigs et al., 2007). These models trade off the positive and negative consequences

[1] We use "consequentialism" here to denote a broad class of theories that share the feature of trading off outcome values weighted by their probabilities, yet there are many different variants of such an account (Scheffler, 1988).

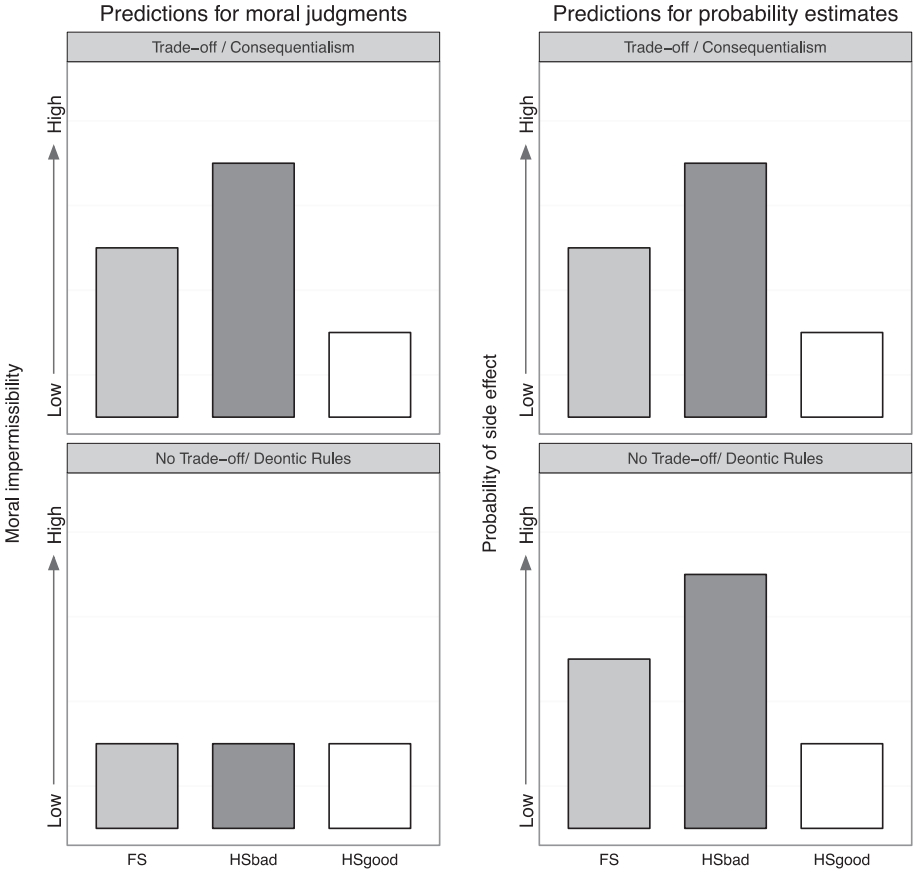

Figure 1. Predicted qualitative pattern of impermissibility judgments and of probability estimates for negative side effects across different epistemic conditions, according to two types of theories (trade-off/consequentialism vs. no trade-off/deontic rules). In *foresight* (FS) the outcomes of the considered action are uncertain, in *hindsight bad* (HSbad) the negative side effect is known to have occurred, and in *hindsight good* (HSgood) the negative side effect is known to not have occurred. Note that the height of bars can only be compared within, but not across graphs.

(benefits and costs) of an option, with each outcome weighted by its probability of occurrence. The option with the higher expected social outcome is morally preferred. In situations of uncertainty, in which no objective probabilities are available (Knight, 1921), individuals are typically assumed to rely on their subjective probability estimates (Savage, 1951). We therefore assume that a descriptive consequentialist model will use as input people's subjective estimates, even if they are adjusted in the direction of already known outcomes in hindsight, as predicted by hindsight research. For instance, if a government considers cultivating GM crops, the moral permissibility of this action should depend on its costs and benefits and the associated probabilities; and these probabilities will differ in foresight and hindsight. A consequentialist model thus predicts that compared to *foresight* the action is judged less permissible in *hindsight bad* because negative side effects are weighted stronger due to higher probability estimates. In contrast, the action will be judged more permissible in *hindsight good*, where negative side effects weigh less because they are estimated to be less likely.[2] In addition, moral judgments should vary systematically as a function of people's subjective probability beliefs: the more likely negative side effects are expected to be, the less permissible the action should be judged.

Second, deontological theories entail that moral judgments rely on rules that consider aspects of the situation beyond mere consequences and probabilities, such as the kind of action or the intentions or knowledge of the actor (e.g., Cushman, 2008; Cushman, Young, & Hauser, 2006; Knobe, 2003; Lagnado & Channon, 2008). If none of these aspects differ between *foresight* and *hindsight*, they predict no variation. For instance, people may follow a rule that judges harmful actions more impermissible than omissions that result in harm (Baron & Ritov, 2009). Whatever is defined as harm within a particular context (e.g., the harm caused by not acting or the harm of the action), the action would be judged independent of whether side effects

[2] Here, we make the simplifying assumption that the value of a consequence is not itself subject to hindsight effects, that is, does not change across conditions. Yet, even if consequences were evaluated differently in hindsight, we should expect negative consequences to be evaluated more negatively if they occurred and less so if they did not. Thus, the predictions would not change, but differences in value would only amplify the expected difference in moral judgments (see General Discussion).

are uncertain or known. Another moral rule may consider whether harm is inflicted as a means to an otherwise morally good end or only results as an unintended side effect (Foot, 1967). For instance, if a government decides to cultivate GM crops to prevent food scarcity, this action may be considered morally permissible independent of whether the decision has negative consequences, as long as they only constitute a (not intended) side effect. As a third rule, people may focus mainly on the beneficial intention of the decision maker (Young & Saxe, 2011) and would judge the action permissible (because the intention is to save people from starving), independent of its consequences. Moral judgments based on such moral rules should thus neither differ between *foresight* and *hindsight* nor between the two *hindsight* conditions.[3] Importantly, while participants applying deontological rules should show the usual hindsight effect in their probability judgments, this effect should not influence their moral judgments.

Experiment

The goal of the experiment was to test the predictions of two kinds of moral theories for moral judgments in *foresight* and *hindsight*.

Methods

Participants and Design

We recruited 731 participants (326 women, M_{age} = 32.6, *SD* = 12.1) through Amazon MTurk who were paid $0.50 for participating. Only candidates from the United States who had already accepted more than 100 online tasks and completed at least 95% of these tasks could participate. Participants were randomly assigned to one of three between-subjects conditions: *foresight*, *hindsight bad*, or *hindsight good*. To avoid possible order or transfer effects in moral judgment (Wiegmann, Okan, & Nagel, 2012; Wiegmann & Waldmann, 2014), each participant judged only one of six moral dilemmas, resulting in a total of 6 × 3 between-subjects conditions.

Materials and Procedure

We constructed six moral dilemmas based on different real-world situations (Table 1; see Electronic Supplementary Material, ESM 1 for a full description). The six dilemmas related to GM corn, influenza vaccination, breast cancer screening, torture, dam building, and provision of state credit. To keep the situation comparable across domains, we selected dilemmas in which an expert or government had to decide about an action, with consequences for the well-being of other people. In each dilemma, the action has the potential to avert a threat (a harm that may result from inaction, e.g., a new famine) but also potentially entails some negative consequences as side effects (e.g., destruction of ecosystems and food chains). All dilemmas also included some uncertainty about the severity and likelihood of the threat and whether the action yields the desired benefit (e.g., prevention of famine).[4]

The experiment was conducted online in a web browser. Figure 2 illustrates the information and questions given to participants in each of the three epistemic conditions using the GM corn dilemma. The top box shows the information that was identical in all conditions: the description of the threat (harm of inaction, e.g., famine), the action under consideration and its benefits (cultivation of GM corn to prevent future famines), and its possible negative side effects (allergies and diseases, reduction of biological diversity, and destruction of food chains).

In the *foresight* condition, no further information was provided before requesting a moral judgment. In the two hindsight conditions, participants were additionally told that the action was eventually taken. In the *hindsight bad* condition, the government decided to cultivate the GM corn, which later caused allergies and diseases in humans and destroyed the food chain of some animal species. In the *hindsight good* condition, the negative side effect did not occur, that is, the GM corn did not cause any allergies or diseases and did not destroy ecosystems. To hold all other information constant across conditions, participants in hindsight received no further information on other aspects of the dilemma, that is, whether the threat occurred or the action was successful. The other five dilemmas followed the same rationale.

Participants judged the moral permissibility of the action on a second screen, on which the question and scale appeared below the dilemma. Judgments were given on a scale ranging from 1 to 4 (1 = *completely morally impermissible*, 2 = *somewhat morally impermissible*, 3 = *somewhat morally permissible*, 4 = *completely morally permissible*; Figure 2). We asked for an evaluation of "moral" permissibility to ensure that participants evaluate the action

[3] Note that this is again a simplification. Not every moral rule is independent of consequences, for instance, a rule prohibiting killing, which depends on the actual death of the victim. Similarly, if a rule forbids intentional harm, one may assess whether an action is intentional, based on whether the consequences were foreseeable or could have been foreseen (see General Discussion).

[4] In a pilot study, we asked participants whether they thought that any information was missing in order to morally judge the situation. Based on their responses, we refined the dilemmas, either by including this information or by explicitly stating that it was not available.

Table 1. Overview of morally-relevant aspects in each dilemma situation (see ESM 1 for the full text of all dilemmas)

Dilemma	Potential harm of inaction (Threat)	Considered action	Potential negative consequences
GM corn	A new famine could occur	Cultivating a new GM corn that could survive under extreme weather conditions	GM corn may trigger allergies or diseases and destroy the food chain of some animals
Influenza	A new strain of flu could cause severe infections and a number of deaths	Large-scale, costly vaccination campaign across countries using a new vaccine	The new vaccine can sometimes cause severe or even fatal side effects
Torture	Not finding a kidnapped boy in time	Threatening the kidnapper to inflict pain on him to get information about the boy's whereabouts	Acquittal of kidnapper due to violation of procedural rules
Screening	Not detecting breast cancer early when a cure is more likely	Recommend regular screening	False diagnosis and unnecessary surgical treatment (partial or full remove of breast) because not all detected cancers would have led to death or sickness
Dam	Severe floods with devastating consequences for living conditions of farmers and economy of a developing country	Building a dam to reduce effects of severe floods by providing flood storage space which also allows for perennial irrigation	Ecological changes may result in lower water quality and higher costs of drinking water
Credit	Loss of 5,000 jobs through bankruptcy of a traditional family company	Providing exceptional state credit by reallocating funds intended to support start-ups	Insolvency of start-ups that rely on state loans

from their moral point of view, rather than from a legal or pragmatic perspective (cf. Baron & Ritov, 2009; Hauser, Cushman, Young, Kang-Xing Jin, & Mikhail, 2007). Participants were also instructed, in the introduction to the experiment, to judge the action of the person or agency independently of what the current law specifies.

On a third screen, participants estimated the probability of the negative side effects, given the action (Figure 2). Following the hindsight paradigm (Fischhoff, 1975), we explicitly instructed hindsight participants to consider the information about the decision problem that was given and to answer as if they did not know the actual decision and whether or not side effects occurred. Given that subjects were not asked to answer as the decision maker in the scenario, but as they would have done themselves without knowing the outcomes, they had no reason to believe they were missing any information (cf. Baron & Hershey, 1988). This enabled us to test for a hindsight effect in probability estimates, that is, whether knowledge of the occurrence of side effects would influence participants' probability judgments relative to the *foresight* condition.

On the next screen, participants were asked to select one of six statements as best describing their most important reason for judging the action impermissible (rating 1 or 2) or permissible (rating 3 or 4) (for details, see ESM 1). Even if participants may have considered several reasons, the goal was to identify the information (cues) that participants considered most important for their moral judgment in order to infer the kind of model for moral judgments that a participant used. Participants were given a choice between categories of cues that were present in each dilemma: the harm of inaction (threat) and the benefits of this action (benefits), its negative consequences (costs), and a trade-off between both. The trade-off category was intended to distinguish participants relying on a consequentialist model from those who do not: different from participants who base their judgment mainly on either the beneficial or negative consequences in a noncompensatory way, a consequentialist should trade off both kinds of consequences. The fifth item was based on Ritov and Baron (1999; Baron & Ritov, 2009) referring to whether a person holds a protected value, that is, a value not to be traded off against anything. It stated that the action is morally wrong and is not permissible in any case (for participants who judged the action to be impermissible) or only permissible in this exceptional case due to its large benefits or the harm it prevents (for participants who judged the action to be permissible; holding protected values does not preclude consequentialist judgments under extreme circumstances, see Bartels, 2008; Bartels & Medin, 2007). As the sixth option, we included an open-ended option in case none of the reasons applied.

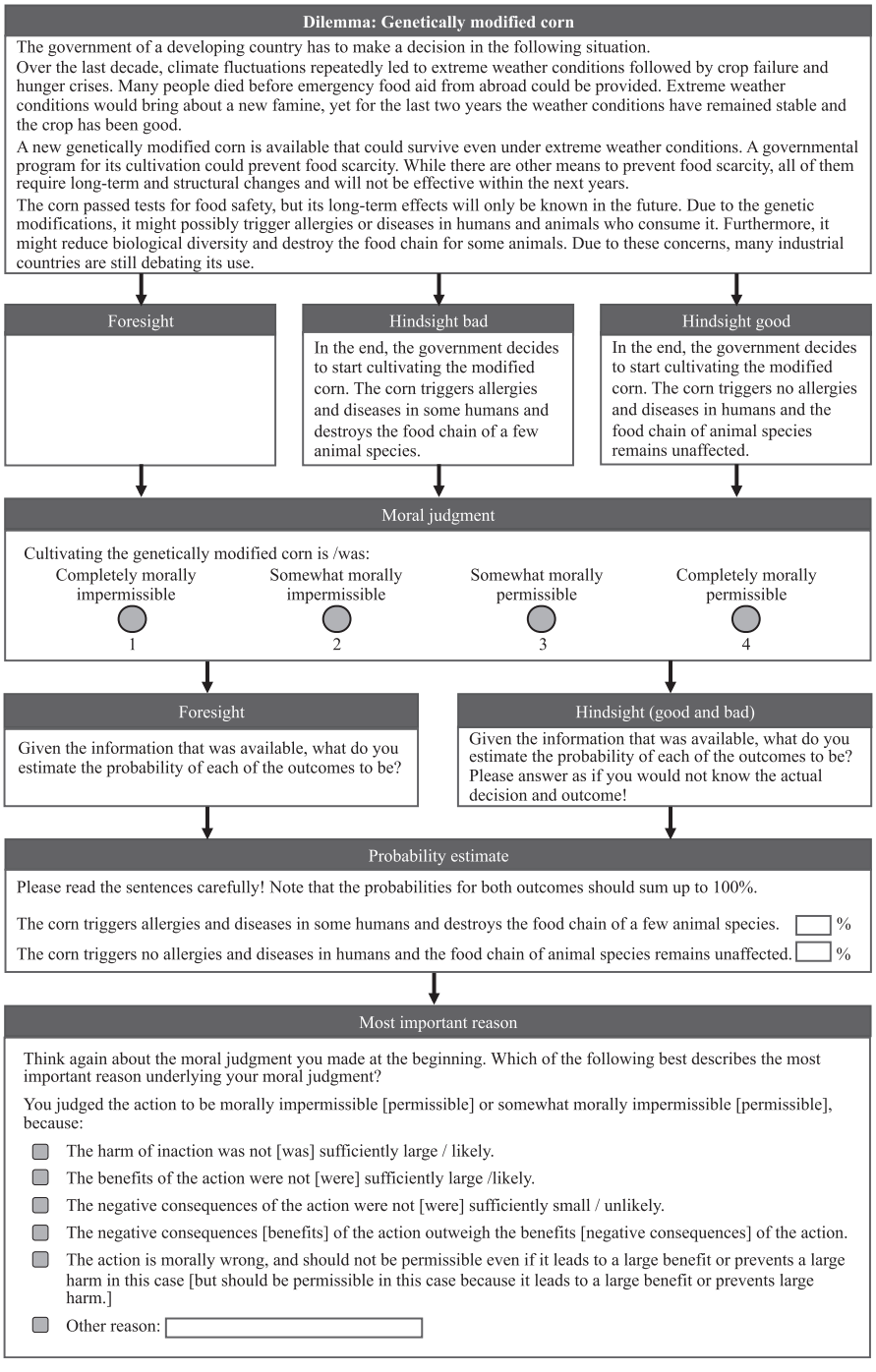

Figure 2. Overview of experimental procedure and information given to participants in each condition, illustrated by the GM corn dilemma. The structure of the other five dilemmas followed the same rationale. The wording of the reason questionnaire was conditional on participants' moral judgments; text in [square brackets] is provided if someone judged the action permissible (see ESM 1 for a detailed description of all dilemmas).

Finally, participants were presented with a simple attention-verification test ("If action A is better than action B, and B is better than C, which action is the worst?") and were asked to provide some demographic information. As an additional control, we asked whether they participated before (in case the IP address or MTurk ID had changed), while stating explicitly that this would not affect payment.

Results

Forty-five subjects failed the attention test and 15 indicated that they had participated before. For the data analysis, 671 participants remained (297 women, M_{age} = 32.8, SD = 12.2), with n = 34–42 in each of the 6 × 3 conditions (mean duration: 4 min 17 s).

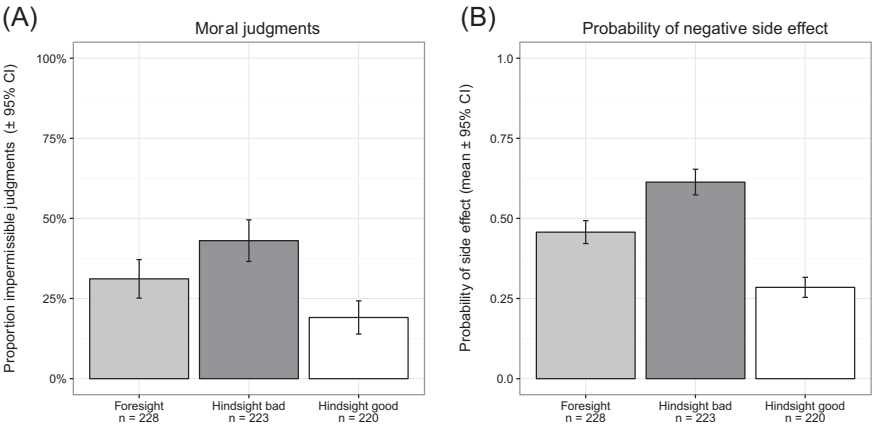

Figure 3. Proportion of participants judging the actions to be morally impermissible (A) and mean probability estimates for negative side effects (B) in *foresight* (FS), *hindsight bad* (HSbad), and *hindsight good* (HSgood) conditions, aggregated across all dilemmas. Error bars represent 95% confidence intervals.

How Do Foresight and Hindsight Affect Moral Judgments?

Participants systematically made different moral judgments in *foresight* than in the two hindsight conditions, exhibiting a hindsight effect for moral judgments. Figure 3A shows the proportion of participants per condition who judged the action to be impermissible, aggregated across all six dilemmas. For simplicity, we always collapse moral judgments into impermissible judgments (rating 1 and 2) and permissible judgments (rating 3 and 4; for results based on the noncollapsed scale, see Figures S1, S2, and Tables S1, S2 in ESM 2). In the *foresight* condition, 31% of participants judged the action morally impermissible, compared to 43% in *hindsight bad*, $\chi^2(1, N = 451) = 6.36$, $p = .012$, Cohen's $h = -0.25$, and only 19% in *hindsight good*, $\chi^2(1, N = 448) = 7.99$, $p = .005$, Cohen's $h = 0.28$. The largest difference was obtained between the two hindsight conditions, $\chi^2(1, N = 443) = 28.53$, $p < .001$, Cohen's $h = 0.53$.

On the level of the individual dilemmas, similar qualitative trends were observed (Figure 4A; for detailed statistics, see Tables S1 and S2 in ESM 2). The exception is the "credit" dilemma, in which the action was not judged to be more impermissible in *hindsight bad* than in *foresight*, but similar to the *hindsight good* condition. We will return to this dilemma below after the analysis of the participants' probability estimates for this dilemma.

Do Moral Judgments Vary Systematically With Probability Estimates?

Figure 3B shows participants' probability judgments for the three conditions, averaged across all dilemmas. The data shows a strong hindsight effect for probability estimates, which matched the observed pattern found for moral judgments. Probability estimates in the hindsight conditions mirrored participants' knowledge of the actual course of events. In line with typical findings in hindsight research (Guilbault et al., 2004; Hawkins & Hastie, 1990), participants were unable to ignore outcome information even though they were instructed to do so. Negative side effects were estimated to be most likely in the *hindsight bad* condition ($M = 61.3$, $SD = 30.2$) and least likely in the *hindsight good* condition ($M = 28.5$, $SD = 23.6$), with the *foresight* condition being in between these estimates ($M = 45.7$, $SD = 27.3$). All differences were statistically reliable: *foresight* versus *hindsight bad* ($U = 17{,}746$, $N = 451$, $p < .001$), *foresight* versus *hindsight good* ($U = 34{,}224$, $N = 448$, $p < .001$), and *hindsight bad* versus *hindsight good* ($U = 39{,}094$, $N = 443$, $p < .001$). The same qualitative results were obtained for each individual dilemma (Figure 4B), again with the exception of "credit," in which probability estimates in the *foresight* condition were even higher than those in the *hindsight bad* condition. The higher probability estimates in *foresight* may explain why the action here was judged least permissible, although it is unclear why probability estimates were higher (for statistics on individual dilemmas, see Tables S3 and S4, ESM 2).

Figure 5 plots the mean probability estimates in the three conditions (*foresight*, *hindsight bad*, *hindsight good*) as a function of moral judgment (impermissible vs. permissible), aggregated across dilemmas. In each epistemic condition, participants who considered the action to be impermissible gave on average higher probability estimates for the negative side effect than participants who considered the action to be permissible (all $p \leq .001$; U-tests for each epistemic condition). Consistent with this finding, there was a moderate negative correlation between participants' individual moral judgments (on the scale from 1 to 4) and their probability estimates when aggregating across all conditions and dilemmas, Spearman $r_s = -.39$; similar correlations hold in each of the three conditions when

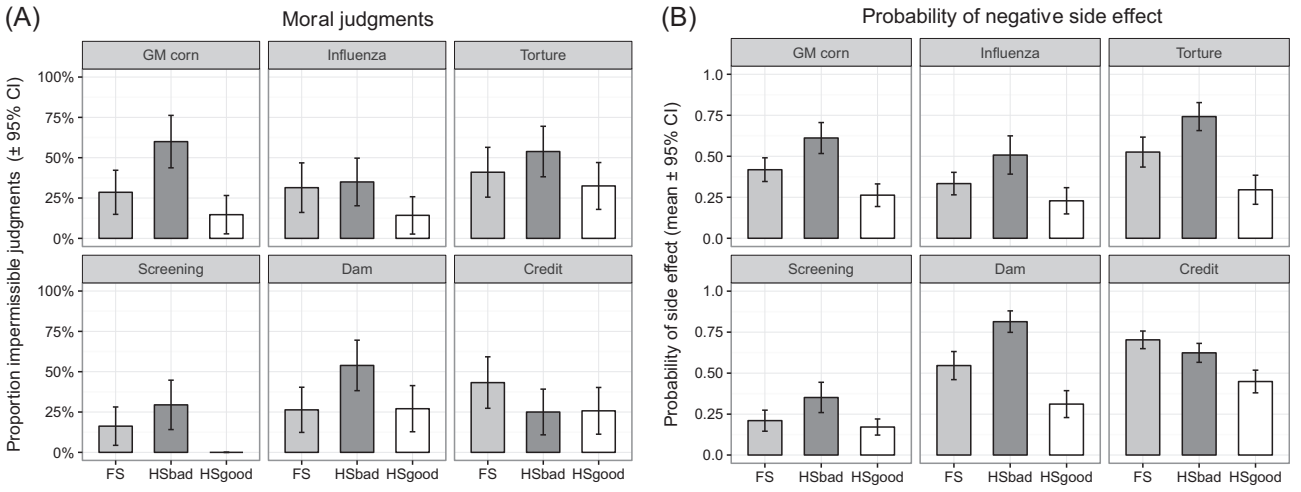

Figure 4. Proportion of participants per individual dilemma judging the actions to be morally impermissible (A), and mean probability estimates for negative side effects (B) in *foresight* (FS), *hindsight bad* (HSbad), and *hindsight good* (HSgood) conditions. Error bars represent 95% confidence intervals.

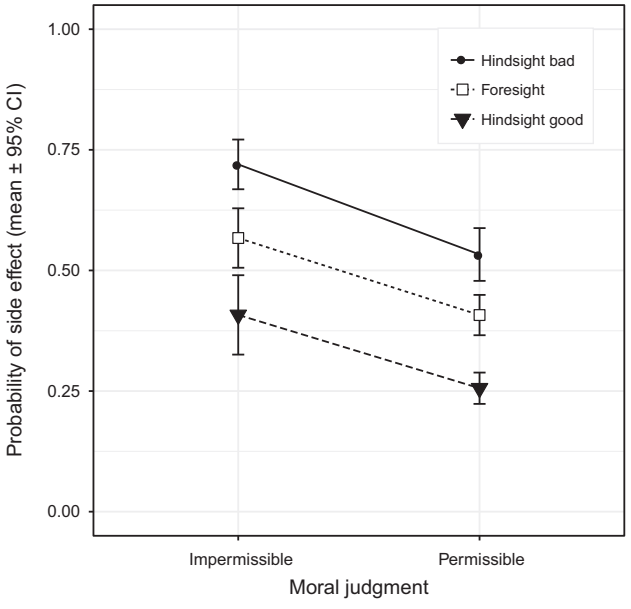

Figure 5. Mean probability judgments that negative side effects occur (± 95% CI) as a function of moral judgment and condition, aggregated across dilemmas.

aggregating across dilemmas (*foresight* $r_s = -.32$; *hindsight bad* $r_s = -.35$; *hindsight good* $r_s = -.29$).

Looking at the individual dilemmas reveals that the correlations within each epistemic condition vary substantially across situations (Table 2). Aggregated across epistemic conditions, the correlations for individual dilemmas varied from weak (torture; $r_s = -.19$) to strong (GM corn; $r_s = -.66$), showing that the relation between subjective probabilities for moral judgment strongly depended on the particular situation.

Table 2. Spearman rank correlations between moral permissibility ratings for the action and probability estimates for its negative side effects by epistemic condition, separately for each dilemma and across all

Dilemma	Foresight (FS)	Hindsight bad (HSbad)	Hindsight good (HSgood)	Across conditions
GM corn	−.59	−.60	−.51	−.66
Influenza	.00	−.28	−.11	−.24
Torture	−.16	−.27	−.11	−.19
Screening	−.52	−.51	−.04	−.46
Dam	−.09	−.38	−.13	−.32
Credit	.08	−.02	−.60	−.26
Across all	−.32	−.35	−.29	−.39

Aggregating across participants, the observed relation between probability estimates and moral judgments seems to be consistent with the predictions of a consequentialist model of moral judgment, according to which people weigh potential outcomes by subjective probabilities adjusted in the direction of the actual outcome (note that we cannot exclude the possibility that people adjusted their probability estimates to fit their moral judgments; see General Discussion). However, the only moderate correlation between both measures suggests that not everyone took a consequentialist approach, which is in line with commonly observed individual differences in moral judgment processes (Waldmann et al., 2012).

Does the Moral Hindsight Effect Exist for all Participants?

To distinguish which kind of models participants may have used to make their moral judgments, we used the reason

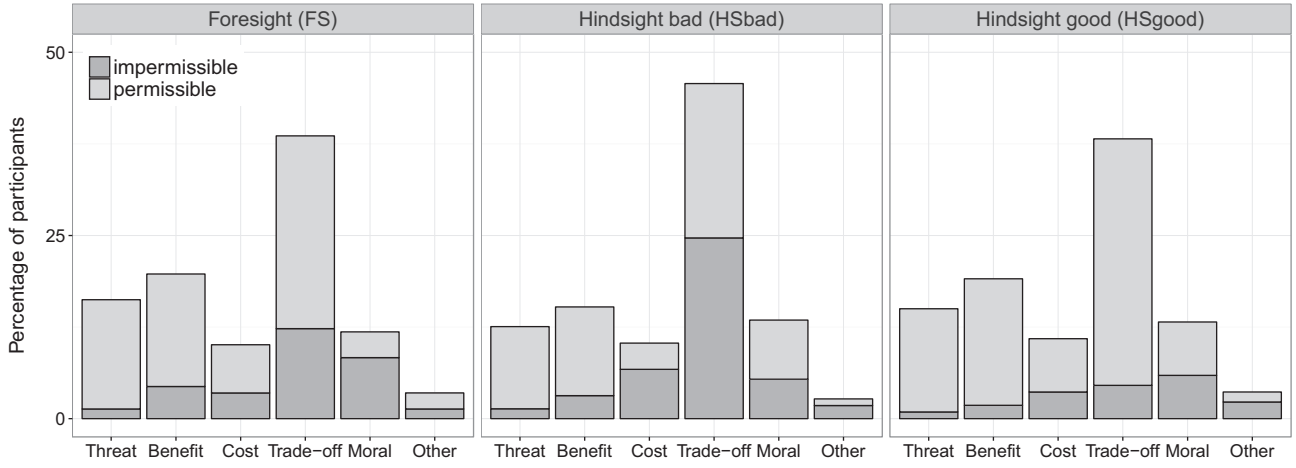

Figure 6. Proportion of participants who selected each reason as being most important for their moral judgment, by epistemic condition. Threat = "The harm of inaction was not [was] sufficiently large/likely"; Benefit = "The benefits of the action were not [were] sufficiently large/likely"; Cost = "The negative consequences of the action were not [were] sufficiently small/unlikely."; Trade-off = "The negative consequences [benefits] of the action outweigh the benefits [negative consequences] of the action"; Moral = "The action is morally wrong and should not be permissible even if it leads to a large benefit or prevents a large harm in this case [but should be permissible in this case because it leads to a large benefit or prevents large harm]." Wording of the reasons in the questionnaire was adapted conditional on moral judgment (permissible vs. impermissible); phrasing in square brackets refers to wording for participants judging the action to be permissible.

they indicated as most important in the questionnaire for a proximal classification (Figure 2). Figure 6 shows the proportion of participants selecting each of the reasons as the most important cue for their moral judgment in *foresight*, *hindsight bad*, and *hindsight good*, aggregated across all dilemmas.

First, the distribution of cues is similar in each condition, suggesting that in the present study the cues people rely upon do not substantially differ under certainty and uncertainty, $\chi^2(10, N = 671) = 5.21$, $p = .88$. In each condition, the most-frequent reason was a trade-off between benefits and harms (39% in *foresight*, 46% in *hindsight bad*, 38% in *hindsight good*), indicating that a substantial number of participants relied on a consequentialist model. Still, more than half of the participants in each condition chose a reason other than a trade-off as most important for their moral judgment.

Second, patterns in moral judgments across conditions differed as expected depending on the type of model used. If we classify participants as consequentialist who indicated that they would make a cost-benefit trade-off ($n = 274$), they should show the moral hindsight pattern predicted by a consequentialist account. By contrast, the moral hindsight effect should not be found for the remaining participants ($n = 397$) who indicated other reasons as being most important for their moral judgments.

Figure 7 shows the proportion of impermissible judgments and mean probability estimates for the negative side effects, separately for people who indicated a trade-off between costs and benefits as most important and those who did not. The *trade-off* subgroup shows a hindsight effect in probability estimates and a corresponding hindsight effect for their moral judgments, both varying systematically as a function of epistemic condition (all pairwise comparisons between epistemic conditions were statistically reliable; see Tables S5–S8 in ESM 2). This concordance is consistent with the predictions of a consequentialist account of moral judgments. The *no trade-off* subgroup, however, shows a hindsight effect for their probability estimates, yet the hindsight effect in moral judgments is absent for these participants (see Tables S5–S8 in ESM 2), which is consistent with the use of deontological rules based on other aspects of the situation. The hindsight effect for probability estimates can thus be dissociated from the moral hindsight effect depending on the information and kind of moral judgment model that people use.[5]

General Discussion

The present study investigated how moral judgments differ under uncertainty and certainty by testing the predictions of

[5] Note, however, that the questionnaire used is too coarse grained to map the other reasons clearly to specific judgment processes. Further exploratory analyses indicate heterogeneity in moral judgments as a function of reasons, suggesting important pathways for future research (see General Discussion).

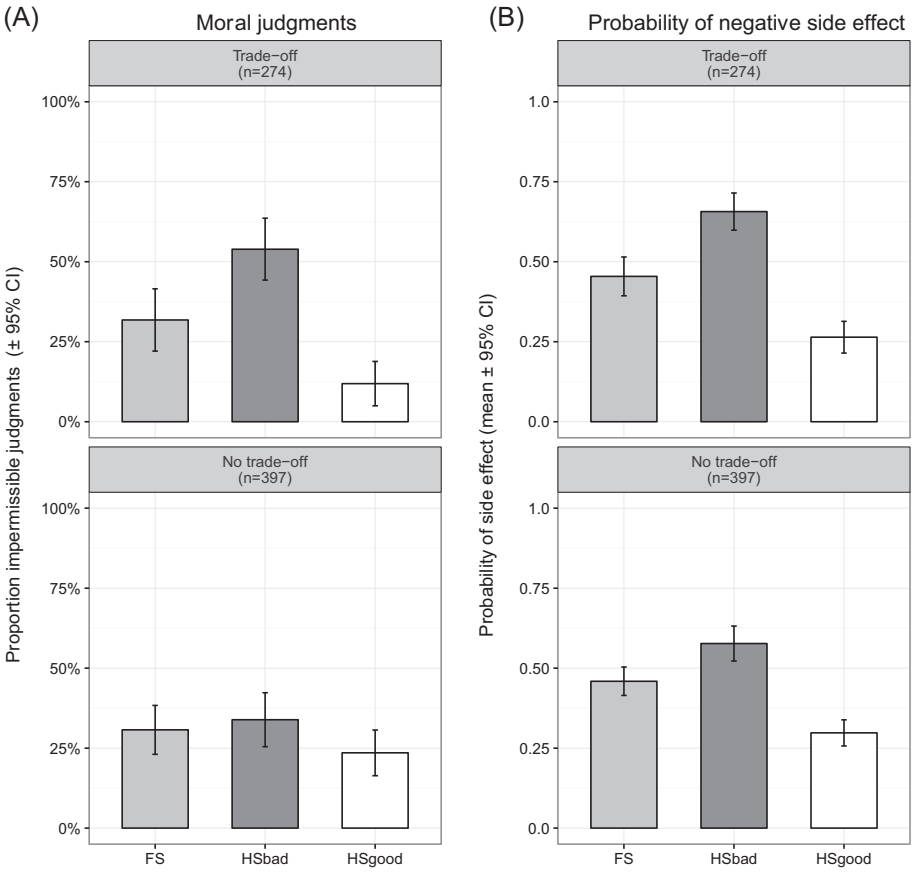

Figure 7. Comparison of participants who indicated a trade-off between cost and benefits of the action as their most important reason for their moral judgment (upper panel) and those indicating other reasons (lower panel). (A) The proportion of participants rating an action impermissible (± 95% CI) and (B) the mean probability estimates for negative side effects (± 95% CI). The hindsight effect in probabilities was found within each subsample, yet the hindsight effect for moral judgments emerged only for the trade-off group.

a consequentialist and deontological account of moral judgments using a hindsight paradigm. The key finding is a hindsight effect in moral judgments. Participants in the *foresight* condition, in which the occurrence of a negative side effect was uncertain, judged actions to be more permissible than participants in the *hindsight bad* condition, where negative side effects occurred. Conversely, in *foresight,* the action was judged less permissible than in the *hindsight good* condition, where negative side effects did not occur.

The second finding was a classical hindsight effect in probability estimates and a systematic relation between moral judgments and probability estimates. In the aggregate, probability estimates reflected knowledge about the course of events and matched the observed pattern in moral judgments. Within each epistemic condition, moral judgments and probability estimates were also correlated, which suggests that the observed differences in moral judgments resulted from different probability beliefs. These findings extend hindsight effects in the retrospective evaluation of judgments and decisions to the moral domain. Aggregating across participants, the relation between moral judgments and probabilities is consistent with the predictions of a consequentialist model that weighs outcomes by their subjective probability adjusted in hindsight.

The third finding, however, shows that the hindsight effect for both probability judgments and moral judgments was only present among participants who reported a cost-benefit trade-off, indicating a consequentialist judgment. Among those who did not report a trade-off as the most important reason, only a hindsight effect in probability judgments was observed, but did not carry over to the moral judgments. This suggests that moral judgments were more prone to hindsight effects when based on a consequentialist trade-off than when people did not make this trade-off in their moral judgments.

Moral Judgments Under Certainty and Uncertainty

Moral dilemmas that present all consequences as certain are widely used in both philosophy and psychology. Philosophers use them as thought experiments to inform normative theorizing; psychologists employ them to tap into laypeople's moral intuitions. What is missing from

the literature is a more thorough consideration of moral dilemmas that have a closer resemblance to real-world situations, which exhibit different degrees and types of uncertainty, resulting in varying epistemic conditions.

From a descriptive point of view, limiting the study of moral judgments to situations of certainty can create blind spots in our understanding of what moral processes are actually adapted to. For instance, our results suggest that some deontic rules may be more stable under varying epistemic conditions than a consequentialist model. They may thus not only be less costly in regulating social behavior (Bennis, Medin, & Bartels, 2010) but also be better adapted to real-world epistemic conditions (but see Brand & Oaksford, 2015, who observed in the aggregate a relation between probabilities and moral judgments for dilemmas that typically elicit deontological judgments).

From a normative point of view, the difference between uncertainty and certainty is also crucial: to provide normative ethical guidance, a moral theory should safeguard a decision maker against varying moral evaluations (negative or positive) in retrospect (Zimmerman, 2010).

Future Directions

The present research raises a number of interesting questions for future work. The first question is whether the hindsight effect in moral judgments found for participants indicating a trade-off is really caused by a hindsight effect in their probability estimates. One alternative is that people adjusted their probability estimates to fit their moral judgments, for instance, as a post hoc justification (Haidt, 2001). However, studies manipulating probability information given to participants *before* their moral judgments support the idea that probability information is considered in moral judgments (Brand & Oaksford, 2015; Shenhav & Greene, 2010). A second alternative is that the effect in moral judgments instead (or partially) results from outcomes alone (for the difference to outcome bias, see Baron & Hershey, 1988), for example, by evaluating decisions based on the quality of the outcome or by reevaluating costs and benefits after the fact. Although in most situations hindsight and outcome effects may be expected to work together and are difficult to disentangle, we think it is an interesting question whether and how the value of outcomes may change after they occurred. Third, it is possible that people based their judgments not on what they believed they would have predicted, but used outcomes to infer the epistemic state of the decision maker, assuming that the decision maker may have had additional knowledge allowing to better foresee events. Like agents are judged to be more responsible and blamed more if negative outcomes could have been foreseen (Lagnado & Channon, 2008), retrospective moral judgments may depend on what a decision maker is expected to foresee. In the present study, hindsight participants believed the course of events to be more foreseeable than in foresight, so maybe they expected the same from decision makers. Moreover, even without believing that they themselves would have foreseen an event, they may expect decision makers to do so. These expectations may be even higher for experts and authorities in the dilemmas used in this study, given their official responsibility for others. In turn, the question arises whether hindsight effects in moral judgments are smaller for decision makers without official responsibilities or expertise.

A second closely related empirical issue is whether the observed hindsight effect generalizes to other types of moral judgments, like judgments of blame or responsibility. Some evidence exists for an effect of outcome knowledge on the attribution of responsibility for negative events and the relation to their perceived predictability (Janoff-Bulman, Timko, & Carli, 1985; Mitchell & Kalb, 1981; but see Walster, 1967). Moreover, it has been suggested that judgments of blame rely even more on consequences and causal considerations than judgments of permissibility (Cushman, 2008; Lagnado & Channon, 2008), so hindsight effects in these judgments may be even stronger than those found in the present study. Given the close connection to what is foreseen and judgments of blame, it would also be interesting to investigate how hindsight influences judgments of intentionality. Knobe (2003) found that people judge actions as more intentional if they resulted in a bad side effect than in a beneficial side effect. Given that hindsight influences beliefs of how likely side effects are, the Knobe effect may thus be much larger in a hindsight version of the scenario compared to a foresight condition.

Third, modeling of the judgment processes underlying people's moral judgments and the utilized information presents an important challenge. Our findings highlight individual differences in the information (cues) that people considered to be most important. Future research would profit from precisely characterizing both the informational input and the computational steps of different moral judgment processes, as done in research in other areas of judgment and decision making (Fleischhut & Gigerenzer, 2013; Gigerenzer, Todd, & The ABC Research Group, 1999; Hertwig, Hoffrage, & The ABC Research Group, 2013). In fact, the broad distinction between deontological and consequentialist models is far too simple to allow for more than qualitative predictions as long as the various models and their input are not clearly specified. Whereas a consequentialist approach resembles linear-additive models widely used in decision science (Gigerenzer, 2010; Lucas & Galinsky, 2015; Shenhav & Greene, 2010), another candidate model class would be lexicographic, noncompensatory judgment processes operating on the

morally-relevant aspect of a situation (Tan, Luan, & Katsikopoulos, 2017). Lexicographic models inspect only one cue at a time and only consider further cues if previous ones are not decisive (Gigerenzer & Goldstein, 1996). For instance, people may first compare the cost of inaction and action and, if both are uncertain, move on to the benefits of action and inaction as the next cue. Moreover, the model would predict different judgments depending on the order in which cues are considered (i.e., in judgments of moral permissibility compared to judgments of blame, see Cushman, 2008). Specifying models of moral judgment would also allow to make quantitative predictions across different epistemic conditions by combining them with models of the updating process, as suggested within hindsight research (Blank & Nestler, 2007; Hoffrage, Hertwig, & Gigerenzer, 2000; Pohl, Eisenhauer, & Hardt, 2003).

Finally, it is an important question whether hindsight effects occur for other aspects of situations that can be uncertain, such as the need for or the success of the action, as well as the kind and magnitude of negative outcomes. The perceived probability of these aspects may even interact to produce the observed effect on moral judgments. For instance, if side effects are believed to be higher in hindsight, this may weaken the confidence that an action is successful or even necessary. However, in many real-world situations, it will even be uncertain whether further potential consequences exist or alternative actions are available. Outside the laboratory, how (much) people search for or are aware of further consequences and options can thus have a great impact on moral judgment and behavior (e.g., Butterfield, Trevin, & Weaver, 2000; Palazzo, Krings, & Hoffrage, 2011). If a candidate action is considered morally impermissible, people may start searching for alternative actions that they consider morally more appropriate. Conversely, without a particular framing, many situations may not initially be considered a moral one and may only be evaluated differently if – and when – additional information is acquired (e.g., about previously unknown side effects; Osman, 2015a, 2015b). Moving beyond "small worlds" (Bennis et al., 2010; Binmore, 2008; Gigerenzer, 2008) in which all relevant information and questions are given will require different paradigms than the ones typically studied in the literature.

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Electronic Supplementary Materials

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ESM 1. Text (pdf).
Experimental Materials.
ESM 2. Tables and Figures (pdf).
Additional Analyses.

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