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RESEARCH REPORT

Hindsight bias and causal reasoning: a minimalist approach

Jennelle E. Yopchick · Nancy S. Kim

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Abstract What factors contribute to hindsight bias, the phenomenon whereby the known outcome of an event appears obvious only after the fact? The *Causal Model Theory* (CMT) of hindsight bias (Nestler et al. in Soc Psychol 39:182–188, 2008a; in J Expl Psychol: Learn Mem Cog 34:1043–1054, 2008b; Pezzo in Mem 11:421–441, 2003; Wasserman et al. in Pers Soc Psychol Bull 17:30–35, 1991) posits that hindsight bias can occur when people have the opportunity to identify potential causal antecedents and evaluate whether they could have led to the outcome. Two experiments incorporating highly controlled minimalist scenarios supported the CMT. As predicted by the CMT, hindsight bias occurred when the causal factor explained the actual outcome better than the alternative outcome, and reverse hindsight bias occurred when the causal factor explained the alternative outcome better than the actual outcome. Moreover, we found new evidence that outcome knowledge alone was insufficient to elicit hindsight bias in the absence of a potential causal antecedent. Implications for future directions in hindsight bias research are discussed.

Keywords Hindsight bias · Causal reasoning · Judgments

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J. E. Yopchick (✉) · N. S. Kim (✉)
Department of Psychology—125 NI, Northeastern University, 360 Huntington Avenue, Boston, MA 02115-5000, USA
e-mail: yopchick.j@neu.edu

N. S. Kim
e-mail: n.kim@neu.edu

It has long been observed that event outcomes often seem inevitable after the fact. For example, after a football game is over, spectators may believe that they knew the outcome was going to occur (and even what the losing team's quarterback should have done differently to win the game). Similarly, after an election, political pundits often claim it was obvious that the victorious candidate was going to win, whereas in reality, the spread in the polls was negligible or non-existent prior to the election. Even the most unexpected economic crises are subsequently portrayed by the popular press as though they had been expected for years and ought to have been circumvented. The tendency for people considering a past event to overestimate the likelihood that they would have predicted its occurrence is known as *hindsight bias* (Fischhoff 1975).

An important goal of research on hindsight bias is to identify the processes by which the bias comes about. Past research on this issue can be roughly divided into two distinct lines of work, each examining a separate process thought to underlie the bias. One line has focused on the role of motivational factors. For example, it has consistently been found that when an outcome has personal relevance to the reasoner, the reasoner is motivated to preserve his or her intelligent self-image; this motivation systematically predicts whether or not hindsight bias appears (Mark and Mellor 1991; Pezzo 1996, 2003; Pezzo and Pezzo 2007). The other major line of research has focused on cognitive processes, such as memory reconstruction and reasoning (e.g., Fischhoff 1975; Hawkins and Hastie 1990; Guilbault et al. 2004; Tversky and Kahneman 1974). The current project falls under this second line of research, examining the role of causal reasoning in eliciting hindsight bias.

In this Introduction section, we briefly review seminal empirical and theoretical work on hindsight bias and, more

specifically, the Causal Model Theory (CMT; Nestler et al. 2008a, b; see also Pezzo 2003, and Wasserman et al. 1991) of hindsight bias. We will then give our rationale for the current work, which takes a highly controlled minimalist approach to testing the CMT. We will return briefly to the issue of motivational influences in the "General discussion."

Fischhoff's account of hindsight bias

In the first empirical demonstration of hindsight bias, Fischhoff (1975) presented people with an event description (e.g., a battle between the British and the Gurka) and told them the actual outcome of that event (e.g., a British win). When people were then asked to judge the likelihood of several possible outcomes *as if* they did not know the actual outcome, their likelihood judgments were always skewed to favor the actual outcome. In contrast, in a foresight condition in which the actual outcome of the event was never provided, another group of people judged all possible outcomes to occur with roughly equal likelihood. This general empirical approach to the study of hindsight bias is known in the literature as the *hypothetical paradigm*.

Fischhoff (1975) argued that hindsight bias occurs because people tend to automatically assimilate the outcome information with the event information. That is, he speculated that people automatically and effortlessly reconceptualize their prior knowledge about the event, so that it now seems to lead inevitably to the now-known outcome. For example, people's ratings of the relevance of individual statements in the event (e.g., that "British officers learned caution only after sharp reverses") differed significantly between the hindsight and foresight conditions. Fischhoff suggested that it was this assimilation process that lead to the feeling that the outcome was inevitable, a phenomenon he termed *creeping determinism*.

Subsequent work further suggested that hindsight bias is comprised of at least three major components (Nestler et al. 2008b), one of which is a memory overwriting component. Studies of the memory component of hindsight bias have typically relied upon a *memory recall paradigm,* in which people are often asked factual questions (e.g., how long is the Danube river?), are told the correct answer, and then after a time lag, are asked to recall and report their initial answer (Pohl 2007). Fischhoff proposed that the reasoner's memory itself is altered once the answer is known, and the reasoner can no longer recall how it was to be completely uninfluenced by that knowledge.

Memory overwriting is a highly plausible mechanism for hindsight bias in the memory recall paradigm, such that the substantial time lag between the initial response and recall allows for memories to be reconstructed. However, overwriting seems less likely to explain the appearance of hindsight bias in studies using the hypothetical paradigm (e.g., Fischhoff's 1975) classic British-Gurka study), because there is no time lag at all, yet hindsight bias appears to occur immediately. Accordingly, two components of hindsight bias have been proposed in addition to the memory component (e.g., Nestler et al. 2010): First, an increased impression that one knew all along what the outcome would be and second, an increased perception of the outcome's inevitability, elicited via a causal reasoning process. The causal reasoning process hypothesized to underlie inevitability perceptions is itself the central point of a model, which was initially proposed by Wasserman et al. (1991), more recently re-specified by Nestler and colleagues (Nestler and von Collani 2008a, b; Nestler et al. 2008a, b), and influenced by a conglomerate of strongly related research (e.g., Fischhoff 1975; Hawkins and Hastie 1990; Hölzl and Kirchler 2005; Pennington 1981; Pezzo 1996, 2003). This model, known as the CMT of hindsight bias, is the focus of the current work.

The Causal Model Theory of hindsight bias

A seminal study conducted by Wasserman et al. (1991) tested whether causal reasoning (in particular, causally linking the actual outcome back to the event) is necessary to elicit hindsight bias. They added two new hindsight conditions to the original Fischhoff (1975) paradigm. In the first, an additional statement was presented, suggesting that the actual outcome was due to *chance* (e.g., "a sudden downpour, totally unexpected in the middle of the dry season, changed the character of the fight"). As Wasserman et al. (1991) predicted, hindsight bias did not occur when a chance statement was present, presumably because it could be causally linked to either possible outcome. In their second new hindsight condition, an additional statement, one that they termed *plausibly relevant* to the outcome, was explicitly stated as having caused the actual outcome (e.g., "because of the tight discipline of Ashbrook's troops, the British won"). Hindsight bias was found to an equal degree in the plausible relevance condition and the Fischhoff (1975) hindsight replication condition, both as compared to the foresight condition. Thus, Wasserman et al.'s study (1991) supported the causal reasoning hypothesis in that hindsight bias disappeared in the chance condition; however, the role of "plausible relevance" in eliciting hindsight bias remained unclear.

To clarify the influence of causal reasoning in the hindsight bias process, Nestler and colleagues further specified the CMT, suggesting that in certain cases, hindsight bias is elicited via a "sense-making" process

(Nestler et al. 2008a). Specifically, the CMT states that when people are presented with hindsight scenarios in the hypothetical paradigm, they are internally motivated to explain *why* the given outcome occurred; for example, following the initial surprise of an unexpected outcome (Pezzo 2003). Past research showing people's reliance on causal reasoning in other kinds of problems (e.g., processing of complex categories; generation of social theories) has repeatedly indicated that people spontaneously construct causal connections between co-occurrences similar to those presented in hindsight scenarios (Anderson and Sechler 1986; Hastie et al. 1990; Kunda et al. 1990). Indeed, it is well known that characteristics or events of similar magnitude, occurring close together in time and in sequence, strongly cue perceptions of causality (Einhorn and Hogarth 1986).

Nestler and colleagues proposed that there are two components to this sense-making process: a search for causal antecedents and the evaluation of those antecedents. That is, when trying to explain a particular outcome (e.g., a British win), people must first search for relevant information in the event scenario (e.g., reading that the Gurkas were only 12,000 strong) or in long-term memory (e.g., prior background knowledge about various factors that affect battle outcomes in general). Then, the evaluation process begins, wherein the retrieved causal antecedents are evaluated with respect to whether they explain the occurrence of the outcome (e.g., people might reason retroactively that having "only 12,000" Gurkas present helped lead to the British win; Nestler and von Collani 2008a, b; Nestler et al. 2008a, b; Pezzo 2003; Wasserman et al. 1991). If one or more causal antecedents readily explain the outcome, then the outcome seems more inevitable, and hindsight bias occurs (see also Hölzl and Kirchler 2005).

Previous hindsight bias studies incorporating the hypothetical paradigm have all demonstrated the bias using highly detailed event descriptions (see Fischhoff 1975; Nestler and von Collani 2008b; Nestler et al. 2008b; Wasserman et al. 1991). These highly detailed event scenarios contain many potentially causal antecedents, which could be construed to apply to the different possible outcomes (e.g., in Fischhoff's (1975) original materials, "the British troops and transport animals suffered from the extremes of heat and cold;" "The Gurkha force was only some 1,200 strong"). Thus, it is difficult to ascertain from past research exactly what factors are necessary to elicit hindsight bias in the hypothetical paradigm.

We propose that under more fully controlled conditions, the role of relevant causal information in eliciting hindsight bias can be more definitively identified. In the following section, we describe how the current project was designed to do so.

Re-examining the CMT of hindsight bias: a minimalist approach

As previously mentioned, Fischhoff's (1975) original materials were scenarios consisting of long paragraphs describing many events, and Wasserman et al. (1991) and Nestler and colleagues (Nestler and von Collani 2008b; Nestler et al. 2008b) also used these and similarly constructed materials. As Wasserman et al. (1991) themselves suggested, there were numerous potentially causal statements already present in the original complex materials that could have allowed for a causal path from any of these events to the outcome to be easily constructed. Thus, even the events in the original Fischhoff (1975) materials could very reasonably elicit hindsight bias in accord with CMT.

Thus, in the current experiments, we used much more sparsely constructed materials, removing the additional potentially causal statements and other extraneous information from the event descriptions. In short, instead of using event descriptions in a long paragraph form, as in past work, we created one-sentence clearly non-causal event descriptions, each followed by a one-sentence additional statement, and lastly a one-sentence outcome. This minimalist approach was intended to allow for clearer interpretations regarding what types of information are needed to elicit hindsight bias. In the "General discussion," we address the potential issue of ecological validity.

We also considered three additional issues unaddressed in previous work. One additional goal was to provide a clean test of a reasonable alternative to CMT. Because previous classic studies eliciting immediate hindsight bias in the hypothetical paradigm have included a large amount of causally relevant information in the event descriptions (e.g., Fischhoff 1975; Wasserman et al. 1991; Nestler et al.), there has not yet been a clean test of the possibility that outcome knowledge alone, in the absence of *any* provided potential causal antecedents, is sufficient to elicit hindsight bias. For this purpose, we also created a "control" hindsight condition, in which only the bare-bones event description and the actual outcome were provided (not the potential causal antecedent). If it is true that just knowing the outcome is enough to elicit hindsight bias, and causal reasoning is not necessary, then we should expect hindsight bias to occur even under these conditions.

Second, in previous work, the plausibility of the additional statement (i.e., how likely it was to occur) and its relevance (i.e., how relevant it was to the outcome) were often confounded. We reasoned that if a statement is highly relevant to the outcome, then reasoners should be able to readily draw a strong causal link between that statement and the outcome. Indeed, studies investigating hindsight bias as a motivational construct have repeatedly found that high relevance appears to play a key role in eliciting the

bias (Mark and Mellor 1991; Pezzo 1996, 2003; Pezzo and Pezzo 2007). Conversely, irrelevant information should in no way help to draw a causal link from the statement to the outcome. In Experiment 1, we directly tested our predictions about relevance by manipulating the relevance of the information, holding plausibility constant.

Third, to investigate the scope of the CMT, we also examined the related phenomenon of reverse hindsight bias in Experiment 2. In reverse hindsight bias, a surprising unexplainable outcome results in the reversal of likelihood estimates for the possible outcomes (Mark and Mellor 1991; Nestler and Egloff 2009; Ofir and Mazursky 1997; Pezzo 2003). The CMT account predicts that when the potential causal factor explains the alternative outcome better than it does in the actual outcome, people will be surprised, and reverse hindsight bias ("I never would have known that would happen!") will result. Therefore, we asked what kinds of information contribute to the appearance of reverse hindsight bias, using our minimalist approach.

The overarching goals of Experiments 1 and 2 were, therefore, to examine the role of causal reasoning in hindsight bias by using less complicated materials and more clearly defined manipulations of relevance in the hypothetical paradigm, to test the alternative hypothesis that only outcome information is needed to elicit the bias, and (Experiment 2) to examine the scope of the CMT by investigating whether it extends to reverse hindsight bias.

Experiment 1

Method

Participants

Participants were 172 Northeastern University undergraduates who took part in the study in exchange for either partial introductory psychology course credit or candy. Of these, 150 took part in the main study (25 in each of six between-subjects conditions) and 22 completed one of two pilot studies (see below).

Materials

We created four scenarios, a battle between the Hutu and the Tutsi, a gold mining expedition, a court case, and an epidemic outbreak. The Hutu–Tutsi scenario was based on the original British–Gurka war scenario (Fischhoff 1975), and the gold mining expedition scenario was adapted from Wasserman et al. (1991). Each of the current scenarios consisted (maximally) of a one-sentence event description, a one-sentence additional statement, and a one-sentence outcome. Each one-sentence additional statement was manipulated to have either high or low causal relevance to the actual outcome's occurrence. To ensure that participants did not assume that the events in the additional statements were rare or unusual, potentially leading them to discredit the information altogether, we specified a high prior probability of occurrence for each (90% of the time in the past), in keeping with previous work (e.g., Mazzoni et al. 2001; Pedzek et al. 2006).

Pilot 1: Overall believability of additional statements. In the first pilot study, we collected pre-ratings to determine whether the additional statements were believable. Accordingly, a separate group of 12 undergraduates rated each of the items for overall believability (e.g., "how believable is it that in 90% of prior battles, the Hutus showed superior discipline with their troops?"). Participants answered each question on a 1–9 scale (1 = not at all believable, 9 = extremely believable).

Pilot 2: Facilitation of causal reasoning. We also ran a manipulation check to test whether our manipulation of the event information's causal relevance to the outcome was indeed perceived as we intended. Following Wasserman et al. (1991) and a large body of work in the causal reasoning literature (e.g., Einhorn and Hogarth 1986), we had presumed that event information highly causally relevant to the outcome (e.g., superior discipline of the Hutus in a battle that the Hutus win) would readily and automatically support causal reasoning, whereas event information of low causal relevance (e.g., beginning the day by traveling west for the Hutus in a battle that the Hutus win) would make causal reasoning very difficult.

We presented ten participants with each of the four event scenarios in randomized order. Each scenario was presented with the event description, followed by both the high and low causal relevance additional information. For example, for the Hutu–Tutsi scenario, participants read: "In 1952, the Hutu tribe and the Tutsi tribe began a relentless battle. In prior battles, the Hutus had shown superior discipline with their troops. Also, in prior battles, the Hutus began the day by traveling west." The order of the high and low causal relevance statements at the end of the scenarios was counterbalanced between subjects. Following the presentation of the scenario, participants were asked two questions about how causally relevant the additional information was to predicting the actual outcome. For example, the questions pertaining to the Hutu–Tutsi scenario read as follows: "In trying to predict whether or not the Hutus would be able to win a particular battle, how relevant would it be to know that that Hutus had shown superior discipline with their troops?" "In trying to predict whether or not the Hutus would be able to win a particular battle, how relevant would it be to know that that Hutus began the day by traveling west?"

Participants used a 1–9 rating scale (1 = not all relevant, 9 = extremely relevant).

Procedure

In the main experiment, there were six between-subjects conditions corresponding to a 2 (task: hindsight, foresight) × 3 (information: baseline, high causal relevance, low causal relevance) design. Thus, there were three distinct hindsight conditions and three distinct foresight conditions tailored to correspond to each of the hindsight conditions. Each participant was randomly assigned to view all four event scenarios (i.e., Hutus–Tutsis, gold mining, court case, and epidemic outbreak) in one of the six between-subjects conditions. Scenarios were presented to each participant in randomized order. Below, we will use the Hutu–Tutsi Scenario as a running example to describe the six between-subjects conditions; again, however, participants viewed four different vignettes, as mentioned above. See electronic supplementary material for all stimuli.

In the *Baseline—Hindsight* condition, for each of the four scenarios, participants received only the introductory event description (e.g., "in 1952, the Hutu tribe and the Tutsi tribe began a relentless battle") plus the actual outcome (e.g., "in this particular battle, the Hutus won"). Participants were provided with two possible outcomes to consider (e.g., the Hutus win; the Hutus lose) and were instructed, "some participants are asked to read this scenario, but are not told the outcome. Your task is to put yourself in their shoes and to attempt to judge the likelihood of each of the following outcomes by writing a probability value from 0 to 100% next to each of the two outcomes below, as if you did not know the outcome already." They then judged the likelihood of each outcome by writing a probability value from 0 to 100% next to each. They were told that the total of their two probability estimates should equal 100%. Whichever outcome was said to be the actual outcome was always presented first.

For each of the four scenarios, participants in the corresponding *Baseline—Foresight* condition received only the one-sentence event description and no outcome. Participants were provided with two possible outcomes to consider (e.g., the Hutus win; the Hutus lose) and were asked to judge the likelihood of each outcome. The remainder of the question continued on exactly as above.

Each scenario in the other hindsight conditions consisted of the same event description, an additional statement of either high or low causal relevance, and the actual outcome, following previous work (e.g., Nestler and Egloff 2009; Wasserman et al. 1991). In the high causal relevance-hindsight condition, participants read the event description and outcome as in the baseline condition, along with the additional statement (e.g., "in 90% of prior battles, the Hutus had shown superior discipline with their troops"). They were then told that, for example, "some participants are asked to read this scenario, but are not told the outcome or the subsequent information about this particular battle. Your task is to put yourself in their shoes and to attempt to judge the likelihood of each of the following outcomes by writing a probability value from 0 to 100% next to each of the two outcomes below, as if you did not know the outcome or the subsequent information already." The remainder of the question continued on exactly as in the baseline hindsight and baseline foresight conditions. The additional statement in the low causal relevance-hindsight condition stated that, for example, "in 90% of prior battles, the Hutus began the day by traveling west" (see Supplemental materials). Whereas a variety of question types have been employed in hindsight bias research, this question wording closely follows previous work and is well documented both in the applied test–retest paradigm (e.g., Goodwin 2010) and, more importantly, the hypothetical paradigm in seminal tests of the CMT (e.g., Nestler and Egloff 2009; Wasserman et al. 1991). For this reason, we chose this question wording to draw directly from prior work on CMT.

A high causal relevance-foresight condition and a low causal relevance-foresight condition were also implemented. In the high causal relevance-foresight condition, participants received the one-sentence event description, the high causal relevance additional statement, and no outcome. This condition contained the exact same information as the high causal relevance-hindsight condition, the only difference being the absence of the outcome in the high causal relevance-foresight condition. Similarly, the low causal relevance-foresight condition was identical to the low causal relevance-hindsight condition, except without the actual outcome. Participants were once again provided with the two possible outcomes and were told, "some participants are asked to read this scenario, but are not told the information about prior battles. Your task is to put yourself in their shoes and to attempt to judge the likelihood of each of the following outcomes … as if you did not know the information about prior battles already." In other words, each foresight question was worded as identically as possible to its corresponding hindsight condition, except that prior outcome information was not provided or referenced. Very slight differences in wording were inevitable in order for each question to make sense when presented independently, as all conditions were between subjects.

If the CMT is correct and hindsight bias arises from causally connecting relevant information in the scenario to the known outcome, then we should obtain hindsight bias in the high causal relevance-hindsight condition as compared to the high causal relevance-foresight condition. However, when the information in the scenario has low causal

relevance to the outcome, then hindsight bias should not be obtained (according to the CMT's predictions) in the low causal relevance-hindsight condition as compared to the low causal relevance-foresight condition. Lastly, without any causally relevant information, hindsight bias should not arise in the baseline hindsight condition as compared to the baseline foresight condition, according to the CMT.

Results and discussion

Pilot 1: Overall believability of additional statements. Our dual purpose in conducting the first pilot study was to ensure that both the high and low causal relevance items were seen as reasonably believable, and that our high causal relevance items were not seen as generally more believable than our low causal relevance items. As we had intended, both high and low causal relevance items were rated as believable, significantly above the midpoint of 5 (high causal relevance: $M = 6.0$, SE = 0.4; $t[11] = 2.57$; $P = 0.03$; $\eta^2 = 0.375$; low causal relevance: $M = 7.1$, SE = 0.4; $t[11] = 5.28$; $P < 0.01$; $\eta^2 = 0.717$). The high causal relevance items were not seen as more believable than the low causal relevance items; if anything, the opposite pattern emerged ($t[11] = -4.64$; $P < 0.01$; $\eta^2 = 0.662$). Therefore, it cannot be argued that hindsight bias appeared in the high causal relevance conditions because the high causal relevance statements happened to be more believable.

Pilot 2: Facilitation of causal reasoning. Critically, the high causal relevance items ($M = 7.8$, SE = 0.4) were rated as drastically more relevant to making predictions about the outcome than the low causal relevance items ($M = 1.7$, SE = 0.2; $t[9] = 15.26$; $P < 0.01$; $\eta^2 < 0.001$). The results of this manipulation check confirm that, as we intended, when event information of high causal relevance to the actual outcome is presented, participants can much more readily draw a causal link between the event and outcome. When the additional information provided is of low causal relevance to the occurrence of that actual outcome, the information does not aid in predicting the outcome, as it has no causal import.

Main experiment results

Analyses were conducted at the $\alpha = 0.05$ level, and the data were collapsed across the four scenarios. A 2 (task: hindsight, foresight) × 3 (information: baseline, high causal relevance, low causal relevance) ANOVA of the likelihood judgments for the actual outcome revealed the critical main effect of information ($F[5,149] = 10.87$; MSE = 0.022; $P < 0.001$; $\eta^2 = 0.131$). To examine the influence of the outcome and causal information, three pairwise comparisons were conducted between the matched conditions; that is, between each of the three foresight conditions (in which no outcome was provided) and their three corresponding hindsight conditions (in which the outcome was provided).

Most importantly, in the high causal relevance-hindsight condition, the mean likelihood rating of the actual outcome ($M = 68.8\%$; SE = 2.9%) was reliably greater than in the high causal relevance-foresight condition (M = 60.3%, SE = 2.9%;[1] $t[48] = 2.08$, $P = 0.043$; $\eta^2 = 0.08$). The direction of means ran in the same direction for all four scenarios. Hindsight bias, therefore, was found when a causally relevant statement was provided in conjunction with the actual outcome, in line with the CMT's predictions.

In the baseline foresight condition, participants judged the actual outcome (e.g., a Hutu win) to occur 53.2% (SE = 2.4%) of the time over the alternative outcome, whereas in the baseline hindsight condition, participants judged the actual outcome (e.g., a Hutu win) to occur 53.7% (SE = 3.0%) of the time over the alternative outcome ($t[48] = 0.11$, $P = 0.912$; $\eta^2 < 0.01$). Thus, there was no evidence of hindsight bias in the baseline conditions, suggesting that merely knowing the outcome is not enough to elicit hindsight bias.

Similarly, in the low causal relevance-hindsight condition, the mean likelihood rating of the actual outcome ($M = 55.2$; SE = 2.8%) did not reliably differ from that given in the low causal relevance-foresight condition ($M = 48.4\%$; SE = 2.7%); $t[48] = 1.47$, $P = 0.148$; $\eta^2 = 0.04$). This result, in conjunction with the results of the high causal relevance conditions, indicates that causal relevance is critical in eliciting hindsight bias.

Summary

Taken together, the results of Experiment 1 and the two pilot studies provide strong support for the CMT (Nestler et al. 2008a; Wasserman et al. 1991) of hindsight bias. Importantly, these effects were found, despite the fact that the scenarios were highly minimal. Namely, Experiment 1 suggests that when conditions allow for the easy construction of a causal link from the event to the outcome, as confirmed in Pilot 2, hindsight bias results. When the ability to construct the causal link is reduced (e.g., in the low causal relevance condition), hindsight bias does not occur. Moreover, there was no effect of hindsight bias in the baseline condition of Experiment 1, in which only the outcome was presented. This result suggests that simply knowing the outcome is not enough to elicit immediate hindsight bias in the hypothetical paradigm; instead, again,

[1] People rarely predict exactly 50–50 in foresight in the hindsight bias literature, most likely because of the incorporation of background knowledge into the task (see Hawkins and Hastie 1990 for a review).

causal reasoning appears to be necessary for the outcome to seem inevitable.

Experiment 2

In Experiment 2, we expanded upon these general findings, testing the breadth of the CMT with respect to a closely related phenomenon known as *reverse hindsight bias*. Again, according to Nestler and colleagues, hindsight bias in the hypothetical paradigm arises from a "sense-making" process, whereby a reasoner attempts to explain an unexpected outcome (Nestler and von Collani 2008a, b; Nestler and Egloff 2009; Nestler et al. 2008a, b; Pezzo 2003). This same "sense-making" process can be applied to reverse hindsight bias, wherein following an unexpected outcome, people's likelihood judgments favor the alternative outcome rather than the actual outcome. Pezzo (2003) first suggested that when an outcome is incongruent with the reasoner's expectations, the actual outcome appears surprising, motivating attempts to explain why the outcome occurred. If the sense-making process fails, or no appropriate causal antecedents are discovered during the search, then a reversal of the likelihood estimates may occur ("I never would have seen it coming;" Mazursky and Ofir 1990, 1996; Ofir and Mazursky 1997). In keeping with the CMT and Pezzo (2003), we further predict that when a causal link can be drawn most easily from the event to the *alternative* outcome, the actual outcome appears surprising, resulting in the seeming inevitability of the alternative outcome (rather than the actual outcome) and reverse hindsight bias.

In Experiment 2, we also re-addressed two of our primary goals using the same minimalist approach, as in Experiment 1. First, to our knowledge, reverse hindsight bias had never yet been examined using minimalist materials, allowing for a controlled examination of exactly what kinds of information are needed to obtain reverse hindsight bias. Second, we examined the alternative possibility that just knowing the outcome of an event, rather than causal reasoning, is enough to elicit reverse hindsight bias.

Method

Participants

Another 100 Northeastern University undergraduates participated in Experiment 2 (25 in each of four conditions) for partial introductory psychology course credit or candy.

Materials and procedure

The materials in Experiment 2 were nearly identical to those in Experiment 1; there were three exceptions. First, and most critically, the actual outcome and alternative outcome from Experiment 1 were switched, so that the actual outcome was now very surprising given the high causal relevance statement, whereas the alternative was more expected. For example, in Experiment 1, the actual outcome (e.g., "in this particular battle, the Hutus won") could be easily causally connected to the event, given the high causal relevance statement (e.g., "in 90% of prior battles, the Hutus had shown superior discipline with their troops"). In Experiment 2, however, the now-actual outcome (e.g., "in this particular battle, the Hutus lost") was surprising given the exact same high causal relevance statement; this causal link should be much more difficult to draw. (See Electronic supplementary material).

Second, we modified the dependent measure question to broaden the generality of our findings and to demonstrate that the robustness of the effect was not susceptible to slight differences in wording. In Experiment 2, the question read, "some participants are told of this [battle] occurring, but are not told the subsequent information, including the outcome." The rest was the same as in Experiment 1, again closely following the methodological approach used by Nestler and Egloff (2009) and Wasserman et al. (1991). Third, Experiment 1 showed that only the presence of a highly causally relevant statement resulted in hindsight bias, and that, simply knowing the outcome, as in the baseline condition, did not result in hindsight bias. Thus, in Experiment 2, we examined the issue of reverse hindsight bias using a simpler 2 (task: hindsight, foresight) × 2 (information: baseline, high causal relevance) design. Participants were randomly assigned to view all four vignettes in one of the resulting four between-subjects conditions.

The procedure, conditions, and design were otherwise the same as in Experiment 1. In the ratings questions, the rating for the actual outcome was always prompted first and the alternative outcome second.

Results and discussion

Analyses were conducted at the $\alpha = 0.05$ level except as noted. A 2 (task: hindsight, foresight) × 2 (information: baseline, high causal relevance) ANOVA of the likelihood judgments for the actual outcome revealed the critical main effect of information ($F[3, 99] = 5.81$; MSE = 0.030; $P = 0.018$; $\eta^2 = 0.057$).

Once again, pairwise comparisons were conducted to examine the role of the outcome and causal information in hindsight bias. Again, most important is the comparison between the high causal relevance-foresight condition (in which the additional relevant statement but no outcome was provided) and the high causal relevance-hindsight condition (in which the relevant statement and the outcome

were provided). In the high causal relevance-foresight condition, participants judged the actual outcome (e.g., a Hutu loss) to occur 56.0% (SE = 2.6%) of the time over the alternative outcome. Ratings in the high causal relevance-hindsight condition showed a significant reverse hindsight bias, such that the actual outcome was judged to occur only 39.3% (SE = 4.7%) of the time over the alternative outcome; this likelihood estimate for the actual outcome was significantly lower than the likelihood estimate for the same outcome in the high causal relevance-foresight condition ($t[48] = 3.09$, $P = 0.003$; $\eta^2 = 0.12$). The means ran in the same direction for three of the four scenarios (the gold mining scenario was the lone exception).

In contrast, the baseline hindsight condition ($M = 59.8\%$; SE = 3.55%) did not differ from the baseline foresight condition ($M = 52.2\%$; SE = 2.6%; $t[48] = 1.75$, $P = 0.086$; $\eta^2 = 0.06$).

Overall, these results support the extension of the CMT to reverse hindsight bias. We further propose that when a causal link is most easily constructed from the event to the alternative outcome (rather than the actual outcome), the alternative outcome seems relatively inevitable, resulting in reverse hindsight bias. Again, there was no reverse hindsight bias in the baseline condition, in which only the outcome, and no causally relevant statement, was presented.

General discussion

Experiments 1 and 2 provide clear support for the Causal Model Theory of hindsight bias. Using minimal materials that allowed us to cleanly manipulate the degree to which causal reasoning was enabled, we found that hindsight bias only appeared when a statement highly causally relevant to the outcome was provided. Additionally, our work broadens the scope of the CMT, as Experiment 2 showed support for the role of causal reasoning in *reverse* hindsight bias. Furthermore, in support of the CMT more generally, neither hindsight bias nor reverse hindsight bias appeared when only an event description and the outcome were provided. We suggest that hindering causal reasoning resulted in the disappearance of hindsight bias and promoting causal reasoning elicited its appearance. Relatedly, recent work by Miceli et al. (2010) suggests that hindsight bias is strongest when an outcome is known and the event information is provided in the correct temporal sequence in which it occurred. When the event information is randomly ordered, hindsight bias is diminished. Given that temporal order is a strong cue to inferring causality (Einhorn and Hogarth 1986), their results, too, are consistent with the CMT.

One disadvantage to our approach of using greatly pared-down materials is that their realistic nature may have been reduced relative to, for example, Fischhoff's (1975) original vignettes. We acknowledge this to be the case; on the other hand, there may nonetheless be many real-world situations in which the amount of information available to aid judgments is similarly sparse. Furthermore, the vast majority of hindsight experiments incorporating the hypothetical paradigm have already utilized highly detailed materials, and our minimalist approach has the advantage of greater experimental control. Most importantly, taken together, both types of materials appear to elicit the same patterns of results, in accord with the same theory.

Additionally, we did not manipulate the outcome in our experiment (e.g., whether the Hutus won or lost) between participants. However, the fact that we compared each hindsight condition to a matched foresight control condition, nonetheless, allows us to be confident in the reliability of our results.

Motivational considerations

These findings concerning the role of relevance in hindsight bias may also be useful in further understanding the motivational factors underlying hindsight bias. For example, Pezzo (2003), Pezzo and Pezzo (2007), and Mark and Mellor (1991) have consistently found that hindsight bias is elicited more strongly by an outcome that has personal relevance to the reasoner. An outcome has personal relevance to an individual if that individual cares about, or is invested in, the way the event might turn out. Specifically, by this account, people show hindsight bias in an attempt to preserve some stability of self-construct (e.g., Sally may believe in hindsight that she always knew the right answer on an exam, because she wants to preserve her belief that she is a smart individual). If an outcome is self-congruent to the reasoner (e.g., getting an A on an exam when Sally thinks of herself as a smart individual), the reasoning often follows the "I knew it all along" mentality, and hindsight bias results.

We can reinterpret these personal relevance findings with respect to the CMT. To illustrate, we return to our example above. If Sally holds the self-construct of being smart, then she will expect, on the basis of this self-construct, that her high intelligence should cause an A on the exam. This is similar to inferring that the Hutu troops' superior discipline caused the Hutus to win the battle. In situations of *personal* relevance, as in the example of Sally, we speculate that the experimenter may not need to explicitly state the relevant statement as we did in our current experiments; rather, the reasoner (e.g., Sally) already has a highly relevant factor in mind (e.g., being smart) that can easily be used to build that causal connection to a particular outcome (e.g., an A on the exam).

On the flip side, if the outcome is self-incongruent to the reasoner (e.g., Sally gets a D on the exam when she thinks of herself as a smart individual), her reasoning should follow the "I never would have known it" mentality and reverse hindsight bias should occur. In other words, the factor of being smart does not readily link causally to the outcome of a D grade, rendering the outcome surprising. Similarly, in Mark and Mellor (1991), subjects who were laid off showed reverse hindsight bias. The applicability of the Causal Model Theory in explaining these classic motivational effects could be systematically tested in future studies using our artificial materials (e.g., by experimentally inducing personal relevance).

Causal reasoning and theory of mind judgments

It is possible that causal reasoning may also underlie a broader range of related judgments beyond hindsight bias. For example, the classic hindsight bias paradigm used in the current experiments, as well as in many others, is in some respects a theory of mind task. In theory of mind tasks, reasoners are asked to consider a problem through the eyes of another individual (specifically, a person who is not privy to information about the state of the world that the reasoner knows). One commonality between theory of mind tasks and classic hindsight bias tasks is that a judgment is made about whether another person holds a false belief—that is, one that is incorrect given information that only the reasoner knows (Stanovich and West 2008).

Although most young children are able to pass classic theory of mind tasks (e.g., the Sally–Anne task and the Smarties task), it has long been known in the heuristics and biases literature that even adults have trouble performing perfectly on more difficult forms of the theory of mind task, in a phenomenon widely known as "epistemic egocentrism" (Royzman et al. 2003) or the "curse of knowledge effect" (Birch and Bloom 2007). The general finding is that adults' perspective-taking judgments reflect that they underestimate the likelihood that another person holds a false belief, even when the correct belief has clearly been revealed only to them and not to the other person. Most importantly for our purposes, the effect is found when it is reasonable, given general background knowledge about the world, that a particular false belief might be held (Birch and Bloom 2007). These findings nicely parallel the current findings that hindsight bias was only found when prior events could be causally connected to the outcome of those events. We speculate that causal reasoning may in fact be one factor underlying such "curse of knowledge" effects in adults, such that failure on theory of mind tasks occurs only when a causal link can easily be drawn from the false belief to plausible background knowledge about the world. This possibility, too, awaits future experimentation.

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