Surprise influences hindsight–foresight differences in temporal judgments of animated automobile accidents

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Abstract The hindsight bias occurs when people view an outcome as more foreseeable than it actually was. The role of an outcome's initial surprise in the hindsight bias was examined using animations of automobile accidents. Twenty-six participants rated the initial surprise of accidents' occurring in eight animations. An additional 84 participants viewed these animations in one of two conditions: Half stopped the animations when they were certain an accident would occur (i.e., in foresight), and the other half watched the entire animations first and then stopped the animations when they thought that a naïve viewer would be certain that an accident would occur (i.e., in hindsight). When the accidents were low in initial surprise, there were no foresight–hindsight differences; when initial surprise was medium, there was a hindsight bias; and when initial surprise was high, there was a reversed hindsight bias. The results are consistent with a sense-making model of hindsight bias.

Keywords Hindsight bias · Surprise · Animations · Judgment · Foreseeability · Sense-making

Once an outcome is known, people tend to view the outcome as more foreseeable than it actually was, a tendency termed the *hindsight bias*. The hindsight bias has been demonstrated in numerous domains (for a review, see Hawkins & Hastie, 1990) and countries (e.g., Pohl,

Bender, & Lachmann, 2002) and has been assessed in several ways (for a review, see Pohl, 2007). The most recent meta-analysis (Guilbault, Bryant, Brockway, & Posavac, 2004) showed an average effect size for the hindsight bias to be in the small-to-medium range, which demonstrates that the hindsight bias is a fairly robust phenomenon. The hindsight bias has important implications for legal decisions, particularly in the determination of liability (Colwell, 2005; Harley, 2007). The use of computer simulations to demonstrate an event may also affect legal decisions (Roese, Fessel, Summerville, Kruger, & Dilich, 2006). In the present experiment, we examined the hindsight bias in animations of automobile accidents to determine whether knowing the point at which an accident occurs would lead people to judge this occurrence as more foreseeable than it actually was.

Recent studies have demonstrated a hindsight bias in visual perception tasks. Harley, Carlsen, and Loftus (2004) presented participants with blurred images of celebrities that gradually became clear and asked them to determine when they could identify the celebrity. They later asked how blurry the images were when the celebrities were identified (Experiments 1 and 2) or when a naïve viewer would be able to identify the celebrities (Experiment 3). Results indicated a hindsight bias: Participants thought the images were more blurry at identification than they actually were and thought naïve viewers would be able to identify celebrities earlier than the participants could themselves. This finding has been extended by using objects instead of celebrities and children in addition to adults (Bernstein, Atance, Loftus, & Meltzoff, 2004). Furthermore, it has been shown that the hindsight bias is eliminated when faces start clear and become blurry (Bernstein & Harley, 2007). Bernstein and Harley explained these findings with the concept of fluency misattribution: Knowing the identity of

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a celebrity makes processing that image more fluent. When images start blurry and become clear, this fluency is misattributed to participants' having recognized the image at a more blurred state than they actually did, resulting in a hindsight bias in the blurry-to-clear condition. When images start clear and become blurry, this fluency is appropriately attributed to the knowledge afforded by starting with a clear, easy to recognize image, resulting in no hindsight bias.

Animations of automobile accidents have also been used to examine the hindsight bias. Roese et al. (2006) presented some participants with animations of automobile accidents (others received diagrams and text) and had them rate the likelihood that accidents would occur. Two groups of participants made these judgments in foresight, and one group made them in hindsight. The foresight groups differed in how far before the accident judgments were made, with one group making these judgments far before the accident occurred and the other group making them just before the accident occurred. Participants in the hindsight group first watched the entire animation and were told to disregard the outcome knowledge and judge the likelihood of an accident's occurring at the point just before it occurred. Roese et al. found that those judgments made in hindsight were greater than those made in foresight far before the accident occurred (i.e., a hindsight bias) but were less than those made in foresight just before the accident (i.e., a reversed hindsight bias). Roese et al. termed this reversed hindsight bias the *propensity effect*. They speculated that animations increase the ease with which one can process the trajectory of objects' motion, which, in turn, increases the perceived likelihood of an outcome's occurring. This processing fluency is misattributed to likelihood estimates, which results in foresight judgments made just before an outcome that are greater than hindsight judgments of the same event.

Other studies have reported a hindsight bias in judgments based on animations of automobile accidents. Fessel, Epstude, and Roese (2009) used one of the two animations from Roese et al. (2006), added more judgment times, and manipulated times and outcome knowledge within subjects. Fessel et al. examined the time course of hindsight–foresight differences and found that although hindsight and foresight judgments of the likelihood of an outcome's occurring were highly correlated and the hindsight and foresight slopes of these judgments over time were similar, increases in likelihood judgments occurred earlier in hindsight than in foresight. Interestingly, at no point in the animations did Fessel et al. find a reversed hindsight bias: Foresight judgments were never greater than hindsight judgments. Calvillo and Gomes (2010) used two different animations and manipulated timing within subjects and outcome knowledge between subjects. Like Fessel et al.,

Calvillo and Gomes did not find evidence for a reversed hindsight bias: Foresight likelihood judgments were not greater than hindsight judgments as the outcome drew near.

One potential explanation for these somewhat discrepant results is the degree to which the accidents were surprising. Fischhoff (1975) first noted that the hindsight bias would probably not exist for highly surprising outcomes. Verplanken and Pieters (1988) found a reversed hindsight bias for a surprising event: the nuclear disaster in Chernobyl. Recalled likelihood estimates of a nuclear power accident made 5 months after the Chernobyl accident (i.e., in hindsight) were lower than those made by the same participants 2 months before the accident (i.e., in foresight). Similarly, Mazursky and Ofir (1990) found that when participants were surprised by the quality of an instructional video or graphing program, their recalled expectations of the quality of these tools were less than their expectations actually were prior to viewing.

Pezzo (2003) proposed a sense-making model of hindsight to explain the role of surprise. According to this model, the hindsight bias results from trying to make sense of an observed outcome. When an outcome results in no initial surprise, the sense-making process is not activated, and there is no hindsight bias. When an outcome is surprising, the sense-making process is activated, which will lead to one of two results. If this process is successful, there will be little or no resultant surprise, resulting in a hindsight bias. If the sense-making process is not successful (e.g., because the outcome was too surprising), there will be resultant surprise, leading to a reduced or reversed hindsight bias. Results have supported this sense-making model of hindsight (Ash, 2009; Nestler & Egloff, 2009; Pezzo, 2003), and it has been extended to include metacognitive components (Muller & Stahlberg, 2007). The sense-making model can also explain the reversed hindsight bias observed in Roese et al. (2006) by assuming that the sense-making process must not have been successful for participants and their resultant surprise led to a reversed hindsight bias.

The goals of the present experiment were to extend visual hindsight research (e.g., Harley et al., 2004) to animations of automobile accidents and to examine the role of initial surprise in hindsight–foresight differences in order to test Pezzo's (2003) sense-making model of hindsight. Pilot study participants viewed animations and rated the initial surprise at the occurrence of the accidents. In the main experiment, participants stopped the animations at the point at which they were certain that an accident would occur. This task was completed in one of two conditions. In the foresight condition, participants stopped each animation during the first viewing (i.e., in foresight). In the hindsight condition, participants watched each animation first and

then stopped the animations during the second viewing (i.e., in hindsight).

On the basis of the sense-making model of hindsight (Pezzo, 2003), it was predicted that (1) when initial surprise was low, there would be no hindsight–foresight differences in stopping the animations; (2) when initial surprise was medium, there would be a hindsight bias (those in the hindsight condition would stop the animation before those in the foresight condition would); and (3) when initial surprise was high, there would be a reduced or reversed hindsight bias (there would be no hindsight–foresight differences, or those in the foresight condition would stop the animations before those in the hindsight condition would). This third prediction was based on the assumption that when an outcome is high in initial surprise, the sense-making process will more likely be unsuccessful and will lead to resultant surprise. It was also predicted that the hindsight bias would be a nonmonotonic function of initial surprise; specifically, the hindsight bias and initial surprise ratings would have a curvilinear, inverted-U-shaped relationship.

Pilot study

Twenty-six undergraduates from California State University San Marcos participated in a pilot study in exchange for credit toward the completion of a research requirement. Participants watched eight animations¹ depicting automobile accidents taken from the World-Wide Web. These animations were computer simulations created by forensic animators to be used as evidence in legal cases. These animations varied in length, frame speed, number of automobiles involved in the accidents, and point of view. The characteristics of the animations are presented in Table 1. After watching each animation, participants rated how surprising that accident was on a scale from 1 (*very unsurprising*) to 5 (*very surprising*). All the participants viewed animations 1–8 in the same order and rated each animation's surprise just after viewing it. Because these ratings were made immediately after each animation had been viewed, there was insufficient time to complete the sense-making process. We refer to these surprise ratings as initial surprise to distinguish them from resultant surprise, which occurs after the sense-making process (Pezzo, 2003). The mean initial surprise ratings for all animations are presented in Table 1.

¹ One of the eight animations was also used in Calvillo and Gomes (2010).

Experiment

Method

Participants and design Eighty-four undergraduates from California State University San Marcos participated in exchange for credit toward the completion of a research requirement. The initial surprise ratings from the pilot study were used to place the animations into low-, medium-, and high-surprise categories. A 3 (initial surprise: low, medium, high) $\times$ 2 (outcome knowledge: foresight, hindsight) mixed factorial design was used, with initial surprise as the within-subjects variable. The dependent variable was the difference (in number of frames) between when a participant stopped an animation and when the accident actually occurred.

Materials and procedure Participants were assigned to one of two conditions, in which the same eight animations as those from the pilot study were viewed in the same order. In the foresight condition, participants were instructed that some of the animations would depict automobile accidents, to keep them naïve about the outcomes. Their task was to stop the animation at the point at which they were certain that an accident would occur in a given animation. The experimenter recorded the frame number at which the animation was stopped and then began the next animation until the participant had stopped the eighth animation. In the hindsight condition, participants were told that all² the animations depicted automobile accidents, to provide them with outcome knowledge. Participants then viewed each animation twice. During the first viewing, they watched the entire animation, and during the second viewing, they were instructed to stop the animation when they thought that a naïve viewer (i.e., someone who had not seen the animation) would be certain that an accident would occur. The experimenter recorded the frame at which the animation was stopped, and this process continued until the eighth animation was viewed twice and stopped during the second viewing. Each experimental session lasted approximately 10 min.

Results

Participants stopped animations when they were certain (in the foresight condition) or thought that a naïve viewer

² The difference in the wording in the instructions was part of the outcome knowledge manipulation to prevent foresight participants from having outcome knowledge and to provide hindsight participants with this knowledge.

Table 1 Animations' length (in seconds and number of frames), point at which the accident occurred (in seconds and frame number), number of cars, point of view (POV), mean surprise rating, and hindsight ratio (HR)

Animation	Length		Accident		Cars	POV	Surprise		HR
	s	Frames	s	Frame			<i>M</i>	<i>SD</i>	
1	13	406	8	248	2	Chase	2.88	1.31	1.26
2	8	266	8	242	1	Lead	3.12	1.34	1.39
3	20	311	13	199	3	Driver	4.23	1.11	0.21
4	12	386	8	270	2	Aerial	2.46	1.36	0.95
5	9	297	6	198	1	Chase	3.15	1.35	1.44
6	7	212	4	120	1	Chase	2.62	1.36	1.27
7	5	168	3	97	2	Aerial	2.58	1.30	1.17
8	9	297	2	84	3	Lead	3.42	1.24	0.58

would be certain (in the hindsight condition) that an accident would occur. The initial surprise ratings from the pilot study were used to create three levels of initial surprise. The two animations with the lowest surprise ratings (animations 4 and 7) were considered low surprise, the two with the highest surprise ratings (3 and 8) were considered high surprise, and those in between (1, 2, 5, and 6) were considered medium surprise. A two-way analysis of variance assessed the effects of initial surprise and outcome knowledge on how far (in frames) participants stopped the animation from the point of the accident. Initial surprise had a significant effect, $F(2, 164) = 41.06$, $p < .001$, $\eta_p^2 = .33$, and post hoc analyses (with Bonferroni corrections) revealed that all pairwise comparisons (medium surprise, $M = 38.71$, $SD = 23.65$; low surprise, $M = 23.63$, $SD = 21.31$; high surprise, $M = 15.04$, $SD = 29.18$) were significant. Outcome knowledge did not affect when participants stopped the animations, $F(1, 82) = 0.17$, $p = .678$, $\eta_p^2 = .00$, but it interacted with initial surprise, $F(2, 164) = 13.34$, $p < .001$, $\eta_p^2 = .15$. Figure 1 illustrates this interaction. Simple effects tests showed that (1) when initial surprise was low, there were no differences between foresight and hindsight conditions, $t(82) = 0.08$, $p = .94$, $d = .02$; (2) when initial surprise was medium, those in the hindsight condition stopped the animations before those in the foresight condition did, $t(82) = 2.30$, $p = .024$, $d = .50$; and (3) when initial surprise was high, those in the foresight condition stopped the animation before those in the hindsight condition did, $t(82) = 2.71$, $p = .008$, $d = .59$.

Because the grouping of the animations into low, medium, and high surprise could have influenced the findings, we conducted a regression analysis that did not require grouping. A hindsight ratio was calculated for each animation, and the relationship between this ratio and initial surprise ratings was examined. Hindsight ratios were calculated in a manner similar to those in previous studies (Bernstein et al., 2004; Harley et al., 2004): For each

animation, we divided the mean number of frames before the accident that participants in the hindsight condition stopped the animation by the same mean for participants in the foresight condition. Hindsight ratios greater than 1 illustrate a hindsight bias; ratios less than 1 illustrate a reversed hindsight bias. The hindsight ratios for all animations are presented in Table 1. Hindsight ratio was significantly predicted by the quadratic regression equation, hindsight ratio = $.63$ (initial surprise²) + 3.64 (initial surprise) 4.08 , $R^2 = .59$, $p = .045$, and was marginally predicted by the linear equation, hindsight ratio = $.52$ (initial surprise) + 2.61 , $R^2 = .48$, $p = .058$. The relationship

Fig. 1 Mean difference from the frame at which participants stopped the animation and the frame at which the accident occurred by levels of surprise and whether judgments were made in foresight or hindsight (error bars show +1 SE)

between hindsight ratio and initial surprise ratings, along with quadratic and linear regression curves, are presented in Fig. 2.

Discussion

The results of the present study were the following: (1) When the outcome was low in initial surprise, there was no difference between when those in the hindsight condition and those in the foresight condition were certain that an accident would occur; (2) when the outcome was medium in initial surprise, those in the hindsight condition stopped the animations before those in the foresight condition did, demonstrating a hindsight bias; and (3) when initial surprise was high, those in the foresight condition stopped the animations before those in the hindsight condition did, demonstrating a reversed hindsight bias. Furthermore, initial surprise ratings significantly predicted the hindsight ratio with a quadratic equation: Initial surprise ratings and hindsight ratios had an inverted-U-shaped relationship. These results are consistent with Pezzo's (2003) sense-making model of hindsight bias.³ The linear regression equation was also moderately significant, providing support for a component explanation of the hindsight bias (Blank, Nestler, von Collani, & Fischer, 2008), which predicts that the effect of surprise on the hindsight bias depends on the component of the hindsight bias being measured (Nestler & Egloff, 2009). Nestler and Egloff predicted a negative relationship between surprise and the type of hindsight bias that was assessed in the present study (i.e., the foreseeability component). Consistent with this prediction, they found that highly surprising outcomes led to decreases in judgments of foreseeability. The negative linear relationship between surprise and hindsight ratio found in the present study is consistent with Nestler and Egloff's findings and the component explanation of the hindsight bias.

This present study extends visual hindsight research to animations of automobile accidents. Harley et al. (2004) had participants view images of celebrities that started blurry and became clear. After participants knew the identity of the celebrities, they judged that others would be able to recognize the celebrities earlier than the participants themselves had. Similarly, hindsight participants in the present study judged that naïve viewers would be certain that an accident would occur earlier than foresight participants actually were certain. However, this hindsight bias occurred only with animations depicting

Fig. 2 Linear and quadratic fits for the predictions of hindsight ratio from initial surprise in the eight animations

events that were moderately surprising. Bernstein and Harley (2007) found that when participants start with a clear image that becomes blurry, there were no hindsight–foresight differences and claimed that this pattern is the result of fluency misattribution. The findings of Bernstein and Harley could also be explained in terms of initial surprise: In the blurry-to-clear condition, the identity of the subjects in the image should result in some initial surprise, which leads to a hindsight bias; however, in the clear-to-blurry condition, the identity is not surprising, which leads to no hindsight bias.

The present study's results provide a possible explanation for the discrepant results of previous studies (Calvillo & Gomes, 2010; Fessel et al., 2009; Roese et al., 2006). Roese et al. used animations of automobile accidents and found a hindsight bias when judgments about the likelihood of an accident's occurring were made far before the accident and a reversed hindsight bias when judgments were made just before the accident. Conversely, Fessel et al. and Calvillo and Gomes found a hindsight bias when judgments were made just before the accidents. Perhaps the accidents depicted in the animations used in these studies varied in surprise, although Fessel et al. used one of the two animations used by Roese et al.. Additional studies should examine differences in the characteristics of the animations used in these studies (e.g., surprise) to determine why there is sometimes a hindsight bias and sometimes a reversed hindsight bias in likelihood judgments of the occurrence of accidents.

Legal decisions made in hindsight are different than those made in foresight. For example, it has been shown that participants' verdicts of guilt are biased toward the known verdicts of a trial when the defendant is a non-stereotypical offender (Bodenhausen, 1990) and that liability judgments are biased toward a known outcome in railroad accidents (Hastie, Schkade, & Payne, 1999), in

³ Pezzo's (2003) model emphasizes sense making, and the present study did not include measurements of sense making. We assumed that accidents that were high in initial surprise would be more difficult to make sense of—therefore, leading to resultant surprise—but resultant surprise was not assessed.

Tarasoff-type cases (LaBine & LaBine, 1996), and in cases of illegal police searches (Casper, Benedict, & Perry, 1989). Furthermore, Bryant and Brockway (1997) found that likelihood estimates of a conviction in the O. J. Simpson criminal trial made before the verdict (i.e., the acquittal) were greater than those estimates made by the same participants after the verdict was known.

The present study has implications for legal decisions. The perceived foreseeability of an outcome may influence liability judgments. Because jurors are aware of the outcomes, these judgments may be biased (e.g., Harley, 2007). In cases of automobile accidents, computer simulations are often presented as evidence (Sainato, 2009), and the presence of computer simulations has been shown to influence jurors' decisions (e.g., Kassin & Dunn, 1997). Computer simulations make it easier to think of the known outcome and more difficult to bring to mind any possible alternative outcomes. This metacognitive experience can influence the magnitude of the hindsight bias (e.g., Sanna & Schwarz, 2006). In accord with Pezzo's (2003) sense-making model of hindsight, the results of the present study demonstrate that the degree of initial surprise in the outcome depicted in these simulations also influences the presence and direction of hindsight–foresight differences in judgments. To maximize the likelihood of a liability judgment, an event depicted in an animation should be somewhat but not too surprising, so that a sense-making process will be activated and successful, resulting in a hindsight bias.

Examining the relationship between animations' point of view, surprise, and hindsight bias is an avenue for future research. Each animation in the present study depicted a different event, and these animations were depicted from several different points of view. Animations with an aerial point of view were the least surprising, the animation from the driver's point of view was the most surprising, and the animations from the chase and leading points of view were in the middle. Lassiter and colleagues (e.g., Lassiter et al., 2002; Lassiter & Irvine, 1986) have reported that a camera's point of view affects judgments of the voluntariness of a confession, the guilt of the confessor, and the recommended sentence for the confessor. It is possible that depicting animations of automobile accidents from different points of view results in differences in initial surprise and, therefore, differences in the perceived foreseeability of the accidents. We speculate that accidents are typically more foreseeable from an aerial point of view, since the automobiles can be seen approaching one another. From a driver's point of view, the accidents are typically less foreseeable, since another automobile usually enters view just before the accident. Examining the effect of animations' point of view on legal decisions has been previously suggested (Feigenson & Dunn, 2003), but there are no published data on this to date.

Conclusions

The present study extends previous visual hindsight research (e.g., Harley et al., 2004) and provides support for a sense-making model of the hindsight bias (Pezzo, 2003). The findings also suggest a possible explanation for the discrepant results of previous studies (Calvillo & Gomes, 2010; Fessel et al., 2009; Roese et al., 2006). There are important implications of these results, particularly in legal decisions made from evidence in the form of computer simulations, and this study also illustrates the need to investigate the effects of animations' point of view on initial surprise and hindsight–foresight differences in judgments. The results of the present study require replication, and additional studies with larger samples of animations are needed to better understand the relationships between point of view, surprise, and the hindsight bias.

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