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BRIEF REPORT

The role of perceptual difficulty in visual hindsight bias for emotional faces

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Abstract
Visual hindsight bias, also known as the "saw-it-all-along" effect, is the tendency to overestimate one's perceptual abilities with the aid of outcome knowledge. Recently, Giroux et al. (2022, *Emotion,* https://doi.org/10.1037/emo0001068) reported robust visual hindsight bias for emotional faces except for happy. We examined whether the difficulty of emotional processing could explain their finding. As in Giroux et al., participants saw a blurred image of an emotional face (happy, angry, or neutral) that progressed to clear and were instructed to stop the clearing process when they were able to identify the emotion (foresight trials). They then were shown the clearest image of each face and determined the emotion, followed by a memory task where they were asked to adjust the blur levels to indicate the point at which they had identified the emotion earlier (hindsight trials). Experiment 1 replicated Giroux et al.'s finding, showing that participants stopped the image at a higher degree of blur during the hindsight trials than they had during the foresight trials (i.e., a visual hindsight bias) for the angry and neutral faces but not happy faces. Experiment 2 manipulated the perceptual difficulty of angry and happy faces. While the easy faces replicated the results of Experiment 1, both angry and happy faces produced strong bias when made difficult. A multinomial processing tree model suggests that visual hindsight bias for emotional faces, while robust, is sensitive to perceptual processing difficulties across emotions.

Keywords Hindsight bias · Visual hindsight bias · Saw-it-all-along effect · Emotion processing

After learning an outcome, individuals tend to overestimate what they could have anticipated in foresight. This is known as *hindsight bias* (e.g., Fischhoff, 1975; Guilbault et al., 2004). In hindsight, individuals judge events or outcomes as more foreseeable than they would have in foresight. This is a robust cognitive error that has been largely observed using almanac questions, real-world events, political election outcomes, and natural disasters (e.g., Bryant & Guilbault, 2002; Roese & Vohs, 2012). The bias has also been found to increase with task difficulty (e.g., Chen et al., 2020; Fischhoff, 1977; Harley et al., 2004) and is difficult to eliminate (e.g., Bernstein et al., 2011).

Recently, Giroux et al. (2022) examined visual hindsight bias using emotional faces. They found a hindsight bias effect for several emotional faces except happy faces. The present study aims to shed light on their findings and determine whether the perceptual difficulty of emotion processing modulates visual hindsight bias.

Public significance statement The way by which people make judgments about their perceptual abilities can have a profound impact on behaviors and inform several fields such as law and medicine. Thus, it is important to understand the circumstances under which hindsight bias occurs. The present study examined whether the perceptual difficulty of emotional expressions influences visual hindsight bias differently across different emotions. We found that it does. These findings offer insight into how visual judgments in hindsight are influenced by the perceptual difficulty of stimuli.

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Visual hindsight bias for faces

Hindsight bias has been studied extensively in verbal forms. Only recently have researchers examined the visual form of hindsight bias (e.g., Bernstein & Harley, 2007; Chen et al., 2020; Harley et al., 2004). Harley et al. (2004) first studied visual hindsight bias using images of celebrity faces. Their paradigm consisted of a baseline-identification (baseline-ID;

analogous to the *foresight phase*) phase, where participants saw a blurred image of a celebrity that gradually became clear and stopped the blurring process as soon as they were able to identify the celebrity. After baseline-ID trials, participants were given a "surprise" memory test (analogous to the *hindsight phase*), where the same celebrities were first presented at the blurriest level accompanied by the celebrity's identity (analogous to outcome knowledge). Participants then adjusted the level of blur of the image until they thought it matched the point at which they identified the celebrity during baseline-ID. Results showed that participants stopped the images at a blurrier level during the memory test compared with the baseline-ID phase (i.e., *a hindsight bias effect*).

Harley et al. (2004) also found that hindsight bias increased with difficulty. That is, faces that were identified at a later stopping point (assumed to be more difficult) showed a larger hindsight bias than faces identified earlier (assumed to be easier). Harley et al. concluded that like traditional hindsight bias, visual hindsight bias is sensitive to task difficulty. Overall, these findings led Harley et al. to argue that outcome information has an influence on one's perceptual judgment in hindsight and that this influence is greater for faces that are more difficult to identify.

While Harley et al.'s (2004) study with face stimuli demonstrates a robust visual hindsight bias, a recent study by Giroux et al. (2022) found a case where visual hindsight bias was abolished. In Giroux et al.'s study, participants were shown a blurred image of an emotional face that progressed to clear during the foresight judgment phase. Participants were instructed to stop the clearing process when they were able to identify the emotion displayed. Following all foresight trials, participants completed the hindsight judgment phase, where the clearest image of each face was shown, and participants had to determine the emotion. They then performed the memory task, adjusting the blur levels to indicate the point at which they were first able to identify the emotion during foresight (see Fig. 1 for an example). Giroux et al. measured the mean number of frames present at participants' responses during foresight and hindsight, with a smaller number of frames during hindsight than foresight suggesting a visual hindsight bias. In Experiments 1 and 2, they found visual hindsight bias for all emotions (angry, disgusted, scared, surprised, and sad) *except* for happy.

Giroux et al. (2022) tested the distinctiveness hypothesis (happy faces were distinctive amongst other emotions) by using three less distinctive emotional faces (happy, ambiguous, and surprised) in Experiment 3. Visual hindsight bias was observed for all emotions, including happy faces. In attempts to replicate their own findings, they blocked the distinctiveness of emotional faces within participants in Experiment 4—the distinctive block was identical to Experiments 1 and 2, whereas the nondistinctive block was identical to Experiment 3. Although the distinctive block replicated their results in Experiments 1–2, the nondistinctive block did not replicate the presence of visual hindsight bias for happy faces. The nonreplication for happy faces led Giroux et al. to conclude that distinctiveness is not the reason for the absence of visual hindsight bias for happy faces.

The special case of the happy face

Although some studies have found that happy faces are remembered and identified more accurately compared with other emotional faces such as angry and neutral (e.g., Baudouin et al., 2000; D'Argembeau et al., 2003; Liu et al., 2014; Shimamura et al., 2006), Giroux et al. (2022) argued that the absence of hindsight bias for happy faces was not due to better memory. Using a multinomial processing tree model (Bernstein et al., 2011; Erdfelder & Buchner, 1998), Giroux et al. (2022) found that parameter *r* (the probability of recalling one's original foresight judgment) and parameter *c* (the probability of confusing outcome knowledge with foresight knowledge) were similar across all emotions and experiments, suggesting that participants did not have a better memory of their foresight judgment for happy faces. Yet, parameter *b*, reflecting the probability of a biased reconstruction given foresight judgment recollection failure was consistently lower for happy faces. They argued that "when people reconstructed their foresight judgments for happy faces, they were not systematically biased toward the outcome information or at least, were much less so than for other emotions" (p. 13). Thus, to what extent that happy faces are immune from hindsight bias is still unknown.

Giroux et al. (2022) discussed the possibility that the earlier identification of happy faces in foresight might be able to explain the lack of visual hindsight bias effects found. This quick identification suggests that happy faces may have been easier to identify, which would be consistent with task difficulty accounts of visual hindsight bias (e.g., Harley et al., 2004). This explanation is consistent with studies showing a happy face advantage in emotional expression recognition (e.g., Calvo & Lundqvist, 2008; Ducci, 1981; Esteves & Öhman, 1993; Leppänen & Hietanen, 2004). For example, Calvo and Lundqvist (2008) found higher accuracies and shorter response times for happy faces than other emotional faces in a free-viewing condition where participants simply judged emotional expression displayed by the face stimulus on the screen. Leppänen and Hietanen (2004) tested two explanations for the recognition speed advantage for happy faces. One was that happy faces contained dissimilar facial features to other emotional faces, resulting in less confusion in recognition. The second was that a single, salient feature of face emotion (an upward-curved, smiling mouth)

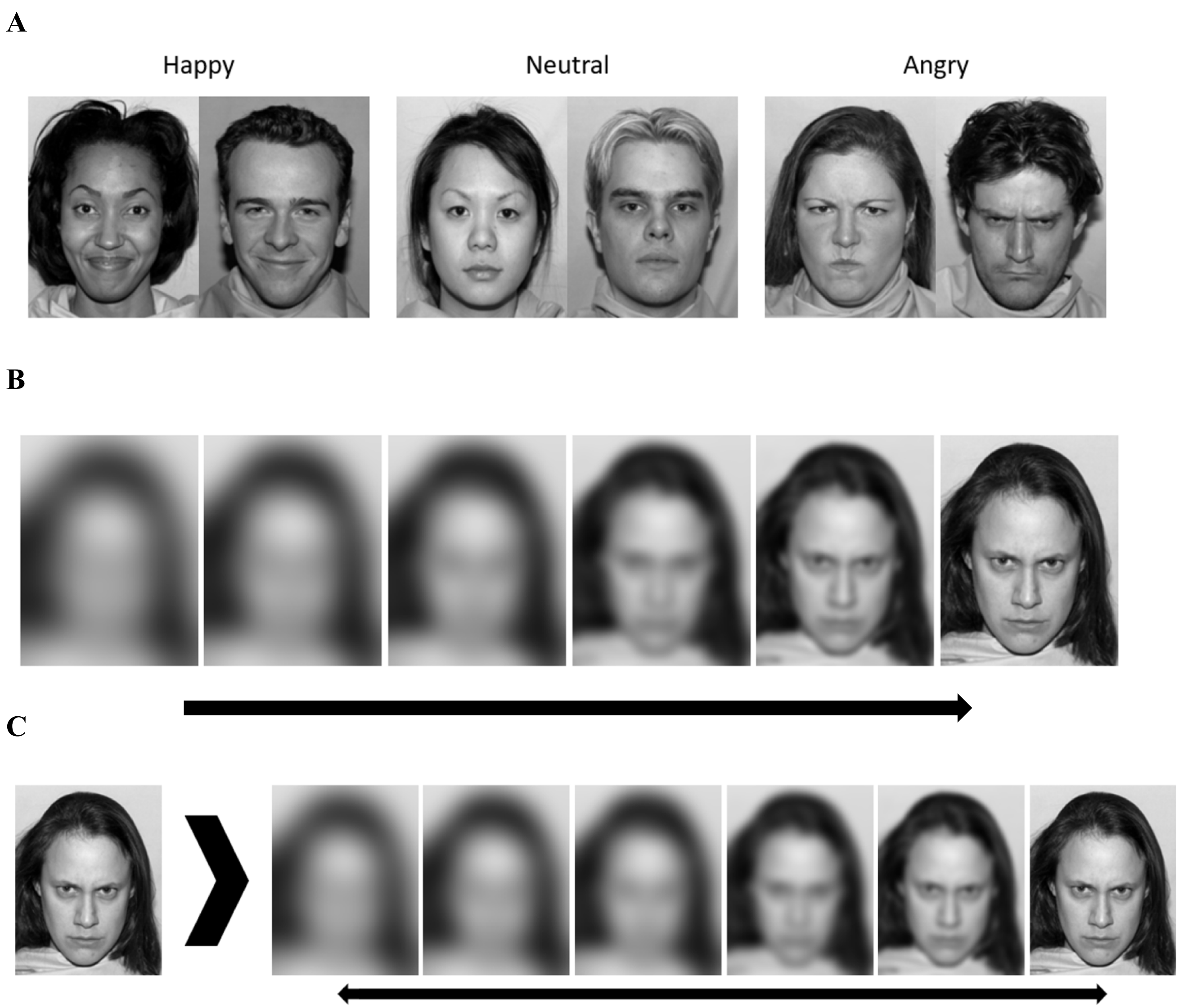

Fig. 1 Examples of emotional stimuli (**A**) and procedure (**B–C**) used in Experiment 1. *Note*. **B** Foresight judgment phase. Thirty successively blurred images were created to make it appear as though the image was gradually becoming clearer. Participants were told to identify the emotion shown as soon as possible during the blurring process. **C** Hindsight judgment phase. Participants were shown the clear image and determined the emotion shown, then toggled back and forth between blurry and clear until they thought the level of blur present was the same as when they first identified the emotion during the foresight judgment phase

can be easily associated with happiness. Controlling for these differences, Leppänen and Hietanen used schematic happy, neutral, and sad faces, with the only difference deviated among them being the shape of mouth (upward, flat, and downward, respectively). They still observed a recognition advantage for happy faces, suggesting that "the happy face advantage reflects faster processing of happy faces rather than a lowered criterion for 'happy' responses" (p. 27). As noted earlier, hindsight bias increases with task difficulty. Thus, it is possible that faster recognition for happy faces may have contributed to the elimination of the bias.

The present study

The present study examined (1) whether visual hindsight bias does occur for emotional faces, and (2) if so, whether it is modulated by the difficulty of the perceptual processing of the emotion. We first attempted to replicate Giroux et al. (2022) using an easy discrimination of happy, angry, and neutral faces in Experiment 1. Experiment 2 manipulated the difficulty of emotion perception (easy vs. difficult) and included only happy and angry faces.[1] As in Giroux et al., we measured the mean number of frames present at participants' responses in both foresight and hindsight trials, with a lower number of frames (i.e., blurrier image) during hindsight suggesting a visual hindsight bias. We predicted that both angry and neutral faces, but not happy faces, would yield a hindsight bias in Experiment 1. We also predicted that a hindsight bias for happy faces would be evident for the difficult faces in Experiment 2.

Experiment 1

Experiment 1 attempted to replicate Giroux et al.'s (2022) findings using face stimuli similar to theirs.

Method

Participants

A total of 52 undergraduates at Oregon State University participated in exchange for course credit. Based on a modified recursive trimming procedure recommended by Van Selst and Jolicœur (1994), we planned to exclude participants whose responses were outside of 2.5 standard deviations of the mean frames in any condition. Seven participants were excluded from the overall analyses on a priori basis. The remaining 45 participants had mean age of 21.75 years (range: 18–45; 35 females and 10 males) and had normal or corrected-to-normal vision. Giroux et al. (2022) reported a medium effect size (e.g., d_z between 0.50 to 0.55 in Experiments 1 and 2) of emotion-specific hindsight bias effects using two-tailed matched-pairs *t* tests. Power analysis using G*Power (Faul et al., 2009) indicated that we would have power of .91 to .95 to detect an effect this large with a sample of 45 ($\alpha = .05$).

Materials and stimuli

Stimuli adapted from Tomasik et al. (2009) were used to develop 36 greyscale images, which were created using MATLAB, where each image was greyscaled using rgb2gray and filtered using the imgaussfilt function. Thirty successive blurred images were developed by increasing the standard deviation of the Gaussian filter by increments of 1 up to 29. Images consisted of individuals of varying ethnicities and sex displaying either a happy, neutral, or angry emotion (see Fig. 1A).

Procedure

With the exception of online data collection, Experiment 1 closely followed the procedure of Giroux et al. (2022), with the following exceptions. Participants completed six practice trials prior to each phase, counterbalancing one male and one female expressing each of the three emotions that were not presented during the experimental trials. Participants completed 36 trials of the foresight judgment phase, where the image of an emotional face started very blurry and gradually become clear. Once participants were able to identify the emotion displayed, participants were to press the "B" key for happy, "N" key for neutral, and "M" key for angry. Each level of blur was shown for 500 ms until all 30 images were shown to equate the amount of time participants were exposed to the stimulus.

After all 36 foresight judgment trials were completed, participants were given hindsight judgment trials. At the start of each trial, participants were shown the clear image of the emotional face first and asked to again respond to the emotion shown. After responding to the clear image, participants were instructed to use the "Z" and "X" keys to toggle between blurry and clear until they thought the level of blur present matched when they were first able to identify the emotion shown during the blurring process in the foresight judgment phase. Once satisfied with the level of blur present, participants pressed the space bar to move on to the next trial. This task was repeated for all 36 emotional faces in a random, different order of presentation than during foresight.

Results and discussion

Only trials where participants accurately identified the emotion were included in the final analysis, excluding 13.9% of trials. The number of frames at the stopping point was submitted to a 2 (phase: foresight vs. hindsight) × 3 (emotion: happy, neutral, vs. angry) within-subjects analysis of variance (ANOVA).[2] An alpha level of .05 was used to ascertain statistical significance. Whenever appropriate, *p* values were adjusted using the Greenhouse–Geisser epsilon correction for nonsphericity.

Results show a significant main effect of phase, $F(1, 44) = 4.05$, $p = .05$, $\eta_p^2 = 0.08$; an overall hindsight bias was

[1] We excluded neutral faces from Experiment 2, as the difficulty of emotional discrimination cannot be manipulated for neutral faces.

[2] We analyzed the data including the sex of the face stimuli (male vs. female). The complete summary of the ANOVA output is provided in Appendix. Neither the main effect of sex nor its interactions with phase and emotion were significant. Therefore, we excluded this variable from the final analyses.

Fig. 2 Mean number of frames as a function of emotions for foresight and hindsight phases in Experiment 1. *Note*. Error bars represent standard errors of the mean

observed (at 95% confidence interval, 21.25 ± 0.84 for foresight and 20.42 ± 0.95 for hindsight). Results also show a main effect of emotion, $F(2, 88) = 61.45$, $p < .001$, $\eta_p^2 = 0.58$. The mean number of frames averaged across the foresight and hindsight phases was smaller for happy faces (19.58 ± 0.79) than angry faces (21.61 ± 0.76) and neutral faces (21.33 ± 0.91).

Critically, the interaction between phase and emotion was significant, $F(2, 88) = 7.76$, $p < .001$, $\eta_p^2 = .15$, suggesting that there were differences in hindsight bias across emotions (see Fig. 2). Further *t*-test analyses for each emotion revealed a hindsight bias for angry faces, $t(44) = 2.42$, $p = .01$, $d_z = 0.43$ and neutral faces, $t(44) = 2.91$, $p = .003$, $d_z = 0.36$, but not happy faces, $t < 1.0$. We replicated key findings of Giroux et al. (2022), where participants overestimated the level of blur present for angry and neutral faces but appeared consistent in matching the level of blur present for happy faces.

Experiment 2

Results in Experiment 1 showed that the overall number of frames in foresight was smaller for happy faces, indicating that happy faces were easier to identify than others (e.g., Calvo & Beltrán, 2014; Calvo & Lundqvist, 2008). Experiment 2 examined whether increasing the perceptual difficulty of emotional faces would yield hindsight bias for happy faces. We reasoned that if hindsight bias increases with task difficulty as suggested by previous studies (e.g., Chen et al., 2020; Harley et al., 2004), then we should expect happy faces to produce bias when made perceptually difficult.

Method

Participants

There were 112 new undergraduates recruited from the same participant pool as Experiment 1.[3] As in Experiment 1, we excluded participants whose responses were outside of 2.5 standard deviations of the mean frames in each condition (Van Selst & Jolicoeur, 1994). Twelve participants were excluded from the overall analyses. The mean age of the remaining 100 participants was 22 years (range: 18–45; 81 females; 19 males). All reported having normal or corrected-to-normal vision. Power analysis using G*Power (Faul et al., 2009) indicated that this sample gave us power exceeding .99 to detect a medium effect size (d_z between 0.50 to 0.55 reported in Giroux et al.'s,

[3] We initially ran a total of 54 participants in Experiment 2. One anonymous reviewer indicated a preference of seeing the replication of Experiment 2. Therefore, we ran 46 new participants with the same experimental design. The results were similar to what we reported with 54 participants. Data from the new 46 participants showed that the hindsight bias effect (foresight–hindsight) was again absent for easy happy faces (−0.15 ± 0.78), $t < 1.0$, but was present for other faces (difficult happy: 0.93±0.90; easy angry: 0.66±0.79; difficulty angry: 1.22 ± 0.80), $ts(45) \geq 1.68$, $ps \leq .05$, $d_z s \geq 0.247$. Therefore, we decided to combine those data.

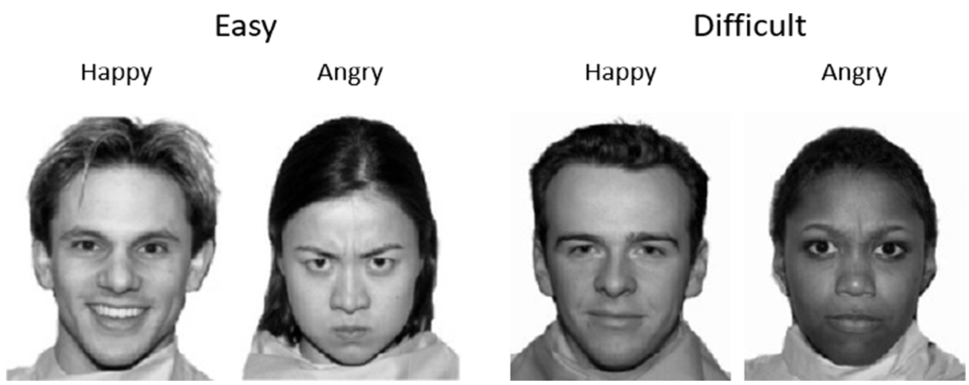

Fig. 3 Examples of emotional stimuli used in Experiment 2. *Note.* Stimuli adapted from Tomasik et al. (2009), showing the easy and difficult manipulations: Easy phases (left) were morphed with 99% of the respective expressions while difficult faces were morphed with 50% neutral expressions (right)

2022, Experiments 1 and 2) of emotion-specific hindsight bias effects for matched-pairs *t* tests.

Materials, stimuli, and procedure

Only angry and happy faces were included in Experiment 2. The images were adapted from Tomasik et al. (2009), which contained the same actors as those in Experiment 1 but with easy and difficult manipulations for each emotion (see Fig. 3). Easy faces were made up of 99% of the emotion shown (angry or happy), while difficult faces were a 50/50 mixture of neutral emotions and the emotion shown (angry or happy). To verify that those faces were classified as emotional faces (angry vs. happy) instead of neutral faces, especially for the difficult level, we ran a control experiment including the neutral faces from Experiment 1. A total of 25 new participants were given a clear facial image and were asked to classify the emotions (angry, happy, or neutral). We found that participants correctly identified about 98% of emotional faces in the easy level and about 82% in the difficult level, with no difference in accuracies between angry and happy faces, $ts(24) \leq 1.47$, $ps \geq .152$. These results suggested that happy faces were no more likely to be identified as other emotions (e.g., neutral) than angry faces even at the difficult level. All procedures were identical to that in Experiment 1, except that participants used the "B" key for happy and the "M" key for angry.

Results and discussion

Only trials where participants accurately identified the emotion were included in the final analysis, excluding 9.1% of trials. The number of frames at the stopping point was submitted to a 2 (phase: foresight vs. hindsight) × 2 (emotion: happy vs. angry) × 2 (difficulty: easy vs. difficult) within-subjects ANOVA. Figure 4 shows the mean for each difficulty level. The analysis revealed significant main effects of all three variables: phase, $F(1, 99) = 12.31$, $p < .001$, $\eta_p^2 = 0.11$; emotion, $F(1, 99) = 15.857$, $p < .001$, $\eta_p^2 = 0.14$; and difficulty, $F(1, 99) = 288.89$, $p < .001$, $\eta_p^2 = 0.75$. An overall hindsight bias was observed (21.77 ± 0.45 for foresight and 21.06 ± 0.45 for hindsight). The number of frames (averaged across foresight and hindsight phases) was smaller for happy faces (21.18 ± 0.45) than angry faces (21.64 ± 0.38). In addition, the overall number of frames was smaller for the easy faces (20.59 ± 0.43) than the difficult faces (22.23 ± 0.40), suggesting our difficulty manipulation worked (see Fig. 4).

Critically, the interaction between phase and emotion was significant, $F(1, 99) = 8.702$, $p = .004$, $\eta_p^2 = .081$, replicating the results of Experiment 1. Significant interactions were also found between phase and difficulty, $F(1, 99) = 6.15$, $p = .01$, $\eta_p^2 = .059$, and between emotion and difficulty, $F(1, 99) = 23.22$, $p < .001$, $\eta_p^2 = .190$. Finally, the three-way interaction between phase, emotion, and difficult approached significance, $F(1, 99) = 3.54$, $p = .06$, $\eta_p^2 = .035$. Further *t*-test analyses on hindsight bias (number of frames for foresight minus number of frames for hindsight) revealed a bias for happy faces in the difficult level, $t(99) = 2.95$, $p = .002$, $d_z = 0.29$, but not for happy faces in the easy level, $t < 1.0$. For angry faces, however, the bias was observed for both easy and difficult levels, $ts(99) \geq 4.05$, $ps < .001$, $d_z s \geq 0.41$.

In sum, we replicated the results of Experiment 1 observing a hindsight bias for angry faces but not happy faces in the easy level with a much larger sample size. When the perceptual difficulty of emotional faces increased, hindsight bias was observed for both happy and angry faces. These results are in line with previous studies' conclusion that hindsight bias increases with task difficulty (e.g., Chen et al., 2020; Harley et al., 2004).

MPT model of visual hindsight bias

The multinomial processing tree (MPT) model in Giroux et al. (2022) suggested that the absence of hindsight bias for happy faces was not due to better recall of participants' foresight

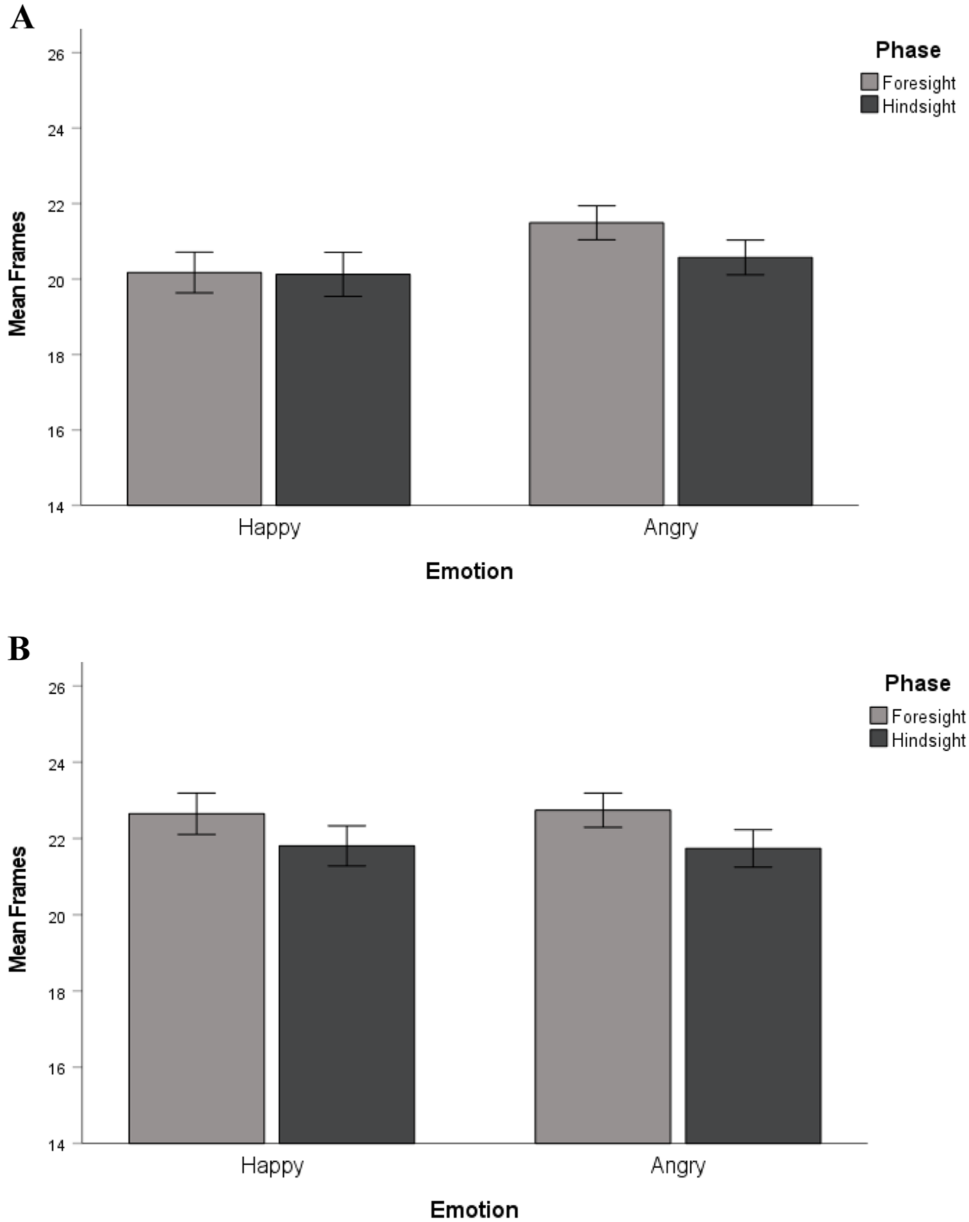

Fig. 4 Mean number of frames as a function of emotions for easy (**A**) and difficulty (**B**) foresight and hindsight phases in Experiment 2. *Note.* Error bars represent standard errors of the mean

judgments. This conclusion was made based on the calculated estimations of the three parameters in the visual hindsight bias model (VHB3) developed by Bernstein et al. (2011).[4]

[4] The adapted model contains parameters r, b, and c; parameter r represents the probability that one successfully recalls their foresight judgment and uses it as their hindsight judgment. Parameter b represents the probability that, given failure to recall their foresight judgment $(1 - r)$, one's hindsight judgment may be biased by the outcome information. If the foresight judgment is unbiased by the outcome $(1 - b)$, participants have an equal likelihood of exhibiting reverse hindsight bias and partial hindsight bias. Finally, parameter c represents the probability that, given biased reconstruction, one confuses their updated knowledge with foresight knowledge.

To assess this possibility, we first calculated frequencies for both experiments of the four possible categories: maximum hindsight bias, partial hindsight bias, reverse hindsight bias, and no hindsight bias. Frequencies were used to estimate the three hindsight bias parameters in our study using the maximum likelihood method in the multiTree program (Moshagen, 2010). Results from the model estimations for Experiments 1 and 2 are displayed in Tables 1 and 2, respectively. As shown in Table 1, the probability of correctly recalling foresight judgments (parameter r) was not greater for happy faces than angry and neutral faces in Experiment 1, consistent with Giroux et al. that participants did not have a better memory for

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Table 1 Visual hindsight bias (VHB3) parameter estimates and standard errors (in parentheses) for each emotion in Experiment 1

Parameter	Emotion		
	Happy	Neutral	Angry
r	.09 (.01)	.09 (.01)	.10 (.02)
b	.02 (.02)	.28 (.04)	.27 (.05)
c	1.00 (.77)	.07 (.02)	.07 (.02)

Note. *r* = probability of recalling one's foresight judgment as the hindsight judgment; *b* = probability of being biased by the outcome information given failure to recall foresight judgment; *c* = probability of confusing outcome information with foresight judgment

happy faces and appeared to be unbiased by the outcome, as seen with the low parameter *b* value.

The critical manipulation in Experiment 2 was designed to test the possibility that, when made perceptually difficult, happy faces would elicit a visual hindsight bias. As can be seen in Table 2, difficult happy faces had a greater parameter *b* (*b* =.18) than easy happy faces (*b* = .02), suggesting that when made perceptually difficult, the outcome stimulus for happy faces generated a larger reconstruction bias. Angry faces, however, showed similar parameter *b* for both easy and difficult levels (.16 vs. .15, respectively), suggesting that the probability of being biased by the outcome information given one's failure to recall their foresight judgment might have reached to the ceiling for easy angry faces, leaving little room to observe a further increase in the bias with increased perceptual difficulty.

Table 2 Visual hindsight bias (VHB3) parameter estimates and standard errors (in parentheses) for happy and angry faces of each difficulty level in Experiment 2

Parameter	Emotion	
	Happy	Angry
Easy		
r	.11 (.01)	.12 (.01)
b	.02 (.02)	.16 (.04)
c	1.00 (.98)	.11 (.03)
Difficult		
r	.13 (.01)	.11 (.01)
b	.18 (.04)	.15 (.04)
c	.13 (.04)	.09 (.03)

Note. *r* = probability of recalling one's foresight judgment as the hindsight judgment; *b* = probability of being biased by the outcome information given failure to recall foresight judgment; *c* = probability of confusing outcome information with foresight judgment

General discussion

The present study examined the findings of Giroux et al. (2022), showing hindsight bias for several emotions except for happy faces. We investigated the influence of perceptual difficulty to determine under what circumstances hindsight bias for happy faces may be observed. Experiment 1 observed visual hindsight bias for neutral and angry faces, but not for happy faces, replicating Giroux et al.'s finding. Experiment 2 manipulated the perceptual difficulty of the emotions. Visual hindsight bias was absent for easy happy faces as in Experiment 1 but was present for difficult happy faces. An MPT model of our data suggested that participants did not show better memory for happy faces, nor were their responses systematically biased by the outcome until the perceptual difficulty of the happy face was increased.

Why then did the visual hindsight bias for happy faces occur for difficult expressions and not easy expressions? Note that in both our study and Giroux et al. (2022), participants identified happy faces sooner than other emotions during the foresight blurring process. This recognition speed advantage for happy emotions may be due to the commonality and familiarity of happy expressions or the uniqueness of the smile in a happy face (e.g., Calvo & Beltrán, 2014). Thus, when the perceptual difficulty of happy faces was increased, making it more difficult to recognize the happy expression, visual hindsight bias effects were observed. A similar pattern of results was observed for angry faces, but the similar parameter *b*'s in the MPT analysis suggests that the angry faces were not as sensitive to the difficulty manipulation as were happy faces. It is possible that the probability of the bias for the easy angry expression was already at ceiling, resulting in less susceptibility to the difficulty manipulation.

Alternative explanations

We argued that visual hindsight bias for happy faces emerged with increased perceptual difficulty of emotion identification. However, emotional faces used in the difficult level displayed more neutral emotions than the ones in the easy level (a 50% morphed mixture of happy and neutral faces in the difficult level comparing to a 99% of a happy face and 1% of a neutral face in the easy level; see Tomasik et al., 2009). Given that neutral faces showed a hindsight bias effect in Experiment 1, therefore, the emergence of hindsight bias with difficult happy faces may just reflect increased neutrality of the happy faces. Although our data did not directly rule out this possibility, the increased neutrality effect should have also boosted the bias for the difficult angry faces, which was not the case. Furthermore, our control experiment showed that difficult happy faces were no more likely to be identified as other emotions (e.g., neutral) than difficult angry faces.

One could argue that including only two emotions in the present Experiment 2, as well as including only three emotions in Experiment 1, increased the likelihood that correct emotion identifications were the result of guessing. However, we argued that it is unlikely as the accuracy rates for emotion identifications were quite high (about 90%). We should also note that Giroux et al.'s (2022) Experiment 3 used only three emotions—ambiguous, happy, and surprised. They still observed a smaller hindsight bias effect for happy faces than other emotions. Most importantly, even with only two or three emotions in the present study, we still replicated Giroux et al.'s finding where the hindsight bias was found for all emotions except happy in the easy level.

Cross-race effects

Research using facial stimuli has demonstrated that race moderates memory processes involved in eyewitness testimony, whereby individuals demonstrate enhanced target identification and recognition performance for faces of the same race (see Meissner & Brigham, 2001, for a meta-analysis). Such cross-race effects have been attributed to familiarity (i.e., perceptual expertise; Meissner & Brigham, 2001; Sporer, 2001). The race of the facial stimuli and participants could have modulated the foresight and hindsight judgments. That is, greater familiarity leads to greater hindsight bias. This prediction stems from previous studies showing that expertise, defined as more experience and knowledge in the subject matter presented, exacerbates the hindsight bias (e.g., Christensen-Szalanski & Willham, 1991; Knoll & Arkes, 2017; Marks & Arkes, 2010; but see Guilbault et al., 2004). Unfortunately, the face stimuli we adopted from Tomasik et al. (2009) did not contain the information regarding the race or ethnicity. Therefore, it remains to be determined in future research whether participant and stimulus ethnicity would modulate visual hindsight bias for facial stimuli.

Conclusion

In conclusion, parallel to Giroux et al. (2022), results from the present experiments demonstrate that visual hindsight bias exists for emotional faces, but that there is a difference between happy faces and other emotion expressions. Our study extends their findings by illustrating that the perceptual processing difficulty of emotional faces may account for the differences in hindsight bias across emotions. When emotion processing is made difficult, visual hindsight bias emerges for happy emotions. We conclude that visual hindsight bias occurs for emotional faces and that further research is warranted to better understand the mechanisms responsible for such effects.

Appendix

A summary table for the ANOVA on Experiments 1 and 2 as a function of phase (foresight vs. hindsight), emotion (happy vs. angry vs. neutral [Experiment 1 only]), sex of the face stimuli (male vs. female), and difficulty (easy vs. difficult [Experiment 2 Only]). P = phase; E = emotion; S = sex; D = difficulty.

Effect	Experiment 1				Experiment 2			
	df	*F*	*p*	η_p^2	*df*	*F*	*p*	η_p^2
P	1, 44	3.891	.055	.081	1, 99	11.961	<.001	.108
E	2, 88	47.035	<.001	.517	1, 99	16.087	<.001	.140
D	–	–	–	–	1, 99	284.360	<.001	.742
S	1, 44	<1.0	.425	.015	1, 99	2.573	.112	.025
P × E	2, 88	9.255	<.001	.174	1, 99	9.209	.003	.085
P × D	–	–	–	–	1, 99	5.633	.02	.054
P × S	1, 44	<1.0	.697	.003	1, 99	7.926	.006	.074
E × D	–	–	–	–	1, 99	24.640	<.001	.199
E × S	2, 88	1.219	.300	.027	1, 99	<1.0	.376	.008
S × D	–	–	–	–	1, 99	<1.0	.424	.006
P × E × D	–	–	–	–	1, 99	3.535	.063	.034
P × E × S	2, 88	<1.0	.600	.012	1, 99	<1.0	.763	.001
P × S × D	–	–	–	–	1, 99	<1.0	.568	.003
E × S × D	–	–	–	–	1, 99	<1.0	.340	.009
P × E × S × D	–	–	–	–	1, 99	<1.0	.388	.008

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Declarations

Ethical approval All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Informed consent Informed consent was obtained from all individual participants included in the study.

Conflict of interest All authors in this study also declare no conflict of interest.

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