Hindsight bias after receiving self-relevant health risk information: A motivational perspective

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The phenomenon of hindsight bias was explored in the context of self-relevant health risk information. Participants in a community screening estimated their cholesterol level (foresight measure) before receiving positive or negative feedback based on their actual cholesterol level. Hindsight estimations were then assessed twice: once immediately after the feedback, and again several weeks later. While the unexpected positive feedback group showed no systematic recall bias, hindsight estimations of individuals receiving unexpectedly negative feedback showed a dynamic change over time. Immediately after the feedback, participants' recollection of their expected cholesterol level were shifted towards their actual cholesterol level (hindsight bias). In contrast, several weeks later, foresight estimations were recalled as less accurate than they had been (reversed hindsight bias). These data might reflect a change of the motivational focus from "hot affect" and fear control, which occur immediately after receiving negative feedback, to danger control, which occurs some time after the feedback, as proposed by the dual process model.

After learning the outcome of an event, people tend to remember their former predictions incorrectly as being more consistent with the outcome than they really were. This phenomenon is called "hindsight bias" and has been demonstrated in numerous studies, employing a wide range of judgement materials such as general almanac questions (e.g., Fischhoff, 1975; Hell, Gigerenzer, Gauggel, Mall, & Müller, 1988; Pohl, Ludwig, & Ganner, 1999a), political events (e.g., Blank & Fischer, 2000; Powell, 1988), medical diagnosis (Arkes, Wortmann, Saville, & Harkness, 1981), poor nursing performance (Mitchell & Kalb, 1981), rape scenarios (Carli, 1999; Stahlberg, Sczesny, & Schwarz, 1999), team decisions (Louie, Curren, & Harich, 2000), and stock purchase decisions (Louie, 1999).

Studies of hindsight bias mostly invoke cognitive explanations, arguing, for example, that hindsight bias is a by-product of adaptive learning (Hoffrage, Hertwig, & Gigerenzer, 2000), or the result of biased reconstruction (e.g., Dehn & Erdfelder, 1998), or memory impairment (e.g. Fischhoff, 1975; Hell et al., 1988). While the influence of cognitive factors has been well demonstrated, hindsight bias might also be governed or moderated by motivational factors. The idea that hopes, fears, wishes, desires, and apprehensions affect judgements is compelling. However, only a few studies have provided evidence for motivational influences (Campbell & Tesser, 1983; Haslam & Jayasinghe, 1995; Hell et al., 1988; Louie, 1999; Louie et al., 2000; Mark & Mellor, 1991; Mark, Boburka, Eysell, Cohen, & Mellor,

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2003-this issue; Pezzo, 2003-this issue; Schwarz, 2001; Stahlberg & Schwarz, 1999; Verplanken & Pieters, 1988). Other studies found no indications for motivational impact (Leary, 1981, 1982; Pohl & Hell, 1996; Pohl, Stahlberg, & Frey, 1999b; Stahlberg, Eller, Romahn, & Frey, 1993; Synodinos, 1986). As a result, it is commonly assumed that motivational influences on the formation of hindsight bias are at most "non-negligible but small" (Hawkins & Hastie, 1990, p. 323; see also Pohl, 1998). One major shortcoming of the investigation of motivational effects on hindsight bias to date has been that the term "motivational factor" served as an umbrella term for widely differing variables such as personality dispositions, monetary incentives for correct recall, event favourableness, or personal involvement. To further specify the conceptualisation of underlying motives, Verplanken and Pieters (1988) proposed a distinction between "person-related" and "decision-related" motives.

Personality dispositions can be summarised under "person-related" motives. It seems plausible that individuals with a stronger tendency to maintain a favourable image of themselves, or a stronger motive for predicting events than others, show greater hindsight bias. Campbell and Tesser (1983), for instance, found that a greater need for favourable self-presentation and a higher self-rated ego-involvement were positively related to hindsight bias. However, the predictive value of these individual differences for hindsight bias was rather small. A high correlation between personality traits and hindsight bias would require hindsight bias to be a result of a "thinking disposition" (Stanovich & West, 1998), i.e., stability of the hindsight phenomenon at the individual level. On the contrary, a review of 29 empirical studies on hindsight bias indicated that the bias varies considerably at the intra-individual level (Pohl, 1998, 1999). Taken together, the evidence so far does not support reliable and interpretable associations between differences in personality dispositions and hindsight bias (Pohl et al., 1999b; but see Musch, 2003-this issue).

Turning our attention to "decision-related" motives or motivational state variables, several studies explored hindsight bias as a function of task involvement. Most empirical studies on hindsight bias conducted to date have only required estimates to be made from artificial event descriptions, or material that has little or no relevance for the judges. Given a low level of personal involvement, people may be especially

prone to performance errors due to momentary lapses such as lack of attention, distraction, or temporary memory deactivation (Stanovich & West, 1998), and motives might not in fact be the issue. In this context, it is especially important to keep in mind that different motives of varying strength may be provoked, depending on the motivational significance of the material to be judged. Two task features in particular might be of great consequence for motivational phenomena: (1) self-involvement and (2) outcome valence. General knowledge questions, for instance, probably induce only a low level of personal involvement in the judgement task, since the outcome of these statements does not bear any significance for the judges. Whether judges, for example, underestimated or overestimated the height of the Empire State Building has no effect on them, and consequently does not elicit motivational dynamism. Of course, motivational drive might arise from an expected assessment of the degree of accuracy in answering these questions. Respondents might strive to appear intelligent or highly prognostic, particularly when the degree of accuracy is explicitly evaluated and rewarded. In line with this notion, Hell et al. (1988) found that monetary incentives for accuracy in recall of 88 general knowledge questions reduced the overall magnitude of the bias, in interaction with delay in the recall task, to a small but significant degree. Unfortunately, these findings represent the exception rather than the rule (see for example Camerer, Loewenstein, & Weber, 1989). Furthermore, experimental variations of this "try hard to recall accurately" instruction, which were intended to elicit stronger task involvement, proved mostly to be ineffective (Hell et al., 1988; Pohl, 1998). Thus, studies manipulating task involvement by monetary incentive or "try hard to recall accurately" instructions do not suggest strong motivational effects on hindsight bias.

One might argue that motivational effects may be prevalent in important, naturally occurring judgement tasks that are relevant for one's personal life. Hence, to investigate motivational effects, outcomes should be constructed that have relevance and bear consequences for the respondents. In this case, motivational effects are not only stimulated by the task, but also by the outcome which impacts positively or negatively on the judges.

Given self-relevant outcomes, the study of hindsight bias can be informed by work in other domains. Within the motivated-judgement

literature, the empirical finding that has received the greatest attention during the last two decades is the robust tendency to view oneself in an unrealistic light, and to perceive favourable information as more valid, accurate and internally caused than unfavourable information (Armor & Taylor, 1998; Ditto, Scepansky, Munro, Apanovitch, & Lockhart, 1998). Consequently, it is commonly assumed that personally relevant feedback that is inconsistent with self-beliefs and personal goals produces systematically self-defensive biases in judgements as a function of its positivity (Armor & Taylor, 1998; Ditto & Boardman, 1995; Kunda, 1987, 1990). Drawing especially on the finding that individuals take credit for favourable outcomes and avoid blame for unfavourable outcomes, Mark and Mellor (1991) proposed that individuals show a reduced or even reversed hindsight bias selectively for unfavourable outcomes (see also Louie, 1999; Mark et al., 2003-this issue; Stahlberg & Schwarz, 1999). Derogating the predictability of the outcome decreases internal attributions for one's plight, and saves individuals from unpleasant feelings of guilt, regret, or blame for their situation, or from the notion that they should have prevented it. Hence, unfavourable outcomes may lessen or even reverse the bias, due to self-serving mechanisms. For testing this assumption, Mark and Mellor (1991) investigated hindsight bias in the context of a "real-life" setting. They asked (a) workers who were laid off for an average of 27 months, (b) workers who were not laid off, and (c) members of the local community, to rate retrospectively the foreseeability of the layoffs in their union local. The result showed that laid-off workers rated the layoffs as less foreseeable than survivors or community members did. They concluded that laid-off workers showed lower hindsight bias in comparison to the other two groups since the implications of blame for their situation motivated them to deny the predictability of the outcome. As foresight estimations were not measured, this interpretation rests on the assumption that the groups did not differ systematically in their perceived foreseeability before the layoffs. However, the results did not change when Mark and Mellor (1991) controlled statistically for potential confounding variables (e.g., year of job seniority), which supports the interpretation that the favourableness of the event influences hindsight bias. In more recent studies, also using a between-subjects design but in an experimental setting with fictitious outcomes, equivalent results

have been obtained (Louie, 1999; Louie et al., 2000; Mark et al., 2003-this issue; Schwarz, 2001; Stahlberg & Schwarz, 1999).

To date, only one other study has investigated hindsight bias in the context of a non-laboratory, highly self-relevant and consequential setting. Haslam and Jayasinghe (1995) asked undergraduates to predict their grades one week prior to a midterm exam (foresight estimation). Two weeks after the exam respondents received their actual grade, and about one week later they were asked to recall their predictions (hindsight estimation). The researchers report a typical hindsight bias for students who were too optimistic in their predictions: those who received an unexpected poor grade improved their foresight estimation in retrospect. In contrast, students who gave too pessimistic predictions showed a reversed hindsight bias. They recalled their foresight predictions as less accurate than they had been. Clearly, these findings are not in line with Mark and Mellor's (1991) interpretation that negative self-relevant outcomes reduce hindsight bias. Haslam and Jayasinghe (1995) also consider their findings as evidence for self-serving mechanisms. However, they propose a different motivational mechanism. They argue that hindsight bias makes the outcome seem more foreseeable, and therefore enhances a sense of control in retrospect. Particularly in the context of negative outcomes that are under behavioural control, such as poor task performance or illness and disease, hindsight bias might function as a strategy for enhancing control by emphasising the relationship between action and outcome. The ability to detect signs of illness beforehand is important for the prevention and control of health problems. Hence, some individuals might gain benefit from the perception that they contributed to their situation because it restores a sense of control, and implies that they will be able to avoid a similar misfortune in the future (Thompson, Armstrong, & Thomas, 1998). From this perspective, individuals who face a negative outcome with most severe and threatening consequences should demonstrate the most hindsight bias. In contrast, individuals who discovered that their predictions were too pessimistic might show reversed hindsight bias, because admitting an unexpectedly favourable test result enhances positive affect, and is a pleasant surprise. However plausible this interpretation might seem, it must remain speculative since these findings have not been replicated.

Taken together, the present literature leads consistently to the pessimistic conclusion that motivational influences on the formation of hindsight bias are at most, "non-negligible but small" (Hawkins & Hastie, 1990, p. 323; see also Pohl, 1998). However, an area of research has been identified which suggests that motivational factors do impact on the formation of hindsight bias. Studies on hindsight bias employing a naturally occurring outcome of high self-relevance have shown that outcome valence does indeed influence the amount of hindsight bias, presumably by invoking self-protective motives. However, to date only two studies have employed a design in which self-relevant outcomes were the focus of the estimates. Interestingly, the pattern of hindsight bias and the proposed underlying self-serving mechanisms were quite different in both studies. These apparently conflicting results may reflect the dynamic nature of the motive structure.

Self-relevant negative feedback invokes a dynamic motive structure, which might involve a rather short-term phase of "hot affects" (e.g., fear), followed by more cognitive representations of the threat such as "perceived vulnerability" (Leventhal et al., 1997; Renner & Schwarzer, in press). Hence, motives could change over time depending on the current situational circumstances, and cannot be considered as constants that uniformly influence judgements. Interestingly, the time of measurement of hindsight estimations differed dramatically in both studies described earlier. While Haslam and Jayasinghe (1995) asked their participants about one week after the feedback to recall their foresight estimations, Mark and Mellor (1991) elicited estimates after an average delay of 27 months. Accordingly, exploring effects of motivation on the hindsight phenomenon might benefit by considering changes in the motive structure over time.

THE PRESENT RESEARCH

The present study explores the impact of motivation on hindsight bias in the context of self-relevant health risk information. A community cholesterol screening was used as a context. Participants received their *actual cholesterol reading* as feedback, which was either positive for the self (normal cholesterol reading) or negative for the self (elevated cholesterol reading). Since a high cholesterol level is a primary risk factor for cardiovascular diseases such as heart attack, the

feedback is naturalistic and of clear emotional importance for the participants. Hence, it is justified to assume that self-protective motives of significant strength are elicited. In order to assess the temporal dynamics presumed to be invoked by self-threatening health feedback, a longitudinal perspective was applied and hindsight bias was measured on two occasions. The time of measurement was chosen according to the motivational dynamics explored in the context of fear-communication. These studies showed that fear appeals led initially to increased fear and acceptance of the recommended action, but both fear and attitude changes faded away after 24 to 48 hours (Leventhal et al., 1997). Thus, in order to clearly separate these different foci of threat-feedback processing, a first estimate of hindsight bias was taken shortly after receiving feedback, while the second measurement was postponed for several weeks.

The specific hypotheses of the present study were developed according to the dual process model (Leventhal, Safer, & Panagis, 1983; see also Leventhal et al., 1997), which distinguishes two motives aroused by self-threatening information: (1) fear-control motivation and (2) danger-control motivation. Fear-control motivation stimulates behaviour or cognitions that are needed to cope with emotion, whereas danger-control motivation stimulates behaviours that are needed to cope with the threatening agent itself. Fear-control motivation is high immediately after receiving a negative self-threatening feedback, whereas danger-control motivation is more prominent later on. This leads to the assumption that after a negative outcome is given, motivational pressures that influence hindsight bias will lessen or change over time. One can speculate that immediately after the self-threatening feedback, people strive to regain a sense of predictability and control in order to calm their emotional upset and to generate action plans for coping, and therefore demonstrate hindsight bias (e.g., "I already knew that my cholesterol level would be high since I have put on some weight in the last few months. But this will soon change"). Hence, hindsight bias may serve the important function of controlling potentially disruptive emotions, which might interfere with adaptive behaviour. Thus, in common with the predictability motive proposed by Haslam and Jayasinghe (1995), it is hypothesised that *immediately* after the feedback participants who received an unexpected *negative* cholesterol test result will demonstrate *hindsight bias*.

After the strong initial emotional impact has faded away and the threatening information has been "digested" people might feel more in control, and may therefore focus more on decreasing their responsibility for the past negative outcome. Alternatively, one can hypothesise that after problem-focused action has been taken and emotional upset has lessened, individuals can more readily admit that their past judgement was inaccurate. This would result in a decreased hindsight bias. Therefore, *delayed* hindsight estimates should be more influenced by the motive to decrease responsibility, as proposed by Mark and Mellor (1991), and should therefore display an inverse pattern: unexpected unfavourable feedback should lead to a *decreased* or even *reversed hindsight bias*.

To ensure that this pattern is due to negative feedback valence, comparisons were made between participants who received unexpected negative feedback and participants who received an unexpected positive feedback. Participants receiving an unexpected negative feedback should show a stronger tendency for hindsight bias immediately after feedback than participants who received a positive test result, since they should be more motivated to regain predictability and control. Delayed hindsight estimations of both groups should also differ: Unexpected negative feedback should lead to a decreased or even reversed hindsight bias in comparison to unexpected positive feedback because the former should elicit a stronger tendency to decrease responsibility at this point in time.

METHOD

Participants

A large proportion of the participants (66%) were recruited for a cholesterol-screening conducted by the Free University of Berlin and the Technician's Health Insurance Agency (Techniker Krankenkasse) through advertisements placed in local newspapers in Berlin, Germany. In addition, a letter describing the study was sent to people insured with the Technician's Health Insurance Agency who lived near the four study locations (two universities and two city halls). In all, 1506 individuals were recruited.

Of these 1506 individuals, 92 participants (6%) had to be excluded from the data set because they did not complete the foresight measure or the first

hindsight measure. Another 511 participants (34%) failed to complete the third questionnaire, which included the second hindsight measure. Accordingly, the "*study sample*" comprised 903 individuals (60%), who provided complete data sets including the foresight and both hindsight questions. The mean age of these participants was 42 years ($SD = 15.7$), 47% were male, and the average cholesterol level was 220 mg/dl ($SD = 45.3$), which is within the borderline high range and below the mean German population cholesterol level of 237 mg/dl (Troschke, Klaes, Maschewsky-Schneider, & Scheuermann, 1998).

The data from the 511 individuals providing only the first hindsight estimate were considered in control analyses. Thus, systematic differences between the study sample providing both hindsight measures and this "*control sample*" were explored regarding the pattern of hindsight bias for the first hindsight measure. Of these 511 participants, 46% were male, and they were on average 37 years old ($SD = 14.5$). Average cholesterol level was 215 mg/dl ($SD = 45.4$). Analysis showed that the control sample was on average 5 years younger than the study sample providing complete data, $t(1412) = 5.38$; $p < .001$. Furthermore, they exhibited a significantly lower mean cholesterol reading, $t(1412) = 2.10$; $p = .036$, in comparison to the study sample. There was no significant gender difference between the two samples, $\chi^2(1) = 0.35$; $p = .55$.

Measures

Foresight estimation. Individuals completed a first questionnaire asking them to indicate their beliefs about a series of different health problems and disorders. The foresight estimation was embedded in the questionnaire. Participants were asked "Immediately after completing this questionnaire your cholesterol level will be measured. What cholesterol level do you expect?" Participant rated their expected cholesterol test result on a scale of 1 (very low) through 4 (optimal) to 7 (very high).¹

¹ Only elevated total cholesterol levels are considered as a health risk factor. Levels under 201 mg/dl do not require medical attention. Since cholesterol levels could be considerably below 201 mg/dl, the rating scale included ratings from very low to very high.

Hindsight estimation. After cholesterol test result feedback was given, participants completed a second questionnaire, which included the first hindsight estimation. The general stem for the item was, "Please think back to the first brief questioning, which took place before the cholesterol measurement. There, you were asked which cholesterol level you expected. What did you expect at that time?". Responses were made on the same 7-point scale used for foresight estimation ranking from 1 (a very low cholesterol test result) through 4 (an optimal cholesterol test result) to 7 (a very high cholesterol test result). The same item was included in the third questionnaire, which was completed at home.

Feedback reception. The second questionnaire, which was given shortly after receiving the feedback, also assessed various responses associated with receiving health-relevant feedback information. Three questions served to assess perceived threat. Participants were asked to rate how *worried* they felt due to their cholesterol test result. Ratings were made on a scale of 1 (absolutely not worried) through 4 (worried) to 7 (very worried). Furthermore, participants were asked to rate how serious a *threat to health* their cholesterol level was on a 7-point scale, anchored by 1 (very low) through 4 (moderately high), to 7 (very high). A further question, the *perceived pressure to change*, reflects the extent to which a person feels the pressure to lower the cholesterol level and change behaviours. High pressure to change is induced by threatening situations, which require personal action to change the situation (cf. Fuchs, 1996). Participants were given the following statement: "It is necessary for me to do something to lower my cholesterol level." The responses were given on a 4-point scale, ranging from 1 (strongly disagree) to 4 (strongly agree). Own worry, perceived threat, and perceived pressure to change were assessed immediately after the test results were given and before the first hindsight estimation. They were measured in fixed order and were separated by other variables (e.g., perceived prevalence of cardiovascular risk factors and diseases).

Following Ofir and Mazursky (1997), feelings of surprise influence the amount of hindsight bias. Accordingly, surprise elicited by feedback was measured by asking participants to indicate how surprised they were by the cholesterol test result on a 5-point scale, ranging from "I was very positively surprised by my cholesterol test result" (+2) through "My cholesterol test result matched

with my initial expectation" (0) to "I was very negatively surprised by my cholesterol test result" (-2). Perceived surprise was assessed before the first hindsight estimation.

Procedure

Upon their arrival at the screening site, participants received a brief description of the study and signed a consent form. Participants were then asked to answer a first questionnaire which included the foresight estimation of the cholesterol test result. Afterwards, participants' height and weight were measured. Then, trained laboratory assistants measured the total cholesterol level using a fingerstick blood draw and a Reflotron desktop analyser. Following the cholesterol measurement, participants were provided with their exact actual cholesterol level. Furthermore, participants received feedback on their cholesterol level risk category according to international standards (National Heart, Lung, and Blood Institute, 1995). Participants with a cholesterol level of 200 mg/dl or below were told that their cholesterol level was optimal and did not pose a risk for cardiovascular diseases. Both individuals with borderline high cholesterol levels (between 201 mg/dl and 249 mg/dl) and participants with high cholesterol levels (above 249 mg/dl) were informed about potential risks of borderline and high cholesterol levels for cardiovascular diseases. The time between filling in the first questionnaire and the cholesterol feedback was about 30–40 minutes. Shortly after receiving the cholesterol feedback, participants were given a second questionnaire. Among filler questions, this questionnaire included the first hindsight measure and assessed perceived threat and surprise elicited by the cholesterol feedback. After completing the second questionnaire participants received individualised follow-up recommendations, they were thanked for their participation, and received a more detailed questionnaire that included an additional hindsight estimation. This one was completed at home and sent back in a sealed envelope. On average, the third questionnaire was sent back 5 weeks after feedback ($SD = 1.7$).²

² A limitation of the study is that the feedback groups may have differed in their exact return time of the third questionnaire. Those who were given unexpected positive feedback might have filled in the questionnaire right away whereas those who received unexpected negative feedback might have shown a greater delay. However, since the standard deviation of the average return time was less than 2 weeks, great differences between the two groups do not seem plausible.

RESULTS

Foresight accuracy

Hindsight bias is a pattern of relationships among foresight estimations, actual cholesterol test results, and hindsight estimations. However, participants who predicted their cholesterol test result accurately could not improve their prediction in hindsight, but could only show either perfect memory or a decrease in accuracy. Only participants who gave a foresight estimation that did not match with the actual test result could theoretically demonstrate either accurate recall, hindsight bias, or reversed hindsight bias. Thus, the first analysis compared the incidence of accurate foresight estimations, determined by comparing participants' foresight estimations with their actual cholesterol test results (see Table 1). Participants received three qualitatively different feedbacks: optimal, borderline high, or high cholesterol level, and foresight estimations were given on a 7-point scale.³ Participants were divided according to whether they expected an optimal or even lower cholesterol test result ("not at risk"), or an elevated reading ("at risk"), and whether they had received an optimal ("not at risk"; ≤ 200 mg/dl) or elevated reading ("at risk"; > 200 mg/dl), resulting in a 2×2 Table.

As shown in Table 1, 64% of the study sample ($n = 580$, i.e., the sum of the areas outside the two frames) were able to accurately predict their actual cholesterol level. These individuals were excluded from all further analyses because due to their accurate foresight estimations they could not show hindsight bias. Hence, the following analyses are solely based on individuals who received unexpected feedback ($n = 323$, i.e., the sum of the two framed areas).

Out of the remaining 323 participants of the study sample who predicted their cholesterol level inaccurately, 198 (22%, the sum of the upper right frame in Table 1) estimated their cholesterol test result to be optimal or even lower while their actual cholesterol level was borderline high or

high (above 200 mg/dl). Thus, these participants received an *unexpected negative test result* and therefore demonstrated an optimistic bias. When the foresight estimation exceeded the actual test result, a pessimistic bias existed (a participant estimated that his or her cholesterol test result would be high or borderline high, and the actual test result was optimal or lower). These participants received an *unexpected positive test result* ($n = 125$, 14%, the sum of the lower left frame in Table 1). Hence, if participants made an inaccurate prediction they were more likely to make an unrealistically optimistic prediction than an unrealistically pessimistic one, $\chi^2(1) = 16.50$, $p < .001$.

Overall frequency of hindsight bias as a function of time

As a first step, the incidence or generality of biased judgements in hindsight was assessed. Biased judgements were calculated by subtracting hindsight responses from those generated in foresight. A score of zero indicates accurate recall. For participants who were given an unexpected high test result (negative feedback) a negative score indicates hindsight bias, while a positive score shows reversed hindsight. Those who received an unexpected low cholesterol test result (positive feedback) displayed hindsight bias if the deviation is positive, and reversed hindsight bias if the score is negative.

Immediately after test result feedback, 70% of the participants confronted with an unexpected test result accurately recalled their foresight estimation (see Table 2). As expected, recall accuracy declined as the recall interval increased: After a time interval of 5 weeks had elapsed, only 47% recalled their foresight estimation accurately. Thus, accurate recall was higher when probed shortly after feedback compared to a 5-week delay, $\chi^2(1) = 36.76$; $p < .001$.

Considering the immediate hindsight measure, there is a clear systematic recall bias, since 26% ($n = 83$) showed hindsight bias whereas only 4% ($n = 13$) displayed reversed bias, $\chi^2(1) = 52.04$; $p < .001$. Hence, the hindsight bias phenomena could be replicated in a naturalistic, personally relevant setting. Considering the delayed hindsight measure, the judgement errors change from a pattern of hindsight to a systematic pattern of reversed hindsight. Participants more often remembered a foresight estimation that was more dissimilar to the feedback than similar to it. To be specific, 32%

³ Due to this discrepancy between the foresight measure and the feedback, one could realise different "matches" between both, depending on the applied cut-off point. For cardiovascular diseases it is only relevant if the cholesterol level is elevated. Hence, the most important qualitative distinction for participants was probably whether they considered themselves at risk (foresight ratings from "moderately high" through "very high") or not at risk (foresight ratings from "optimal" through "very low").

TABLE 1

Frequencies and percentages for study sample and control sample as a function of expected cholesterol test result (foresight estimation) and actual cholesterol test result (feedback)

Foresight estimation (expected cholesterol level)	Feedback			Total
	Optimal (≤ 200 mg/dl)	Borderline High (201–249 mg/dl)	High (≥ 250 mg/dl)	
Very Low (1)	2 (1) 0.2% (0.2%)	3 (1) 0.3% (0.2%)	1 (0) 0.1% (0%)	6 (2) 0.7% (0.4%)
Low (2)	17 (9) 1.9% (1.8%)	10 (10) 1.1% (2.0%)	1 (2) 0.1% (0.4%)	28 (21) 3.1% (4.1%)
Moderately Low (3)	10 (8) 1.1% (1.6%)	5 (5) 0.6% (1.0%)	3 (3) 0.3% (0.6%)	18 (16) 2.0% (3.1%)
Optimal (4)	159 (106) 17.6% (20.7%)	131 (63) 14.5% (20.7%)	44 (26) 4.9% (5.1%)	334 (195) 37.0% (38.2%)
Moderately High (5)	115 (68) 12.7% (13.3%)	200 (117) 22.1% (22.9%)	133 (50) 14.7% (9.8%)	448 (235) 49.6% (46.0%)
High (6)	10 (8) 1.1% (1.6%)	17 (13) 1.9% (2.5%)	37 (18) 4.1% (3.5%)	64 (39) 7.1% (7.6%)
Very High (7)	0 (0) 0% (0%)	1 (1) 0.1% (0.2%)	4 (2) 0.4% (0.4%)	5 (3) 0.6% (0.6%)
Total	313 (200) 34.7% (39.1%)	367 (210) 40.6% (41.1%)	223 (101) 24.7% (19.8%)	903 (511) 100.0%

Study sample $n = 903$. Control sample $n = 511$.

Numbers outside parentheses represent frequencies for the study sample.

Numbers within parentheses represent frequencies for the control sample.

The upper right frame includes participants who estimated their cholesterol test result to be optimal or low, and whose actual cholesterol level was borderline high or high (above 200 mg/dl), thus they received an *unexpected negative test result*.

The lower left frame includes participants who estimated their cholesterol test result to be borderline high or high, and whose actual test result was optimal or low. Therefore, they received an *unexpected positive test result*.

showed reversed hindsight bias, whereas 21% displayed hindsight bias $\chi^2(1) = 6.72$; $p = .01$.

Biased judgements in hindsight as a function of feedback valence and measurement point in time

A 2×3 mixed between-within-subjects analysis of variance (ANOVA) was conducted to determine whether participants showed a memory bias towards the actual cholesterol level (hindsight bias), or a reversed hindsight bias as a function of feedback valence and time of measurement. In this analysis, the within-subject factor named "Time of Measurement" represents the three judgements of the expected cholesterol level, i.e., foresight, first and second hindsight estimate. The between-subjects factor "Feedback Valence" is

based on the feedback participants were given and consists of two levels, unexpected negative or unexpected positive feedback. The reported results are based on a full factorial model which meets standard requirements of ANOVA. Each effect was adjusted for all the other effects in the model. Therefore, the total SS is divided into a source attributable to the between-subjects factor "Feedback Valence", and a source attributable to the within-subject factor "Time of Measurement". In addition, changes over time in hindsight estimations were examined by constructing simple main effects, which means the effect of the within-subject factor "Time of Measurement" was computed within each level of the between-subjects factor "Feedback Valence". This is a rather conservative approach, since total SS remains constant over all analyses, but it has the advantage that all F values are comparable (cf. Kirk, 1968).

TABLE 2
Frequency of hindsight bias immediately after feedback (t1) and delayed after feedback (t2)

	<i>Accurate</i>	<i>Hindsight bias</i>	<i>Reversed hindsight bias</i>	<i>Total</i>
Immediately after feedback (t1)	227 (70%)	83 (26%)	13 (4%)	323 (100%)
Approximately 5 weeks after feedback (t2)	151 (47%)	69 (21%)	103 (32%)	323 (100%)

Results only for the study sample who received unexpected feedback, $n = 323$.

The 2×3 ANOVA yielded a significant main effect of the between-subjects factor "Feedback Valence", $F(1,321) = 422.23$; $p < .001$ ($\eta^2_{\text{partial}} = .57$). Inspection of the mean estimations revealed that participants who received unexpected positive feedback gave higher foresight and hindsight estimations compared to participants who received unexpected negative feedback. In addition, the within-subject factor "Time of Measurement" was significant, $F(2,642) = 15.07$; $p < .001$ ($\eta^2_{\text{partial}} = .04$). Hence, mean foresight and hindsight estimations varied across time, confirming the results of the frequency analysis (Table 2). However, as expected, the two main effects were further qualified by a significant

interaction, $F(2,642) = 18.76$; $p < .001$ ($\eta^2_{\text{partial}} = .06$).

Accordingly, further simple main effects of the within-subject factor "Expected Cholesterol Level" were assessed within each feedback group. Within the unexpectedly negative feedback group, estimates differed significantly across the three measurements, "Time of Measurement" $F(2,642) = 39.23$; $p < .001$. Post hoc Scheffé contrasts were calculated according to the hypothesis. As shown in Figure 1, participants who were given an unexpectedly negative feedback demonstrated hindsight bias when they had to recall their foresight estimate immediately after the negative health feedback. That is, recall of the foresight

Figure 1. Mean foresight and hindsight estimations as a function of feedback valence and time of measurement. (Means not sharing a common superscript differ at $p < .05$.)

estimate showed an upward shift, and hence in hindsight immediately after the feedback a foresight estimation was remembered which was more similar to the actual test result than it actually was. Interestingly, the pattern of biased judgement reversed across time, showing a downward shift at the second hindsight measurement. Thus, compared to the foresight estimate, participants recalled their foresight estimate as more discrepant from the actual cholesterol level.

To ensure that the observed pattern is due to feedback valence rather than to self-relevance of feedback, the effect of the within-subject factor "Time of Measurement" was assessed within the unexpected positive feedback group. As Figure 1 shows, the results for this group contrast with the group receiving unexpected negative cholesterol feedback. Their recall of the foresight estimate was characterised by a slight and statistically non-significant shift in direction of the given feedback for both estimates, $F(2, 642) = 2.83$; $p = .06$.

To summarise, mean hindsight estimations differed as a function of measurement point in time and feedback valence. As hypothesised, when measured immediately after feedback, unexpected negative feedback resulted in hindsight bias, while conversely, if measured following a delay after feedback, a reversed hindsight bias emerged. The unexpected positive feedback group showed on average neither a dynamic change over time nor a systematic bias in recall. The asymmetry between both feedback groups supports a motivational account of hindsight bias.⁴

⁴To examine whether the observed recall bias at the second hindsight estimate was restricted to participants who mis-recalled their prediction at the first hindsight measurement, a $2 \times 2 \times 2$ ANOVA was conducted with "Feedback Valence" (positive vs negative), "Accuracy" (accurate first hindsight estimate vs inaccurate first hindsight estimate), and "Time of Measurement" (foresight and second hindsight estimate). However, neither the main effect for "Accuracy" nor any two-way interaction term including this factor reached statistical significance (all F s < 1). Conversely, the triple interaction was significant, $F(1, 319) = 5.64$, $p = .018$. Further inspection revealed that within the unexpected negative feedback group, participants who gave an inaccurate hindsight estimation at the first measurement (t1) showed a reversed hindsight bias at the second measurement: foresight, $M = 3.9$ vs second hindsight, $M = 3.4$; $F(1, 319) = 23.71$, $p < .001$. Participants who gave an accurate hindsight estimation at the first measurement (t1) demonstrated a less pronounced but still significant reversed hindsight bias: foresight, $M = 3.8$ vs second hindsight, $M = 3.5$; $F(1, 319) = 3.71$, $p < .025$. Within the unexpected positive feedback group no significant differences between the two accuracy groups were obtained, all F s < 1.

Control analyses: Hindsight bias in the control sample that provided only the first hindsight measure

Analogous to the study sample, 64% ($n = 325$) of the control sample received a cholesterol test result that was consistent with their initial expectation, 21% ($n = 110$) displayed an unexpected negative cholesterol reading, and 15% ($n = 76$) were confronted with an unexpected positive result. There were no significant differences among the control group and the study group in frequency of realistic, optimistic, or pessimistic expectations, $\chi^2(2) = 0.29$; $p = .87$ (see Table 1). Analogous to the analyses for the study sample, participants who predicted their cholesterol level accurately were excluded from further analyses, since by definition they could not demonstrate hindsight bias. This left 186 individuals for analyses who received unexpected feedback.

Immediately after the test result feedback, most participants of the control sample who received an unexpected feedback recalled their foresight estimation accurately (68%), but even so hindsight bias (28%) was more frequent than reversed hindsight bias (4%) with $\chi^2(1) = 34.3$; $p < .001$. Hence, the hindsight bias phenomenon could be replicated in a second sample. In addition, the control sample and the study sample did not differ significantly in respect to frequency of biased recall, $\chi^2(2) = 0.32$; $p = .85$.

To explore whether feedback valence moderated the frequency of hindsight bias immediately after the feedback, a 2×2 ANOVA analysis with the within-subject factor "Time of Measurement" (foresight and first hindsight estimate) and the between-subjects factor "Feedback Valence" (unexpected positive and unexpected negative feedback) was conducted. The main effect of "Feedback Valence" was significant, $F(1, 184) = 205.98$; $p < .001$ ($\eta^2_{\text{partial}} = .53$), whereas the within-subject factor "Time of Measurement" did not reach statistical significance, $F(1, 184) = 1.00$; $p = .32$ ($\eta^2_{\text{partial}} = .01$). More important, the hypothesised significant interaction emerged, $F(2, 184) = 29.48$; $p < .001$ ($\eta^2_{\text{partial}} = .14$). In accordance with the study sample, participants who received an unexpected negative feedback showed hindsight bias, $F(1, 184) = 25.28$; $p < .001$. In contrast to the study sample, the unexpected positive feedback group also showed hindsight bias $F(1, 184) = 8.30$; $p < .01$, but to a smaller degree than the unexpected negative feedback group (Table 3).

TABLE 3
Mean foresight estimation (t_0) and hindsight estimation immediately after feedback (t_1) by valence of feedback

	Unexpected negative feedback ($n = 110$)	Unexpected positive feedback ($n = 76$)
Foresight estimation (t_0)	3.7 (.70)	5.1 (.31)
Immediately after feedback (t_1)	4.2 (.74)	4.8 (.67)
	$F(1, 184) = 25.28, p < .001$	$F(1, 184) = 8.30, p < .01$

Results only for the Control Sample that Received Unexpected Feedback, $n = 186$.
Numbers in parentheses are standard deviations

While the overall pattern of the study sample was replicated in the control sample, some differences did occur. To explore whether both samples differed significantly in their estimations, a $2 \times 2 \times 2$ ANOVA analysis was conducted with the two samples as an additional between-subjects factor named "Design Group" (study sample and control sample). The interaction between "Time of Measurement" and the between-subjects factor "Feedback Valence" was again significant, $F(1, 505) = 66.76; p < .001$ ($\eta^2_{\text{partial}} = .12$). Neither the main effect of the factor "Design Group", nor any interaction term including this factor, was significant (all F s < 1 , ns).

In summary, the result pattern observed for the study sample was replicated within the control sample.

Unexpected cholesterol feedback: Feelings of threat and surprise

In order to ensure that unexpected negative feedback elicited threat, additional analyses were performed comparing self-reported worry, perceived threat to health, and perceived pressure to change as a function of feedback valence. For analyses, 2×2 ANOVAs were computed with "Feedback Valence" (unexpected negative or unexpected positive feedback) and "Design Group" (study sample or control sample) as between-subjects factors ($n = 509$).⁵ Neither the main effect for the factor "Design Group" nor the interaction effect reached statistical significance (all F s $< 1.15; p > .29$). Conversely, the factor "Feedback Valence" was significant. Participants who received an unexpected negative feedback ($M = 3.1; SD = 1.4$) were more worried about their test result than participants who received an

unexpected positive feedback, $M = 2.1; SD = 1.3; F(1, 500) = 45.50; p < .001; \eta^2_{\text{partial}} = .09$. In addition, they rated their unexpected negative cholesterol test result as a higher threat to their health than did participants who were told an unexpected positive test result, $M = 3.1; SD = 1.3$ versus $M = 2.4; SD = 1.4; F(1, 501) = 26.47; p < .001; \eta^2_{\text{partial}} = .06$. An unexpected negative test result also elicited a stronger pressure to change compared to an unexpected positive feedback, $M = 3.0; SD = 1.0$ versus $M = 1.9; SD = 1.0; F(1, 491) = 98.08; p < .001; \eta^2_{\text{partial}} = .18$. Hence, unexpected negative feedback elicited significantly more self-reported threat than unexpected positive feedback.

In addition, mean surprise ratings of participants differed as a function of feedback valence in the anticipated direction. Thus, participants with an unexpected negative feedback were negatively surprised ($M = -0.50; SD = 0.90$), whereas participants with an unexpected positive feedback were positively surprised ($M = 0.85; SD = 0.91$). Interestingly, the absolute level of reported surprise differed significantly, $F(1, 495) = 16.59; p < .001; \eta^2_{\text{partial}} = .04$. An unexpected positive test result elicited stronger surprise in comparison with an unexpected negative feedback. Again, the study sample and the control sample did not differ significantly (all F s $< 0.39; p > .53$).

Hindsight bias and perceived threat

Additional analyses within both feedback groups were conducted to elaborate more on the underlying motives for biased recall. It might be expected that the perceived threat elicited by the unexpected negative cholesterol feedback was more pronounced for individuals who demonstrated hindsight bias compared to individuals who showed accurate recall or reversed hindsight bias immediately after the feedback. In contrast,

⁵ Due to missing values, degrees of freedom vary between analyses.

TABLE 4

Mean ratings for self-rated worry, perceived health threat, and perceived pressure to change by accuracy of recall (t_1) within unexpected negative feedback and within unexpected positive feedback

		<i>Unexpected negative feedback</i>			<i>Unexpected positive feedback</i>		
		<i>Accurate</i>	<i>Hindsight bias</i>	<i>Reversed hindsight bias</i>	<i>Accurate</i>	<i>Hindsight bias</i>	<i>Reversed hindsight bias</i>
Worry ($n = 504$)	<i>Mean</i>	3.0 ^a	3.3 ^a	2.7 ^b	2.1 ^c	2.2 ^c	1.9 ^c
	<i>SD</i>	1.4	1.4	1.9	1.3	1.4	1.5
Adj. $R^2 = .09$	<i>n</i>	202	91	13	148	43	7
Perceived Threat ($n = 505$)	<i>Mean</i>	3.0 ^c	3.4 ^a	2.5 ^b	2.4 ^c	2.4 ^c	2.3 ^c
	<i>SD</i>	1.3	1.3	1.4	1.3	1.6	1.2
Adj. $R^2 = .06$	<i>n</i>	202	91	13	149	43	7
Perceived Pressure to Change ($n = 495$)	<i>Mean</i>	2.9 ^c	3.2 ^a	2.6 ^b	1.9 ^d	2.0 ^d	2.1 ^d
	<i>SD</i>	1.0	1.0	1.0	1.1	0.9	1.4
Adj. $R^2 = .18$	<i>n</i>	198	89	13	145	43	7

n varies due to missing values.

Means without rows not sharing a common superscript differ at $p < .05$.

perceived threat might not vary as a function of recall accuracy for participants who were given an unexpected positive feedback. Both samples (study sample and control sample) were collapsed for these analyses ($n = 509$), and separate ANOVAs containing the three-level between-subjects factor "Recall Accuracy" (hindsight bias, accurate recall, and reversed hindsight bias at the first hindsight measure) and the two-level between-subjects factor "Feedback Valence" (unexpected negative and unexpected positive feedback) were calculated.⁶ Simple main effects of recall accuracy within each feedback group and post-hoc Scheffé contrasts were conducted to compare the extent to which participants who showed either hindsight bias, accurate recall, or reversed hindsight bias, differed in perceived threat.

Within the unexpected negative feedback group, a significant effect for recall accuracy emerged for all three threat variables, worry, perceived threat, and pressure to change (all $F_s > 3.32$; $p < .04$). As Table 4 depicts, participants who were confronted with an unexpected negative test result and showed hindsight bias reported, on average, more worry, they felt more threatened by their test result, and they perceived a higher pressure to change than those who were also

confronted with an unexpected negative feedback, but showed reversed hindsight bias. In addition, those who recalled their foresight estimation accurately fell in between these two groups. As hypothesised, perceived threat did not differ within the unexpected positive feedback group as a function of recall accuracy (all $F_s > 1.77$; $p < .17$). However, these results must be interpreted with caution because cell frequencies vary greatly and the differences are rather small. Since the findings are very similar for all three threat variables, however, this could be interpreted as support for the notion that the more unexpected the negative feedback was, the more threat it elicited, and the more hindsight estimations were biased towards the given feedback.

DISCUSSION

The present study explored the phenomenon of hindsight bias in the context of self-relevant health risk information. More specifically, individuals participating in a community screening received feedback based on their actual cholesterol level, while foresight measures were obtained before cholesterol measurement, and immediate and delayed hindsight measures probed afterwards for memory bias. The findings suggest three conclusions: First, the phenomenon of hindsight bias and reversed hindsight bias has been demonstrated for

⁶ Recall accuracy was determined by the method used for calculating overall frequency of hindsight bias.

the first time in the domain of health psychology, and did hold up outside the laboratory in "real life". Second, the present data might also contribute towards framing hypotheses on "motivated" hindsight bias. The unexpected positive feedback group showed no systematic recall bias, whereas the unexpected negative feedback group showed evidence for memory bias. The difference between the two feedback groups suggests a motivational account for the observed recall distortions. Third, a dynamic change of direction in the judgement bias was observed for participants confronted with unexpected negative feedback. Immediately after feedback, recalls of foresight estimations were shifted towards the actual cholesterol level, indicating hindsight bias. In contrast, reversed hindsight bias emerged when recalled foresight estimations were probed several weeks later. These data might reflect a change of motivational focus from "hot affect" and fear control to more cognitive event representations and danger control, as proposed by the dual process model (Leventhal et al., 1983, 1997). Interestingly, the dynamic shift in judgement bias over time suggests that motivated hindsight reflects an adaptive mechanism.

Hindsight bias and self-regulation

It was proposed that systematic changes in hindsight judgements would be observed for participants receiving self-threatening information. This hypothesis was derived according to the literature on motivated judgement (Armor & Taylor, 1998; Ditto & Boardman, 1995; Ditto et al., 1998; Kunda, 1987, 1990), and health psychology (Leventhal et al., 1983, 1997), and incorporated the assumption that motivated hindsight bias works in the service of self-protective motivation (Haslam & Jayasinghe, 1995; Louie, 1999; Mark & Mellor, 1991; Stahlberg & Schwarz, 1999). In line with this hypothesis, feedback valence moderated hindsight bias. Considering the immediate hindsight measure, both the positive and negative feedback groups shifted their foresight estimate towards the actual cholesterol level (cf. Figure 1 and Table 3). However, in both samples, the shift was more pronounced for participants who were given an unexpected negative cholesterol feedback. Considering the delayed hindsight measure, a unique dynamic shift was observed within the unexpected negative feedback group. They demonstrated hindsight bias at the immediate

measure and reversed bias at the delayed measure. In contrast, unexpected positive feedback was not accompanied by a dynamic shift from immediate to delayed hindsight estimations.

Motivated hindsight bias elicited by negative self-threatening information might be considered as a particular instance of the more general asymmetric effects elicited by positive and negative events (Taylor, 1991; Berntson, Cacioppo, & Gardner, 1999). Accordingly, it is assumed that negative events elicit particularly strong immediate responses, followed by responses to minimise or cope with adverse events compared to positive events. Interestingly, the dynamic shift in immediate and delayed hindsight measures within the group receiving unexpected negative feedback suggests that motivational effects on hindsight have an adaptive role and are consequent upon the change in motivational focus over time, instigating different coping strategies (Lazarus & Folkman, 1984; Leventhal et al., 1983, 1997). In other words, it is hypothesised that memory distortions might play a functional role within the self-regulatory processes elicited by negative feedback, and, as a by-product, recall errors vary as a phase-specific phenomenon.

It was proposed that receiving negative cholesterol feedback elicits *fear-control* processes. Unlike many other health problems, an elevated cholesterol level is not associated with symptoms. One can reasonably assume that participants who expected their cholesterol level to be favourable felt well. Thus, while expecting a favourable or normal cholesterol level, negative cholesterol feedback might not only induce fear and worry, but could also be accompanied by shattered feelings of control and self-efficacy. At this stage, controlling the threatening agent itself is not possible, since this requires long-term changes in health behaviour. Consequently, the only possible way of coping at this particular point in time is to change one's beliefs and appraisals. The results of the immediate hindsight measure indicate a hindsight bias, i.e., the recalled foresight estimate was shifted towards the actual cholesterol level. Furthermore, analyses showed that those who displayed hindsight bias after receiving unexpected negative feedback felt more threatened than those who did not display the bias. This suggests that people strive to shield their feelings of control and self-efficacy by making the outcome seem more foreseeable, as assumed by Haslam and Jayasinghe (1995). Focusing on the causal importance of prior behaviour appears

functional, since this allows visualising of a connection between what they could be doing and the course of the disease (Thompson et al., 1998).

Other empirical evidence from coping research also suggests that people try to shield their feelings of perceived control and self-efficacy, especially in the face of threatening information (Armor & Taylor, 1998). For example, Taylor (1983) reported that 95% of the patients she studied had developed a theory of why their cancer occurred. Many of the causes mentioned by these patients were behavioural patterns which could be modified through the patient's own efforts. Similarly, Croyle and Sande (1988) showed that participants who believed that they suffered from (non-existent) thioamine acetylase (TAA) deficiency reported more deficiency-associated symptoms and more TAA risk-related behaviours than participants who believed their TAA level was normal. Overall, striving to shield feelings of control and self-efficacy in the face of threat might be an adaptive reaction, since these optimistic self-beliefs are crucial for the behavioural change that is needed for successful risk management (Taylor, Kemeny, Reed, Bower, & Gruenewald, 2000; Renner, Knoll, & Schwarzer, 2000; Renner & Schwarzer, in press; Schwarzer & Renner, 2000). Hindsight bias could accordingly be understood as a by-product of the attempt to regain control in the face of threat, which in turn facilitates *danger-control* oriented behaviour in the long run.

Considering the delayed hindsight measure, participants receiving unexpected negative feedback recalled their foresight estimations as more discrepant to the feedback than they actually were, i.e., reversed hindsight. This pattern is in line with the hypothesis of Mark and Mellor (1991), who proposed that people tend to derogate the foreseeability in order to avoid blame for the situation. This avoidance tendency could emerge because after a certain time people might feel more in control and adapted, and consequently their goal orientation shifts more towards avoiding blame.

One might be suspicious that the particular pattern of hindsight change from the first to the second hindsight measure would appear different when considering the control sample, which only provided data from the first hindsight measure. Since the study involved a mailed questionnaire, systematic drop-outs from t1 to t2 could impair the conclusions. The attrition was 34%, which is considerable but in line with other screening

studies (cf. Glanz & Gilboy, 1995). Control analyses showed that the study sample and the control sample did not differ systematically, neither in respect of their foresight accuracy, perceived threat, or reported surprise, nor in respect of hindsight bias immediately after feedback. Hence, the findings do not support the notion of a response bias or systematic drop-out which might have influenced hindsight measures. Admittedly, this discussion is somewhat speculative and future studies are needed including the assessment of motivational factors at a more detailed level, which was not possible in this study.

Furthermore, the sequence proposed above might only apply to negative self-relevant stimuli that require a behavioural response to avoid loss or harm. Negative events that are not under behavioural control, or require no adaptive behaviour change, may immediately generate, for example, more blame-avoiding reactions. This might partly explain why in experimental contexts, for instance where participants were asked for stock market decisions (Louie, 1999; Mark et al., 2003-this issue), negative self-relevant outcomes were judged as less foreseeable in comparison to positive outcomes. Perceived control could be manipulated, for instance, by providing information about the treatability of the given condition. However, the data already suggest that paying attention to the dynamic change of motivation might resolve otherwise conflicting results (Haslam & Jayasinghe, 1995; Mark & Mellor, 1991). Both patterns of recall bias reported in previous studies were replicated in this study, with time of measurement as a critical variable.

Hindsight bias and feelings of surprise

In order to further support the hypothesis that self-threatening feedback is crucial for motivated hindsight bias, one has to consider the surprise elicited by the cholesterol feedback. Mazursky and Ofir (1990; Ofir & Mazursky 1997, but see also Mark & Mellor, 1994; Pezzo, 2003-this issue; Schkade & Kilbourne, 1991) postulated a "reversal" hypothesis, arguing that high levels of surprise will result in a reversed hindsight bias. They assume that the feeling of surprise serves as a memory cue to the outcome unexpectedness, which in turn leads people to exaggerate in hindsight the discrepancy between foresight estimation and outcome. In line with this reasoning, one

could propose that negative and positive feedback evoked different surprise levels, and consequently different recall patterns. Analysis of the surprise level in this study revealed that immediately after the feedback, participants who received an unexpected positive result demonstrated more surprise and less hindsight bias than participants who received an unexpected negative result. Hence, these results provide support for the cognitive-oriented notion suggested by Ofir and Mazursky (1997), which claims that the more people are surprised by the outcome, the less they demonstrate hindsight bias. However, this interpretation is limited because perceived surprise was assessed before hindsight estimations and could therefore have altered the process of recall, favouring the cue hypothesis. Another limitation is that the surprise measure confounded both the valence (positive vs negative) and amount of surprise. Consequently, positive feedback might not have been more surprising, but elicited more pronounced perceived valence. However, in both samples, participants who received an *expected positive* feedback gave similar surprise ratings to those who received an *expected negative* feedback (all $F_s < 1.7$, $p < .05$), suggesting that the degree of valence of positive and negative feedback was comparable.

While the cue proposition offers an explanation for reactions immediately after the feedback, it does not explain the observed shift within hindsight estimates across time. In addition, one could reason that the causal sequence proposed by the cue hypothesis is rather ambiguous. Ofir and Mazursky (1997) assume that memory distortions are caused by perceived unexpectedness. However, people who are prone to hindsight bias, claiming they knew it all along, could not reasonably state at the same time that the outcome took them by surprise. Thus, high perceived unexpectedness could be seen as a logical consequence of reversed hindsight bias, rather than being the cause of it. In addition, assuming that reversed hindsight bias is a consequence of experienced surprise, or vice versa, people ought to display hindsight bias on "objective" measures (that means hindsight estimations that are more similar to the outcome than foresight estimations) as well as on "subjective" measures, which concern the *perceived* foreseeability in retrospect. Conversely, one could assume that subjective and objective measures can differ considerably. For example, some participants may recall a more accurate foresight estimation in hindsight (dis-

playing "objective" hindsight), but nevertheless they could believe that they would not have foreseen the diagnosis, and still report feelings of surprise. The opposite is also plausible: i.e., people who do not show hindsight bias on objective measures could claim that they did not foresee the outcome. "Subjective" hindsight measures (e.g. Mark & Mellor, 1991) as well as "objective" hindsight measures (e.g., Haslam & Jayasinghe, 1997) have been applied, but most researchers do not differentiate between these two phenomena (but see Blank & Fischer, 2000; Blank, Fischer, & Erdfelder, 2003-this issue). However, a numerical difference between foresight and hindsight measure is not sufficient to state that people claimed they knew it all along. This distinction might be particularly fruitful for the understanding of how motivational and cognitive factors influence hindsight bias. "Subjective" hindsight bias might be more influenced by motivational factors, whereas "objective" hindsight bias might depend more on cognitive factors.

Limitations of the study

Limitations of internal and external validity of the presented study must be acknowledged. Since all participants were volunteers and there was no pressure to attend, sample selection biases might reduce external validity. People who choose to be tested are by definition self-selected and may be in part psychologically and behaviourally prepared for dealing with bad news. Consequently, the degree to which the findings generalise to people who refrained from testing is limited.

The phenomenon of hindsight bias was explored here in an ex-post facto study (Broota, 1989). Thus, the cholesterol feedback given to the participants was not randomly assigned to the two feedback groups (positive and negative feedback), but was based on their actual cholesterol test results. The advantage of giving actual feedback is that it is naturalistic, was not forced onto the participants, and importantly, has a clear emotional importance for the recipients. As outlined in the introduction, it was hypothesised that self-relevant negative feedback is a necessary prerequisite for investigating effects of self-defensive motivational mechanisms on hindsight estimations. Conversely, without any question, an ex-post facto design puts limitations on the generality of the findings presented here. However, while randomised group assignment is easily

accomplished by studying cognitive phenomena using, for example, test performance on almanac questions as feedback, this bears on a number of possible concerns in the domain of health psychology. It appears that random assignment to experimental conditions is only ethically feasible for studying short-term effects. For instance, Jemmott, Ditto, and Croyle (1986), developed an experimental paradigm for studying reactions to risk factor information using a fictitious enzyme deficiency (TAA) as a context. Importantly, the negative feedback was clearly emotionally upsetting for the participants (cf. Croyle, Sun & Hart, 1997). Even worse, Baumann, Cameron, Zimmerman, and Leventhal (1989) stated that participants who received false high blood pressure feedback reported more physical symptoms afterwards and rated their health status significantly lower. The longitudinal perspective of motivational change was the main goal of the study, and accordingly, the present study would have needed to withhold debriefing information for an average of 5 weeks. This long delay did not appear ethically justifiable, considering the emotional impact of false negative feedback.

A further complication in realising the present study as experimental design emerges when both independent variables (cholesterol feedback and feedback expectations) are considered. Random assignment to the feedback condition (positive or negative) would not control for a priori differences between the two conditions in terms of feedback expectations. Consequently, a full experimental design would not only involve the random assignment to feedback, but would in addition require the experimental manipulation of expectations regarding the cholesterol test. This is probably difficult to achieve since risk perceptions and self-related health ratings are quite resistant to interventions (e.g., Weinstein & Klein, 1995). According to these ethical and practical limitations, an "ex-post facto" design appeared more appropriate for a first study in this area of research.

Since participants were not randomly assigned to the feedback conditions, a priori differences between the two feedback groups could have seriously impaired internal validity. One could argue, for example, that the two groups differed on personality variables, such as coping styles or depressive realism. Conversely, several studies have shown little relationship between risk factor appraisals and individual difference variables such as self-esteem, monitoring vs blunting coping

style, or repression-sensitisation (Croyle, Sun, & Louie, 1993; Ditto, Jemmott, & Darley, 1988). In addition, personality traits could certainly provide alternative explanations for the findings concerning the first hindsight measure, but not for the observed changes in the direction of the hindsight bias over time. However, they may function as a moderator within feedback groups, explaining why some individuals demonstrated hindsight bias and some did not when faced with unexpected negative feedback.

Summary

The present study demonstrated the phenomenon of motivated hindsight bias in the context of health-related feedback. Interestingly, applying a longitudinal perspective, hindsight bias was observed for the immediate hindsight measure, while reversed hindsight bias was observed after a delay of about 5 weeks. These data are consistent with the notion of biased memory recall reflecting self-serving mechanisms. However, the focus of self-protection might be dynamic, changing focus over time. These findings need to be extended in future studies employing more rigorous experimental designs, and exploring the relation of threat, motivation, and memory bias at a more specific level.

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