Journal of Behavioral Decision Making, Vol. 1, 131–147 (1988)

Individual Differences in Reverse Hindsight Bias: I Never Thought Something Like Chernobyl Would Happen. Did I?

BAS VERPLANKEN
Leiden University, The Netherlands

AND

RIK G. M. PIETERS
Erasmus University, The Netherlands

ABSTRACT

Hindsight bias was studied in the context of the accident in the Chernobyl nuclear power plant, which took place on April 26th 1986. An individual difference factor which relates to the motivation to process information, need for cognition, was expected to moderate the occurrence of hindsight bias. Probability estimates of many casualties due to the use of nuclear power in The Netherlands were obtained from 212 individuals two months before the accident in Chernobyl. These estimates were compared with similar estimates made in hindsight by the same individuals five months after the accident. Loglinear Analyses reveal a systematic hindsight bias. However, the direction of the bias was contrary to expectations. In hindsight, individuals gave lower probabilities than they actually did two months before the Chernobyl accident. These results reveal a reverse hindsight bias. As hypothesized, need for cognition moderates hindsight bias: individuals low and medium in need for cognition express a systematic reverse hindsight bias, while individuals high in need for cognition do not. High need for cognition individuals also show higher literal consistency between the two measurements, which supports a memory explanation of the moderating effect of need for cognition.

KEY WORDS Hindsight bias Need for Cognition Subjective probabilities Moderating variables Chernobyl

It is extremely difficult to neglect events that occurred in the past when one estimates in hindsight the probability that these events would occur. In studying history, people seem to be making consistent mistakes. The advantages of knowing how things turned out may be 'oversold' (Fischhoff, 1975a, b). In hindsight, we consistently exaggerate what could have been anticipated in foresight. We '... not only tend to view what happened as having been inevitable but also to view it as having appeared "relatively inevitable" before it happened' (Fischhoff, 1982, p.341). Research shows that we even misremember our own predictions so as to exaggerate in hindsight what we knew in foresight (Fischhoff and Beyth, 1975). This illustrates the so-called hindsight bias phenomenon. If people can hardly study the past without misremembering their own predictions, so as to exaggerate in hindsight what they knew in foresight, and if they view events as having been almost inevitable, they will not learn optimally from the past. The failure to be surprised by certain events or their outcomes may lead to underestimating what can be

0894–3257/88/030131–17$08.50

Received 15 November 1987
Revised 1 March 1988

learned from the past. Therefore, investigating hindsight bias may provide more insight into basic human information processing, and as a result may lead to learning more optimally from the past, and to making more optimal future decisions.

Fischhoff (1975a) describes an illustrative experiment on hindsight bias. Five groups of subjects first read a short paragraph about a not well known historical event. To one group of subjects four possible outcomes of the event were described (the Before group). The other four groups (the After groups) read the same information, except that in the final sentence only one, apparently the true, outcome was presented. Next, subjects were asked to estimate the likelihood that each of the four possible outcomes would have occurred. Reporting an outcome of the event resulted in consistently higher hindsight estimates for that particular outcome. This result emerged both when comparing the hindsight estimates of the Before group with those of the After groups, and when comparing the hindsight estimates of the four After groups. Moreover, reporting the outcome of events altered the judged relevance of information describing the situation preceding the event. A second experiment revealed that the subjects were either unaware of this effect of outcome knowledge, or, if aware, unable to ignore or rescind it.

Hindsight bias or, in more popular terms, the I-knew-it-all-along effect, is a robust phenomenon. It has been demonstrated over a variety of populations, experimental paradigms and response instructions (Campbell and Tesser, 1983). It has been demonstrated with respect to many different events, e.g., buying decisions (Walster, 1967), historical events (Fischhoff, 1975a, b; Fischhoff and Beyth, 1975), scientific experiments (Slovic and Fischhoff, 1977; Davies, 1987), general knowledge information (Wood, 1978; Hasher, Attig and Alba, 1981; Campbell and Tesser, 1983), medical diagnoses (Arkes, Wortmann, Saville and Harkness, 1981; Pennington, Rutter, McKenna and Morley, 1980), games (Leary, 1981), elections (Leary, 1982; Synodinos, 1986), contemporary world events (Pennington, 1981; Guerin, 1982), and person perception (Snyder and Uranowitz, 1978; Janoff-Bulman, Timko and Carli, 1985).

In the present study, the hindsight phenomenon will be focused upon in the context of a technological calamity: the accident in the Chernobyl nuclear power plant, which took place April 1986.

DETERMINANTS OF HINDSIGHT BIAS

Effort has been put into ruling out artifact explanations of hindsight bias. For instance, Fischhoff (1977) included a 'debiasing condition' in an experiment on hindsight bias. In the debiasing condition, the hindsight bias phenomenon was explained to the subjects. The subjects were asked to avoid making biased estimates. The debiasing efforts clearly failed to attenuate the hindsight bias effect. Wood (1978) found that 'demand characteristics' did not influence the magnitude of hindsight bias. Such results weaken the validity of a demand characteristic explanation of hindsight bias. Also, different response formats have been used in hindsight bias studies: numerical probability estimates (e.g., Fischhoff, 1975a), verbally labeled probability estimates (e.g., Janoff-Bulman, Timko and Carli, 1985), true-false statements (e.g., Campbell and Tesser, 1983), and direct outcome estimates (e.g., Leary, 1981). These response formats yield the same results.

Given the generality of the hindsight bias phenomenon and given its implications, it is important to investigate the factors that influence the magnitude of hindsight bias. Several explanations of the hindsight bias phenomenon have been formulated. Campbell and Tesser (1983) distinguish two classes of explanations: (a) information processing explanations, and (b) motivational explanations.

Information processing explanations focus on the effect that new information has on the retrieval and use of existing information. Knowledge about the outcome of an event is incorporated into existing information structures, and individuals tend to make a meaningful picture out of this. Fischhoff (1975a) suggests that the use of heuristics, such as the availability principle (Tversky and Kahneman, 1973),

might lead to hindsight bias. A person may find great difficulty in imagining how things could have happened in another way than they actually did. The event that occurred and its outcomes are so available that higher probabilities are ascribed to the occurrence of the event. Also, an anchoring process might take place (Fischhoff, 1975a; Fischhoff and Beyth, 1975). Individuals who know that a certain event occurred may look for reasons to adjust the probability of the event downward from 1.00. This will often result in higher probabilities than would have been obtained otherwise. Also, the 'representativeness'-heuristic may lead to biased hindsight estimates (Fischhoff, 1975a). According to this heuristic, an event is judged as more probable to the extent to which it is perceived to have salient features of the class of events to which it belongs. Davies (1987) manipulated the amount of foresight cognitions, and the amount of foresight cognitions individuals had access to in hindsight. In particular the latter factor moderated hindsight bias: individuals who had access to their foresight cognitions expressed less hindsight bias than individuals who hadn't.

Information processing explanations of the hindsight bias phenomenon capitalize on the abilities (and inabilities) of human decision makers. Another class of explanations deals with the way individuals make use of their abilities to achieve certain goals, or to satisfy certain needs.

Motivational explanations focus on the effect of satisfying certain needs on the magnitude of hindsight bias. Two kinds of motivational factors that may be of particular relevance have been distinguished:

(1) motivations to maintain a positive self-image, both privately and publicly,
(2) motivations to understand, to predict, and to control

The first kind of motivations includes, e.g., self-presentational motives (Campbell and Tesser, 1983), and motives related to self-esteem (Leary, 1982). The second kind of motivations includes, e.g., the desire for certainty (Brimm and Hoff, 1957), and the need to know and to be able to predict the environment (see, e.g. Pervin 1970). An additional distinction in relevant motivations can be made. Motivations are not uniformly at one specific level, but can be:

(a) person-related, and/or
(b) decision or situation-related.

Individual difference factors, personality variables, traits, are person-related. Certain individuals may, in general, have a stronger tendency to maintain a positive image in public than others, and may consequently show more hindsight bias. Certain motivations can also be related to the context or situation in which foresight and hindsight estimates are made. For example, a particular situation can give rise to the motivation to present a positive self-image. This may lead to a considerable hindsight bias. Also, for some individuals certain issues or decisions are more related to their self-esteem than other issues. This may also affect the hindsight estimates concerning these issues or decisions. Combining the two distinctions, four basic motivations that can influence the magnitude of hindsight bias can be distinguished (1a to 2b).

In the next sections the attention will be focused on the motivational explanations of the hindsight bias phenomenon. Research with respect to these explanations will be briefly reviewed. The effect of motivations to think on the magnitude of hindsight bias will be elaborated upon. The relationship between the information processing and motivational explanations of hindsight bias will be stressed.

Hindsight bias and self-presentation motives

It can be hypothesized that people who are motivated to hold or present a positive self-image, will show a larger hindsight bias than people who are not or less motivated to do so. When self-presentation

motives are present, people, in order to avoid the thought (by others or themselves) of having been 'wrong', will give hindsight estimates that are more in line with the actual outcomes, than when self-presentation motives are absent. Some research has tested this hypothesis.

Leary (1981) studied the effect of issue-related self-esteem on the magnitude of hindsight bias. On the basis of a median split on the issue related self-esteem measure, the total group of subjects in Leary's (1981) experiment was separated into two subgroups. An Analysis of Variance revealed no significant difference between the two subgroups in the magnitude of hindsight bias. In a second study, Leary (1982) investigated hindsight bias in the context of the 1980-presidential elections. As in the 1981-study, the analysis did not reveal an effect of issue-related self-esteem on the magnitude of hindsight bias.

Synodinos (1986) studied the effect of global self-esteem and political involvement on hindsight bias in the 1982-Hawaiian gubernatorial election. A total of 474 subjects participated in the survey study. Political involvement was measured by (a) summing up the scores on three items reflecting interest, knowledge and importance of the election, and (b) combining the sumscore with a dichotomous variable of voting intentions. The construct validity of this measurement is questionable. Interest, knowledge, and importance can be conceived of as elements of involvement. However, behavioral intentions are not necessarily associated with involvement in an issue (see for relevant results, Petty, Cacioppo and Schumann, 1983). In the Synodinos study, subjects also answered the Rosenberg Global Self-Esteem scale. An Analysis of Variance did not reveal a statistically significant difference in hindsight bias for individuals differing in global self-esteem, or in political involvement.

Campbell and Tesser (1983) investigated the effect of the need for positive self-presentation on hindsight bias regarding general knowledge questions. The need for positive self-presentation was measured with the Marlowe-Crown Social Desirability Scale. Sixty eight subjects participated in the study. The measure of the self-presentation motive was (statistically) significantly, although only to a relatively small extent, related to the magnitude of hindsight bias.

The results of these studies do not provide strong support for the hypothesis that self-presentation motives, either as a trait, or as an issue/decision-specific factor, affect the magnitude of hindsight bias.

Hindsight bias and motives to understand, predict or control

It can be hypothesized that motivations to understand, predict or control affect the magnitude of hindsight bias. Several studies have tested this hypothesis.

In an early study, Walster (1967, p. 239) hypothesized that when '... an outcome event is serious, and one spends very much time thinking about it, one probably becomes especially interested in seeing how the outcome and its antecedents fit together'. As a consequence, the outcome might seem more predictable in hindsight than if one had not thought it through so completely. Walster reasoned that (a) the more serious the outcome of an event is, the more people think about the extent to which the outcomes were predictable, and (b) this increased thinking will lead to more hindsight bias. In her study, subjects were confronted with a description of a person's decision to buy a house. Different groups of subjects had different information as to whether the consequences of the decision had been more or less serious (the amount of money lost or gained). After having heard and read a description of the decision and its outcomes, subjects were asked whether they felt they would have been able to guess whether or not the decision would have had good or bad consequences, just from their knowledge of the situation. The subjects could check one of six alternatives, ranging from the definite guess that the decision would result in a gain in money, to the definite guess that the decision would lead to a loss in money. Analysis of the subects' responses confirmed the hypothesis: the less the gain and the more the loss of the decision, the more likely subjects were to indicate that they would have anticipated loss. Also, subjects became increasingly confident that they would have correctly foreseen an outcome as that outcome increased in importance. The focus in Walster's study was the effect of decision-related motivation to understand on hindsight bias.

In her study, Walster asked the subjects what they would have anticipated before the decision, only after that they read and heard a description of the decision and its outcomes. In other words, subjects in her experiment did not have nor give any estimates in foresight. Subjects were asked the hypothetical question what they would have anticipated in foresight. In that context, manipulating the importance of the outcomes of a decision led, via enhanced thinking about the decision, to an increase in hindsight bias. The question is whether enhanced thinking always leads to increased hindsight bias.

The results of a study by Wood (1978) provide a partial answer. Wood hypothesized that when subjects are asked to make a judgement both prior to and after receiving outcome knowledge, the size of the hindsight bias will be smaller than when subjects are only required to make postoutcome judgments. Subjects who make preoutcome judgments are forced to consider their knowledge state prior to receiving feedback. Possible outcomes of a decision or an event have to be thought of. Giving preoutcome judgments therefore leads to enhanced thinking. As a consequence, individuals may be better able to remember their preoutcome knowledge state and their preoutcome judgments when asked to make postoutcome judgments, resulting in less hindsight bias. Wood (1978) conducted two experiments with respect to a large number of events and facts. The results of his analyses confirmed the hypothesis.

These results indicate that the more people think about a decision (or event) and its possible outcomes before the actual decision is made the less the hindsight bias will be. The less they think about it before the decision is actually made, and the more they think about it after the decision is made, the larger the hindsight bias will be. The effectiveness of the amount of prior thinking is not only a function of ability or motivation factors. The more complex or difficult a decision is, the more thought is required to understand it. So, it can be expected that hindsight bias is also a function of the complexity of the decision. In fact, Wood (1978) found that hindsight bias was larger for difficult than for easy tasks.

Both Walster and Wood manipulated the amount of thinking in their studies. Individual differences in the extent to which individuals want to understand, predict or control were not studied. Research concerning individual difference factors may be of relevance in the present context, since, by definition, such factors are of an enduring nature. They may influence information processing both at the time the foresight estimates are made, and at the time that the hindsight estimates are made, although not necessarily in the same way.

Campbell and Tesser (1983) studied the effect of two personality characteristics related to motivations to understand, predict and control, on hindsight bias. Their analysis revealed that subjects' scores on a Dogmatism Scale and an Intolerance for Ambiguity Scale independently contributed to the prediction of the amount of hindsight bias. Specifically, Campbell and Tesser (1983) found that the higher a person scored on dogmatism, or on intolerance for ambiguity, the larger the hindsight bias was. In discussing their results, Campbell and Tesser (1983, p. 617) remark that the scales used as indicators for the motivation to understand, predict and control are not necessarily the best scales, and that the Need for Cognition Scale could have been used as well. However, although intolerance for ambiguity and dogmatism are conceptually related to need for cognition, they are not equivalent to it. Need for cognition will be introduced in the next section.

Need for cognition

In 1905, Freud already postulated that under certain conditions individuals may develop a generalized and stable tendency to know and to research ('Der Wiss- oder Forschertrieb'). Others have developed similar ideas (see, e.g., Berlyne, 1960). Cohen, Stotland and Wolfe (1955) were the first to investigate systematically this tendency to know and to research. The construct was labeled 'need for cognition'. Recently, Cacioppo and Petty (1982; Cacioppo, Petty and Kao, 1984) have reconceptualized the construct, and have developed an instrument, the need for cognition scale (NCS), to measure it.

Cacioppo and Petty (1982) define need for cognition as the tendency to engage in and enjoy effortful cognitive endeavors. Need for cognition refers to the fact that some people, in general, engage more in thinking than others, and that these people do so because they enjoy to be engaged in thinking.

Need for cognition is not statistically related to test anxiety and social desirability, and it is significantly related to American College Testing Program Exam (ACT) scores (Cacioppo and Petty, 1982, study 2 and 3). Also, need for cognition is significantly related to verbal intelligence (Cacioppo, Petty and Morris, 1983; Cacioppo, Petty, Kao and Rodriguez, 1986). Research reveals that on relevant variables, e.g., recall and self-reported cognitive effort, the effects of need for cognition remain significant when verbal intelligence is statistically controlled for (Cacioppo, Petty, Kao and Rodriguez, 1986). This suggests that need for cognition and intelligence are separable constructs with distinctive effects.

Research in a persuasion context shows that high NCS individuals base their attitudes more on a careful consideration of the arguments contained in a persuasive message than low NCS individuals (Cacioppo, Petty and Morris, 1983). High NCS individuals, in general, use and desire more information than low NCS individuals (Pieters and Verplanken, in press). Also, the consistency between attitudes and expressed behavior is higher for high than for low NCS individuals (Cacioppo, Petty, Kao and Rodriguez, 1986). Petty and Cacioppo (1986) provide an overview of research on the NCS.

Hypotheses about the effect of need for cognition on estimating probabilities can be formulated. Individuals high in need for cognition tend to think more before and when asked to give foresight and hindsight probability estimates, than individuals low in need for cognition. It can be hypothesized that, all other things being equal, high need for cognition individuals will remember their foresight estimates better than low need for cognition individuals do. Consequently, individuals high in need for cognition will express less hindsight bias than individuals low in need for cognition. This hypothesis is in line with Wood's (1978) finding that the more one thinks about an event prior to the event the less hindsight bias is observed. Also, this hypothesis is in line with research on the effects of need for cognition on memory processes. In a study on person memory, Srull, Lichtenstein and Rothbart (1985) found that individuals high in need for cognition recalled more items that were used to describe a person than individuals low in need for cognition.

In the context of hindsight bias, need for cognition is relevant in that it connects the two classes of explanations of hindsight bias that were described in the foregoing: (a) motivation, and (b) information processing. Need for cognition is the tendency to enjoy information processing (Pieters and Verplanken, in press). Contrary to what Campbell and Tesser (1983) imply, need for cognition is not identical to 'dogmatism' or 'intolerance for ambiguity'. In fact, Cacioppo and Petty (1982, study 3) found that dogmatism only weakly and negatively correlates with need for cognition ($r=-.27$, $n=104$, $p<.05$).

In the present study the moderating effect of need for cognition on biases in hindsight estimates was studied in the context of the Chernobyl accident.

METHOD

Data collection

February and March 1986 (T0), a mail survey on risks and benefits of the use of nuclear energy and coal for the generation of electricity in The Netherlands was conducted among 3000 citizens of Leiden (The Netherlands). 2439 usable questionnaires were returned (a net response of 81.3%). April 1986, two months after the mail survey, a malfunction occurred in the nuclear power plant in Chernobyl (USSR), located at a distance of approximately 1500 kilometers from the Dutch border. One of the four nuclear reactors of the Chernobyl power plant exploded. Large quantities of radio-active material were emitted. During several weeks, the level of radio-activity in the Netherlands was significantly higher than

normal. The highest levels of radio-activity were measured on May 3 and 4, 1986. Farmers were ordered to keep the cattle inside the stables. Furthermore, the Dutch government prohibited the consumption of certain vegetables, such as spinach. The events were covered extensively by all media.

October 1986 (T1), five months after the Chernobyl accident, a second survey on electricity generation in The Netherlands was conducted. This wave comprised a face-to-face survey among 212 citizens of Leiden who had participated in the first survey. These citizens were randomly chosen from the sample of participants in the first survey. The mean age of the respondents was 44.9 years (standard deviation 11.2 years); 50.9% of the respondents was male, 49.1% was female. The research reported here is based on the responses of the 212 citizens, who were interviewed both prior to and after the Chernobyl calamity.

Questionnaire

The questionnaire used in both waves of the study comprised questions on a number of aspects of the use of nuclear energy for the generation of electricity. One of the items, at both occasions (T0 and T1), was a belief-statement formulated as follows: '*If in The Netherlands electricity is generated with nuclear energy on a large scale, this can lead to large numbers of casualties (more than one thousand within ten years)*'. 'A large scale' was defined as 30–40% of the electricity supply in The Netherlands (at the moment as well as at the time of the data collection, this percentage is approximately 9%). Subjects were asked to indicate their subjective probability of the occurrence of this consequence on a 9-point scale with verbal labels from 'absent' (0), 'very small' (1), 'small' (2), 'relatively small' (3), 'moderate' (4), 'relatively large' (5), 'large' (6), 'very large' (7), to 'this is sure to happen' (8). This item is referred to as the first foresight estimate (at T0), and the second foresight estimate (at T1).

At T1, about 5 months after the Chernobyl accident, an additional item was included in the questionnaire. Subjects were asked to indicate their *hindsight* estimate of the events described in the foresight estimate. Specifically, this item was formulated as follows: '*Please indicate how large you thought the probability was, before the calamity with the nuclear power plant in Chernobyl, that generating electricity in The Netherlands on a large scale with nuclear energy can lead to large numbers of casualties (more than one thousand within ten years).*'

The scale accompanying this item was identical to the scales of the foresight estimates. In the questonnaire at T1, the (second) foresight and the hindsight estimates were separated from each other by some 20 other belief and attitude statements.

The research design of the study is presented in Exhibit 1. In the figure Y represents the Chernobyl accident, O_i 'a large number of casualties in The Netherlands', X 'the generation of electricity on a large

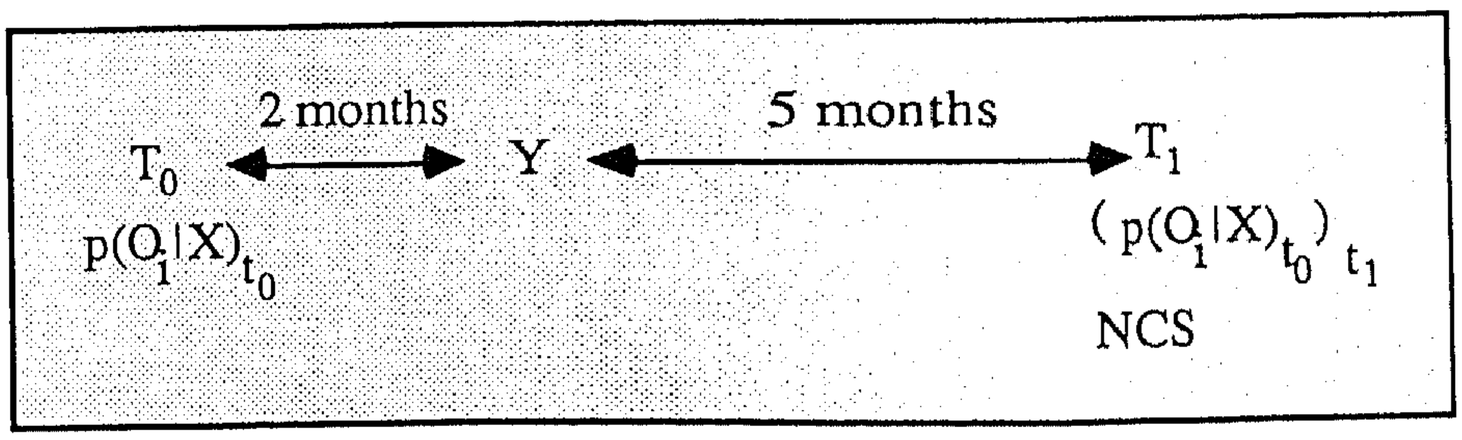

Exhibit 1. Research design with the foresight estimate at T_0 ($p(O_i|X)_{t0}$), the Cherobyl accident (Y), the hindsight estimate at T_1($(p(O_i|X)_{t0})_{t1}$, and the Need for Cognition Scale (NCS)

scale in The Netherlands with the use of nuclear energy', $p(O_i|X)_{t0}$ the first foresight (at T_0), $(p(O_i|X)_{t0})_{t1}$ the hindsight estimate at T_1, and NCS the Need for Cognition Scale.

Note that in most research on hindsight, $p(O_i)$ is asked, where the event X is sure to happen (e.g., a football match) or has happened (e.g., a historical event). Here, the probability of consequences O_i given the occurrence of event X_i was asked, where $p(X_i)$ is set to one. Also note that in standard hindsights studies, the hindsight estimate $(p(O_i|X)_{t0})_{t1}$ is asked after X has occurred. Here, X did not occur. Y did. Also, the time period between first foresight and hindsight measurement is small in most research (ranging from a few minutes to a few weeks; see, e.g., Davies, 1987). Here, the time period between the first foresight and hindsight estimate is seven months.

At T1, six items to measure need for cognition were included in the questionnaire. The six items were selected from the Dutch Need for Cognition Scale (Pieters, Verplanken and Modde, 1987). The six items were the items with the highest item total correlations in the complete scale. Cronbach's alpha of the six items was 0.82. All items were accompanied by 7-point scales ranging from 'totally disagree' (1) to 'totally agree' (7), with a neutral midpoint labeled 'neither disagree nor agree' (4). The scores on the six-items, after recoding the negatively worded items, were counted. The sum was divided by 6 to form a need for cognition index ranging from 1 (low need for cognition), to 7 (high need for cognition).[2]

In order to study the effect of need for cognition on hindsight bias, the total group of subjects was split into three subgroups on the basis of the scores on the need for cognition index. The three-split was performed as close as possible to the 33.3-percentiles in the distribution of need for cognition scores. Individuals scoring in the lower part of the NCS index were labeled low NCS (n=62), while those scoring in the middle and upper part were labeled respectively as medium NCS (n=59) and high NCS (n=91).

Finally, at T1 individuals were asked to indicate how confident they were that their hindsight estimate was consistent with their first foresight estimate. The question was accompanied by a 7-point scale, ranging from 'not at all confident' (1) to 'very confident' (7).

Hypotheses

It was hypothesized that in this context a systematic hindsight bias would occur. Analogous to prior research on hindsight bias, it was expected that in hindsight, individuals would attribute a higher probability to the occurrence of the outcomes than in foresight. Only an analogy is viable here, since contrary to prior research, the event in question (X) did not occur, but a related event (Y) did. Based on the finding that the more serious the consequences are, the larger the hindsight bias is (Walster, 1967), a large bias could be expected here. Based on Wood's (1978) findings that giving estimates both before and after the occurrence of the event attenuates hindsight bias, a small hindsight bias could be expected here. Since (a) the time period between the first foresight and hindsight estimates was relatively long (approximately 7 months) in the present study, and (b) the consequences of the event (Y) were very serious, the overall hindsight bias was expected to be large. The hindsight bias was expected to be in the direction of higher probabilities. Furthermore, it was hypothesized that need for cognition moderates the occurrence of hindsight bias: hindsight bias was expected to be high in the low NCS subgroup, and low or absent in the high NCS subgroup.

RESULTS

Instead of focusing on systematic differences between the means of the first foresight and the hindsight estimates, more detailed analyses on the basis of crosstabulations were performed to test the main hypotheses.[3]

First, a cross-tabulation of the first foresight and the hindsight estimates of the total group of subjects is presented in Table 1. Similar contingency tables were constructed for each of the three NCS subgroups.

hindsight estimate \ foresight estimate	will never happen	very small	small	relatively small	moderate	relatively large	large	very large	sure to happen	
will never happen	1	0	0	0	1	0	0	0	0	2
very small	2	6	9	7	6	3	1	1	0	35
small	1	5	5	5	7	9	2	0	2	36
relatively small	1	12	4	8	10	7	3	4	0	49
moderate	0	0	4	2	8	8	7	1	0	30
relatively large	0	2	1	2	4	3	8	4	4	28
large	0	1	1	1	3	4	4	5	1	20
very large	0	0	1	0	3	3	0	1	3	11
sure to happen	0	0	0	0	0	0	0	0	1	1
	5	26	25	25	42	37	25	16	11	212

Table 1. Crosstabulation of the first foresight and the hindsight estimates for the total sample

If a systematic hindsight bias is completely absent, all individuals are located at the diagonal of the table. If a systematic hindsight bias is present, either more individuals are above than below the diagonal, or the other way around.

Marginal homogeneity

A systematic hindsight bias in the contingency tables is revealed as a statistically significant net difference in the marginals of the two probability estimates, i.e. as a lack of marginal homogeneity. In order to test the hypotheses that (a) hindsight bias occurred, and that (b) need for cognition moderates hindsight bias, Loglinear Analyses were performed on the foresight-by-hindsight contingency tables of the total group, as well as of the three NCS subgroups.

To test for marginal homogeneity, a procedure described in Bishop, Fienberg and Holland (1975, chapter 8) was followed. In this procedure, two models are examined: a symmetry model and a quasi symmetry model. When, in a I × J contingency table (where I = J) m_{ij} represents the expected cell value, the symmetry model assumes that $m_{ij} = m_{ji}$, for all $i \neq j$.

Symmetry implies marginal homogeneity, while marginal homogeneity does not imply symmetry, for $I > 2$. Marginal homogeneity can be examined by testing the difference between the symmetry model

and the so-called quasi symmetry model. The latter does not assume marginal homogeneity. The difference between the two models is tested using the log-likelihood ratio G^2, which is Chi-square distributed.

This procedure was followed for the total group, and for the three NCS subgroups. Since some rows and columns at the extremes of the contingency tables of the three subgroups were empty, the 'will never happen' and 'very small' categories at the one end of the scale, and the 'very large' and 'sure to happen' categories at the other end were collapsed. For reasons of consistency, the same was done in the contingency table of the total group. All subsequent analyses are based on the resulting 7 × 7 contingency tables. The results of the procedure to test for marginal homogeneity are summarized in Table 2a.

Models	total group G^2	df	sign.	NCS low G^2	df	sign.	NCS medium G^2	df	sign.	NCS high G^2	df	sign.
Symmetry	54.1	21		36.1	21		30.9	21		37.6	21	
Quasi symmetry	22.8	15		6.4	15		4.8	15		29.4	15	
Marginal homogeneity	31.3	6	p<.001	29.7	6	p<.001	26.2	6	p<.001	8.3	6	p>.10

Table 2a. Summary of tests for marginal homogeneity on the data of the total sample and of the three need for cognition subgroups

Estimate	low NCS			medium NCS			high NCS		
	fore-sight	hind-sight	diffe-rence	fore-sight	hind-sight	diffe-rence	fore-sight	hind-sight	diffe-rence
absent/very small	6	16	-10	7	10	-3	18	11	7
small	11	16	-5	6	9	-3	8	11	-3
relatively small	8	15	-7	9	19	-10	8	15	-7
moderate	18	3	15	7	5	2	17	22	-5
relatively large	10	8	2	13	10	3	14	10	4
large	3	2	1	10	5	5	12	13	-1
very large/sure to happen	6	2	4	7	1	6	14	9	5

Table 2b. Marginal frequencies of the foresight and hindsight estimates of the low, medium, and high need for cognition individuals

Inspection of Table 2a reveals a consistent hindsight bias for the total group. The statistically significant G^2 shows that, for the total group, there is a lack of marginal homogeneity. Yet, as can be seen at the marginals of Table 1, the direction of the hindsight bias is opposite to what was expected: individuals

gave *lower* hindsight probability estimates than the probability estimates they actually gave in foresight, two months before the Chernobyl accident. Clearly, these results reveal a *reverse hindsight bias*.

As was the case for the total group, marginal homogeneity is not present in the low and medium NCS subgroups. The G^2 of the test for marginal homogeneity is statistically significant for these NCS subgroups. This indicates the hindsight bias effect. As hypothesized, marginal homogeneity is present in the high NCS subgroup, indicated by a statistically non-significant G^2. There is no systematic hindsight bias in the high NCS subgroup. These results confirm the hypothesis that need for cognition moderates hindsight bias.[4] The marginal frequencies of the first foresight and the hindsight estimates of the three NCS subgroups are presented in Table 2b. Note the systematic shift in the estimates of the low and medium NCS subgroups, as indicated by the difference in the marginals.

Literal consistency

The test for marginal homogeneity reveals that high NCS individuals do not express a systematic hindsight bias, while low and medium NCS individuals do. However, this result does not imply that high NCS individuals express a high literal consistency between their first foresight and the hindsight estimates. In the extreme case, the diagonal of the foresight-by-hindsight table of the high NCS individuals could be (almost) empty. This would indicate that, although marginal homogeneity is present, high NCS individuals do not express a higher literal consistency between their first foresight and the hindsight estimates than can be expected on the basis of independence of the two estimates. In other words, marginal homogeneity indicates absence of *systematic* bias, whereas literal consistency indicates the degree of *accuracy* displayed by the individuals.

Research of Srull, Lichtenstein and Rothbart (1985), referred to before, suggests that high NCS individuals may be better able to remember their first foresight estimates than low NCS individuals. In the present research, individuals were asked to recall their first foresight estimate after seven months. With such a long time period, literal consistency between the estimates can not be expected to be very high.

The hypothesis that high NCS individuals express a higher literal consistency between their first foresight and their hindsight estimates than can be expected on the basis of independence, was tested using a z-test for dependent proportions. In the high NCS subgroup 26.4% of the individuals express literal consistency (i.e., a hindsight estimate which is identical to their first foresight estimate). On the basis of independence (marginal frequencies), 14.5% of the high NCS individuals would express literal consistency. Testing this difference results in a z-value of 2.55, which is statistically significant at .05-level. In the medium and low NCS subgroups, respectively, 8.5% and 21.0% of the individuals express literal consistency. Both percentages are not significantly different from independence. The z-values for the medium and low NCS subgroups are, respectively, –1.73 and 1.30. Subsequent analyses reveal that the literal consistency is significantly higher in the high NCS subgroup than in the medium NCS subgroup (z-value = 2.71), but not significantly higher than in the low NCS subgroup (z-value = .77).

At T1, individuals were also asked how confident they were that their hindsight estimate was consistent with their first foresight estimate. An Analysis of Variance revealed that low NCS individuals were less confident than medium and high NCS individuals. The respective means for the low, medium and high NCS subgroups are 4.52, 4.93, and 5.04 ($F=7.04$; $p.<.001$).

These results indicate that high NCS individuals express a higher literal consistency between their first foresight and their hindsight estimates than can be expected on the basis of independence. This is not the case for the medium and low NCS individuals. High NCS individuals express a higher literal consistency than medium NCS individuals, but not than low NCS individuals. Also, high NCS individuals are more confident that their hindsight estimate is consistent with their foresight estimate than low NCS individuals.

CONCLUSIONS AND DISCUSSION

Several conclusions can be drawn from this study.
(a) A systematic reverse hindsight bias is present in the hindsight estimates given five months after the Chernobyl accident, compared with the estimates given in foresight two months before the accident; in hindsight, individuals gave lower probabilities than they did in foresight, which was contrary to expectation;
(b) Need for cognition moderates the occurrence of a systematic hindsight bias; hindsight bias is found for the groups of individuals medium and low in need for cognition; no systematic bias is found in the high need for cognition individuals;
(c) Support is found for the hypothesis that high NCS individuals are better able to remember their first foresight estimate than other individuals.

As was noted before, the research situation in this study was different from the standard research situation on hindsight bias: the probability estimates did not concern outcomes of an event which really took place. The Chernobyl accident was an event which might be *associated* with the consequence which was the target of the estimates, i.e., a large number of casualties due to large scale use of nuclear power in The Netherlands, but actually was a different event. In other words, between giving the first foresight estimates and giving the hindsight estimates, no new information directly pertaining to the event at stake became available, as is the case in the classical hindsight research paradigm. Also, the time period between the first foresight and hindsight estimates was much larger than in standard hindsight bias research. In spite of these differences, a systematic bias in the hindsight estimates was clearly present. When the subjects estimated in hindsight the probability of catastrophical consequences from the use of nuclear energy in The Netherlands, it appeared to be difficult for many of them to neglect the fact that a major accident concerning the same technology had happened in the USSR. In this respect, the results in this study are in line with the results from previous hindsight research.

Practically all research on hindsight bias yields uniform results with respect to the direction of the bias in the probability estimates. Generally, in hindsight, probabilities are in the direction of the outcome of an event, once it has happened. In the present study, a reverse hindsight bias was found: the hindsight probability was lower than the actual foresight estimate. Lower hindsight probabilities of actual outcomes are rarely reported. Guerin (1982) studied the effects of salience and hindsight bias on judgments of the likelihood of real and fictitious world events. In general, he found higher hindsight probabilities for salient events that did occur (e.g., the Russian movement of troops into Afghanistan). However, in one case (the death of John Lennon) he found lower hindsight probabilities. According to Guerin, the salient feature of the latter event was the *unexpectedness* of it. He speculated that the unexpectedness of the event led to a hindsight bias effect in the opposite direction.

When the unexpectedness of an event is salient, processes of contrast might have been involved in giving hindsight probability estimates. One might expect that after the Chernobyl accident many individuals will express a 'that-will-never-happen-here' attitude, a point of view which was frequently expressed in the mass media at the time. However, such an attitude will reveal itself in anything but higher *foresight* probabilities *after* the Chernobyl accident (the second foresight estimate in this study). Between T0, two months before the Chernobyl accident, and T1, five months after the accident, the foresight probability estimate of many casualties associated with the use of nuclear energy in The Netherlands changed: *after* the Chernobyl accident, at T1, the second foresight estimate was (statistically) significantly higher than the first foresight estimate, made two months before the calamity at T0 (a mean shift from 4.03 to 4.70; $F = 23.05$; $p < .001$). The subjective idea of having changed may have resulted into attempts to create a contrast between 'before' and 'after' the Chernobyl accident. If individuals have the feeling that they changed considerably because of the Chernobyl accident, they might have used their present foresight estimate (the second foresight estimate) as an anchor, and

'created' the subjective feeling of change by inadvertently giving lower hindsight probability estimates than their actual foresight estimates made before the Chernobyl accident. In that case, the subjective idea of change may have been considerably larger than the actual change that took place. Further research might address the question, whether unexpected events lead to contrast effects in hindsight estimates, while less unexpected events lead to assimilation into the direction of the outcome, the latter result being the one commonly found in research on hindsight bias.

Janis and Mann (1977) describe 'defensive avoidance' strategies as possible reactions to escape from a decisional conflict in which the decision maker believes that there is no realistic hope that negative consequences can be avoided. One of such strategies is 'bolstering', i.e., exaggerating positive consequences, and minimizing negative consequences. At first sight reverse hindsight bias might well fit into this category of solutions. However, if cognitive restructuring would be based on defensive avoidance strategies in the study reported here, it remains unclear why subjects raised their subjective probabilities of nuclear disasters after Chernobyl, as was revealed by the second foresight estimate at T1. Moreover, a defensive avoidance explanation is less obvious when one considers the relatively high subjective probabilities on negative consequences of nuclear energy as these were given before the Chernobyl accident.

Considering the fact that the object of the probability estimates ('O', i.e., large numbers of casualties), actually did not occur, while subjects rated 'O' in hindsight to be less likely after its non-occurrence, it could be argued that the observed bias is an example of classical hindsight bias, instead of reverse hindsight bias. However, on the basis of the observed increase in foresight subjective probabilities, the conclusion seems valid that subjects did perceive 'O' to have taken place, beit in the USSR instead of in The Netherlands. If this is true, the bias reported here indeed is reverse hindsight bias.[5]

Although the data and results of the present study are clear, the interpretation of the reverse hindsight effect remains somewhat difficult. Unlike much hindsight research in the laboratory, we did not include a control condition that did *not* learn of the Chernobyl accident. In fact, we couldn't. Thus, it is not quite clear what would have happened to the probability estimates if the Chernobyl accident had not occurred. In future research on reverse hindsight bias, the salience and unexpectedness of events could be manipulated and their independent and joint effects on the magnitude and direction of hindsight bias could be observed.

As was hypothesized, the analyses reveal that need for cognition moderates hindsight bias. Individuals high in need for cognition gave probability estimates in hindsight that were more consistent with their prior foresight estimates than individuals low and medium in need for cognition. Where a systematic reverse hindsight bias was obvious for individuals low and medium in need for cognition, this was not the case for the high need for cognition individuals. By definition, individuals high in need for cognition tend to think more both prior to and after the Chernobyl accident than individuals low in need for cognition. It was hypothesized that individuals high in need for cognition remembered the first foresight estimates better, than individuals low in need for cognition do, resulting in less hindsight bias for the former than the latter group. The results of analyses on the amount of literal consistency in the three NCS subgroups support this hypothesis. High NCS individuals expressed a higher literal consistency between their first foresight and their hindsight estimates than other individuals. They were also more confident than low NCS individuals that their hindsight estimate was consistent with their first foresight estimate. The results of the present study indicate that a simple distinction between information processing and motivational explanations of hindsight bias is less fruitful. Certain motivational factors directly relate to information processing, and can explain why some people, under certain conditions, process information in a different way than others. Need for cognition is such a factor.

Knowledge can be gained from the past when people realize that the actual outcomes of events differ from what they expected in foresight. After the fact, people often feel that they know what was going to

happen. Even if it is obvious that they did not, or that they could not. Such a hindsight bias leads to learning sub-optimally from the past. In the present research subjects tended to feel that they had *not* expected an event to occur, which in fact they had expected beforehand. As yet, the generality and implications of this reverse hindsight bias remain to be explored.

The present research addressed two simple questions, i.e., the question whether in the context of the Chernobyl accident a hindsight bias would be present, and whether need for cognition moderates it. Simple questions lead to simple answers. Both answers are 'yes'. Future research could address more complicated questions. Which factors lead to a reverse hindsight bias? Does need for cognition influence the extent to which the foresight estimate is stored in memory, or the extent to which it is retrieved from memory, or both? If the unexpectedness of an event affects the direction of hindsight bias, in which way is need for cognition related to the perception of unexpectedness? The importance of studying the past warrants that questions like these will be addressed in the future.

NOTES

1. The authors thank Peter van der Heijden for his help with the analyses and his insightful comments on an earlier draft.

   An earlier version of this article was presented at the 11th Conference on Subjective Probability, Utility and Decision Making, Cambridge, U.K., August 23–27, 1987, and at the 12th Colloquium of the International Association for Research in Economic Psychology, Arhus, Denmark, September 25–28, 1987.
2. Need for cognition was assessed both at T0 and T1. No statistically significant difference in need for cognition was found between the two measurements ($t=1.62$, $p > .10$). The NCS-index of T1 was used in the subsequent analyses.
3. The mean first foresight estimate was 4.03, and the mean hindsight estimate amounted to 3.39 ($F = 20.92$, $p < .001$), all scales ranging from 0 to 8.
4. These differences cannot be attributed to differences between the three subgroups in their foresight estimates on T0, since these were statistically not significant. ($F=0.71$; n.s.).
5. The question whether the observed bias is standard or reverse, as well as the defensive avoidance argument were suggested by some of our reviewers: we would like to thank them for their contributions in explaining reverse hindsight bias.

REFERENCES

Arkes, H. R., Wortmann, R. L., Saville, P. D. and Harkness, A. R. 'Hindsight bias among physicians weighing the likelihood of diagnoses', *Journal of Applied Psychology*, **66** (1981), 252–254.

Berlyne, D. E. *Conflict, arousal and curiosity*, New York: McGraw-Hill, 1960.

Bishop, Y. M. M., Fienberg, S. E. and Holland, P. *Discrete multivariate analysis: theory and practice*, Cambridge, Mass.: The MIT Press, 1975.

Brim, O. G. and Hoff, D. B. (1957). 'Individual and situational differences in desire for certainty', *Journal of Abnormal and Social Psychology*, **54** (1957), 225–229.

Cacioppo, J. T. and Petty, R. E. 'The need for cognition', *Journal of Personality and Social Psychology*, **42** (1982), 116–131.

Cacioppo, J. T., Petty, R. E. and Kao, C. F. 'The efficient assessment of need for cognition', *Journal of Personality Assessment*, **48** (1984), 306–307.

Cacioppo, J. T., Petty, R. E., Kao, C. F. and Rodriguez, R. 'Central and peripheral routes to persuasion: an individual difference approach', *Journal of Personality and Social Psychology*, **51** (1986), 1032–1043.

Cacioppo, J. T., Petty, R. E. and Morris, K. J. 'Effects of need for cognition on message evaluation, recall, and persuasion', *Journal of Personality and Social Psychology*, **45** (1983), 805–818.

Campbell, J. D. and Tesser, A. 'Motivational interpretations of hindsight bias: an individual difference analysis', *Journal of Personality*, **51** (1983), 605–620.

Cohen, A., Stotland, E. and Wolfe, D. M. 'An experimental investigation of need for cognition', *Journal of Abnormal and Social Psychology*, **51** (1955), 291–297.

Davies, M. F. 'Reduction of hindsight bias by restoration of foresight perspective: effectiveness of foresight-encoding and hindsight retrieval strategies', *Organizational Behavior and Human Decision Processes*, **40** (1987), 50–68.
Fischhoff, B. 'Hindsight ≠ foresight: the effect of outcome knowledge on judgment under uncertainty', *Journal of Experimental Psychology: Human Perception and Performance*, **1** (1975a), 288–299.
Fischhoff, B. 'The silly certainty of hindsight', *Psychology Today*, April (1975b), 71–76.
Fischhoff, B. 'Perceived informativeness of facts', *Journal of Experimental Psychology: Human Perception and Performance*, **3** (1977), 349–358.
Fischhoff, B. 'For those condemned to study the past: heuristics and biases in hindsight', In: D. Kahneman, P. Slovic and A. Tversky (Eds.), *Judgment under uncertainty: heuristics and biases*, Cambridge: Cambridge University Press, 1982.
Fischhoff, B. and Beyth, R. '"I knew it would happen"—remembered probabilities of once-future things', *Organizational Behavior and Human Performance*, **13** (1975), 1–16.
Freud, S. *Drei Abhandlungen zur Sexualtheorie*, Leipzig und Wein: Deuticke, 1905.
Guerin, B. 'Salience and hindsight biases in judgements of world events', *Psychological Reports*, **50** (1982), 411–414.
Hasher, L., Attig, M. S. and Alba, J. W. 'I kew it all along: or, did I?', *Journal of Verbal Learning and Verbal Behavior*, **20** (1981), 89–96.
Janis, I. L. and Mann, L. *Decision making: a psychological analysis of conflict, choice, and commitment*, New York: Free Press, 1977.
Janoff-Bulman, R., Timko, C. and Carli, L. L. 'Cognitive biases in blaming the victim', *Journal of Experimental Social Psychology*, **21** (1985), 161–177.
Leary, M. R. 'The distorted nature of hindsight', *The Journal of Social Psychology*, **115** (1981), 25–29.
Leary, M. R. 'Hindsight distortion and the 1980 presidential election', *Personality and Social Psychology Bulletin*, **8** (1982), 257–263.
Pennington, D. C. 'The British firemen's strike of 1977/78: an investigation of judgements in foresight and hindsight', *British Journal of Social Psychology*, **20** (1981), 89–96.
Pennington, D. C., Rutter, D. R., McKenna, K. and Morley, I. E. 'Estimating the outcome of a pregnancy test: woman's judgments in foresight and hindsight', *British Journal of Social and Clinical Psychology*, **79** (1980), 317–323.
Pervin, L. A. *Personality: theory, assessment and research*, New York: Wiley, 1970.
Petty, R. E. and Cacioppo, J. T. *Communication and persuasion. Central and peripheral routes to attitude change*, New York: Springer Verlag, 1986.
Petty, R. E., Cacioppo, J. T. and Schumann, D. 'Central and peripheral routes to advertising effectiveness: the moderating role of involvement', *Journal of Consumer Research*, **10** (1983), 134–148.
Pieters, R. G. M. and Verplanken, B. 'The joy of thinking about nuclear energy', In: S. Maital (Ed.), *Applied behavioral economics*, London: Wheatsheaf, in press.
Pieters, R. G. M., Verplanken, B. and Modde, J. M. 'Neiging tot nadenken: samenhang met beredeneerd gedrag' ('Need for cognition: the relationship with reasoned action'), *Nederlands Tijdschrift voor de Psychologie*, **42** (1987), 62–70.
Slovic, P. and Fischhoff, B. 'On the psychology of experimental surprises', *Journal of Experimental Psychology: Human Perception and Performance*, **3** (1977), 544–551.
Snyder, M. and Uranovitz, S. W. 'Reconstructing the past: some cognitive consequences of person perception', *Journal of Personality and Social Psychology*, **36** (1978), 941–950.
Srull, T. K., Lichtenstein, M. and Rothbart, M. 'Associative storage and retrieval processes', *Journal of Experimental Psychology: Learning, Memory, and Cognition*, **11** (1985), 316–345.
Synodinos, N. E. 'Hindsight distortion: "I knew-it-all along and I was sure about it"', *Journal of Applied Social Psychology*, **16** (1986), 107–117.
Tversky, A. and Kahneman, D. 'Availability: a heuristic for judging frequency and probability', *Cognitive Psychology*, **5** (1973), 207–232.
Walster, E. 'Second guessing important events', *Human Relations*, **20** (1967), 239–249.
Wood, G. 'The knew-it-all-along effect', *Journal of Experimental Psychology: Human Perception and Performance*, **4** (1978), 345–353.

Authors' biographies
Bas Verplanken works as assistant professor at the Centre for Energy and Environmental Research, Department of Social and Organizational Psychology at Leiden University (The Netherlands). He studied social psychology at the

Leiden University. His research interests are attitude theory, attitude change, risk perception, and risk communication.

Rik Pieters works as assistant professor at the Department of Economics, Erasmus University, Rotterdam (The Netherlands). He studied economic psychology at the universities of Tilburg (The Netherlands), and Augsburg (Germany). His research interests are attitude-behavior relations, environmental behavior, and effects of marketing communication.

Commentary on the Article by Verplanken and Pieters

One of the many positive features of the Verplanken and Pieters paper is that it allows us to examine the hindsight bias in the context of an important event. The study is also provocative in that it forces us to come to grips with the issue of what constitutes normative behavior.

Consider first the fact that the second foresight estimate exceeds the first one. Is this rational or irrational? Since the Chernobyl incident did not produce a large number of casualties (more than 10,000 in ten years), the occurrence of this eventuality given the large-scale adoption of nuclear power by the Netherlands should be rated *less* likely. The total destruction of a Soviet nuclear reactor built with obsolete design and no containment building could produce no more than a couple dozen casualties. Therefore one might predict that modern reactors in the Netherlands would be much less likely to produce 10,000 deaths than someome might have predicted before the Chernobyl incident. Hence the elevated second foresight estimate may be considered irrational.

On the one hand, before the Chernobyl calamity most persons were probably unable to think of a single documented death due to a nuclear accident. Since several deaths did occur due to the Chernobyl incident, shouldn't this heighten the estimated probability that 1,000 deaths might occur? Hence the elevated second foresight estimate may be considered rational.

Now consider the low hindsight estimate. Slovic and Fischhoff (1977) have shown that people claim in hindsight that they would have rated as unlikely those events which have subsequently not occurred. Hence, the Verplanken and Pieters study may be considered a manifestation of the hindsight bias, not the reverse hindsight bias.

However, the second foresight estimate went *up*, suggesting that people thought that a large number of casualties either would take place or perhaps even did take place. Then the low hindsight estimate may be considered a manifestation of the reverse hindsight bias, since it goes in the reverse direction (*down*).

Suppose you were standing next to a respondent to the Verplanken and Pieters survey at T_1. The person turns to you and says, 'I know that you are sophisticated in decision making, since you read *The Journal of Behavioral Decision Making*. I want to respond rationally to these questions, so as a consultant please tell me what ratings to provide these two researchers'.

How would you respond? 'Give the same rating at all three opportunities"? Shouldn't the occurrence of the Chernobyl incident cause a rational person to change one's estimate of the likelihood of a nuclear calamity? To the extent this is so, then the first two estimates must differ. But The Netherlands did not adopt large scale nuclear generation capabilities nor did 1,000 deaths occur. Perhaps the first two estimates should therefore not differ. The life of a consultant is not an easy one.

One rating we might be able to agree upon is that the hindsight estimate should equal the first foresight estimate. Since these subjects failed to provide the same number for these two estimates, we may consider them to be biased. However, the authors may be correct when they state that subjects may have been aware that their second foresight estimate was higher than their first one, and subjects may have tried to lower their hindsight estimate to compensate for this. This purposeful lowering may have resulted in an artificially depressed rating at hindsight. Neither the authors nor I can be certain of this, of course.

What may we conclude?

When examining generalization of the hindsight bias, it is difficult to know whether the to-be-rated event should or should not change in rated likelihood. After all, it did not occur. Some other event did.

REFERENCE

Slovic, P. and Fischhoff, B. (1977). On the psychology of experimental surprises. *Journal of Experimental Psychology: Human Perception and Performance*, 3, 544–551.

Hal R. Arkes
Ohio University, U.S.A.

A second look at hindsight

We were very pleased with Professor Arkes' remarks on our reverse hindsight bias paper. He raises a central point in research on decision making: rationality. Before turning to this issue, several elements of our study should be stressed. First, the task of the respondents actually was to recall what they had told us a few months before. That is, the task was (framed as) a memory task. The analyses showed that, generally, the replies the respondents gave us were different from the ones they had given us a few months before. So, in hindsight, the respondents were *wrong*, irrespective of whether this was rational or not. Second, certain respondents expressed more consistency and less bias between foresight and hindsight estimates than other respondents. The former respondents were high in need for cognition; they tend to think more, and enjoy this more than others. Whether these high need for cognition individuals were more rational, we don't know; but they did perform their task better.

What *was* the rational thing to do? One choice to define rationality is to call people rational if what they do seems sensible under the circumstances. They may also be called rational, if the processes or mechanisms underlying their behavior are sensible. Let us consider the first description, since we only know the 'behaviors' of our respondents (probability estimates). Was it sensible to our respondents to raise their foresight estimate after the Chernobyl accident? Was it sensible to lower their hindsight estimate to such an extent that it actually was lower than the first foresight estimate? And what about the high need for cognition respondents? They expressed no systematic hindsight bias, but raised their foresight estimate. Was that sensible? The results of our study may raise such questions; unfortunately, it cannot answer them. Rachlin (1980) argues, that the question whether or not behavior is sensible (or maximizes utility) should be avoided, and that it is more useful to ask *in what respect* behavior is sensible (i.e., what is maximized). In fact, that is a question of goals, needs, or motives. In our study the respondents differed in their motivation to think and process information, and this difference covaried with expressed reverse highsight bias. Given the framing of our hindsight question, the most sensible answer was to repeat the first foresight estimate. The high need for cognition respondents did so. The low need for cognition respondents did not. These latter respondents might have been sensible with respect to other goals, needs or motives, which we only may guess. Obviously, this is a modest conclusion, but it may be the only one allowed at present.

Further studies on processes and mechanisms underlying probability estimates are needed, in order to be able to judge how sensible such estimates are in a certain context. The importance of such studies is stressed by Niwa's (1987) results, who found that after Chernobyl a sample of nuclear experts from the Atomic Energy Society of Japan gave higher estimates of the occurence of radioactive leaks by accidents and by disasters in nuclear power plants, compared with estimates they gave before the accident. We fully agree with Professor Arkes' sigh that the life of a consultant is difficult. So is the life of a respondent. The question then is *why* their lives are difficult.

REFERENCES

Niwa, F. (1987). *A comparative study of attitudes toward science and technology between experts and non-experts.* Sakura, Ibaraki (Japan): University of Tsukuba.

Rachlin, H. (1980). Economics and behavioral psychology. In: J. E. R. Staddon (Ed.), *Limits to actions.* New York: Academic Press.

Bas Verplanken
Rik Pieters