Accident Analysis and Prevention 51 (2013) 310–317

Contents lists available at SciVerse ScienceDirect

Accident Analysis and Prevention

journal homepage: www.elsevier.com/locate/aap

Effects of the feeling of invulnerability and the feeling of control on motivation to participate in experience-based analysis, by type of risk

Safiétou Mbaye[a,*], Dongo Rémi Kouabenan[b]

[a] Groupe Facteurs Humains, Département Management des Risques Industriels, EDF Recherche et Développement, 1, Avenue du Général de Gaulle, 92141 Clamart Cedex, France
[b] Laboratoire Interuniversitaire de Psychologie, Personnalité, Cognition et Changement Social, UFR SHS, Université Pierre Mendès France-Grenoble 2, BP 47, 38040 Grenoble Cedex 09, France

ARTICLE INFO

Article history:
Received 23 February 2012
Received in revised form
21 November 2012
Accepted 29 November 2012

Keywords:
Experience-based analysis (EBA)
Risk perception
Feeling of invulnerability
Feeling of control
Occupational accidents
Work accidents

ABSTRACT

Experience-based analysis (EBA) refers to a set of safety-management practices consisting of detecting, analyzing, and correcting the individual, material, and organizational causal factors of accidents in order to prevent their reoccurrence. Unfortunately, these practices do not always garner the adherence of employees. This article presents a study that examines the impact of risk perceptions on agents' motivation to participate in EBA in various production sectors. The study was conducted at two sites, a chemical factory and a nuclear power plant, by means of a questionnaire administered to 302 employees. The results indicated that the feeling of control was not only positively linked to the feeling of invulnerability, but that these two factors were negatively linked to risk perception. In addition, the actors in both production sectors were more motivated to participate in EBA of accidents linked to the core processes of their industry (which were more accurately perceived) than in EBA of ordinary accidents (accidents not specific to chemical or nuclear processes). Moreover, the agents' feeling of invulnerability and feeling of control both reduced EBA motivation for ordinary accidents to a greater extent than for chemical and radiation-related accidents. Recommendations are made in view of encouraging agents to get more involved in EBA.

1. Introduction: from risk perception to participation in experience-based analysis of accidents

For some years now, France has seen a drop in work accidents that appears to be due to better knowledge of occupational risks and stricter regulations pertaining to prevention. However, it seems that these changes are more a reflection of modifications in the occupational risks themselves than of improved prevention of accidents on the job (Cuny and Gaillard, 2003). In high-risk industries like those examined in the present study (chemical and nuclear), today's most worrisome safety problems concern ordinary accidents (falls while walking, handling and packing operations, use of tools, etc.) rather than accidents linked to the core processes of these industries (discharge or ejection of chemical substances, poisoning, radioactive contamination, etc.). In matters of prevention, this situation has led to changes not only in terms of risk communication, but also in terms of lessons learned from the analysis of accidents involving company personnel. In this context, a current concern of firms is how to increase their employees' participation in experience-based analysis (EBA) of "ordinary" accidents. "Ideally, after-action reviews should function as forums through which groups can discuss candidly perceptions about regular work operations. Through this communication forum, employees in high-risk environments have the opportunity to learn from recent incidents and retain these lessons for future incidents" (Allen et al., 2010, p. 751). At the industrial sites where we conducted our studies, these forums, also called "safety talks", are held monthly by the managers. Each forum focuses on a particular risk, selected according to the events records within the company or the industrial site. Workers are encouraged to analyze the selected accidental event in order to seek what causes it and to find out ways to prevent such an event in the future.

Unfortunately, EBA – designed to help organizations learn lessons from past accidents or events in order to improve safety at the workplace – does not always seem to rally a large amount of adherence among operators. EBA of ordinary accidents apparently doesn't interest workers much, even though such accidents are becoming more and more common. They tend to consider EBA related to such accidents useless, and tend to be more passive when they are invited to analyze and share their experiences on such risks. The diffuse nature of these accidents, and the fact that the nuclear and chemical industries are immersed in a very strong corporate culture when it comes to radioactive or chemical

* Corresponding author.
E-mail addresses: safietou.c.mbaye@gmail.com (S. Mbaye), remi.kouabenan@upmf-grenoble.fr (D.R. Kouabenan).

0001-4575/$ – see front matter © 2012 Elsevier Ltd. All rights reserved.
http://dx.doi.org/10.1016/j.aap.2012.11.026

hazards, seem to generate a lack of interest whenever EBA of ordinary accidents is at stake. This disinterest may also come from the perceptions that employees in these two sectors have of ordinary risks as compared to risks related to the core processes of their industries (chemical risks or radiation risks). It looks like the workers tend to minimize the usefulness of "safety talks" concerning ordinary accidents because they perceive their consequences on their health as being low, while they tend to maximize the usefulness of forums related to accidents linked to the core processes of their company, the health consequences of which are perceived as high and threatening. Such an attitude could refer to a melioration bias (Herrnstein et al., 1993).

This being the case, it seems important not only to determine how employees in these two production sectors perceive both ordinary risks and core-production risks, but also to examine their feeling of exposure or vulnerability to these different kinds of risks, as well as their perceptions of how much control they have over them. Another plausible hypothesis regarding the lack of interest in EBA could be that perceived vulnerability and perceived control affect people's motivation to participate in EBA. More specifically, might the fact of feeling invulnerable to a risk, or of believing that one has some degree of control over it, cause agents to pay less attention to actions aimed at preventing that risk? These considerations led us to take an interest in the link between risk perception and employee involvement in EBA practices aimed at improving risk identification, management, and prevention.

Research on risk perception looks at how individuals assess the risky situations they encounter. In this area, Kahneman et al. (1982) proposed the idea that probabilistic judgments made by individuals (whether a lay person or an expert) rest on a limited number of heuristics which often allow them to make reasonable judgments, but also sometimes cause their judgments to be erroneous. These authors showed, for example, that individuals exhibit a tendency to perceive events that are likely to affect a large number of people as being more serious than events affecting only a few people.

In matters of communication, it also seems that people generally judge new information to be relevant and full of lessons to be learned, whenever that information agrees with their own prior beliefs. And when the information contradicts their prior knowledge, it is perceived as being uninteresting, erroneous, or even non-representative of the situation being judged (Nisbett and Ross, 1980, cited by Slovic, 1987). In their study, Renn et al. (1992) showed that individual and social perceptions of risk can be amplified or diminished, depending on the mainline thinking in a group. In the same vein, other studies have shown that people are inclined to make judgments that conform to the beliefs conveyed by their group of membership (Dake, 1992; Kouabenan, 2006; Rippl, 2002). In sum, risk assessment is structured "by multiple variables linked either to the nature and dimensions of the risk itself, or to factors related to the individual characteristics of the risk-perceiving subjects" (Kouabenan and Cadet, 2005, p. 68).

In the area of motivation to protect oneself, individual and social perceptions of risk have been shown to be among the most decisive factors in people's dispositions about adopting prevention behaviors. Accordingly, perceived probability, perceived seriousness, and perceived vulnerability are the dimensions of risk perception that appear to have the greatest impact on protection motivation (Weinstein, 1993). In a meta-analysis of 36 studies (n = 15,988) conducted between 1979 and 2004, Brewer et al. (2007) examined the link between risk perception and a health-related behavior (in this case, vaccination against infectious diseases). The results confirmed the effect of the risk's perceived probability on participants' willingness to be vaccinated (r = .26). They also confirmed the positive effects of perceived vulnerability to the risk (r = .24) and perceived seriousness of the risk (r = .16).

However, risk perception does not always cause individuals to adopt safe behaviors, for the simple reason that perceptions can be biased and thereby result in distorted risk assessments (Kouabenan, 2006). Such biases can, for example, lead people to underestimate or overestimate the risks they are facing. Called positive illusions by some (Taylor and Brown, 1994), this type of bias may also correspond to a tendency to expect to experience a greater number of happy life events than unhappy ones in the future (Scheier et al., 1989). Other studies have stressed people's propensity to underestimate certain risks while overestimating others (Rothman et al., 1996).

Our rationale for using the above theoretical approach is the fact that the very process of engaging in an after-event review has been shown to provide a cognitive framework for elaborating experience-based data likely to change the behavior of individuals and improve system performance (Ellis and Davidi, 2005). It follows from this that the purpose of EBA – as a set of practices for detecting, analyzing, and transmitting experience gained from past accidents – is to induce changes in risk-related behaviors. Clearly, then, it is important to better understand how people perceive these risks so as to be able to predict their willingness to engage in EBA (Kouabenan, 2006). We are particularly interested here in discrepancies between people's perceptions of various types of risks, and we will attempt to find out whether the type of risk itself can be a source of differences in commitment to EBA.

We focused on positive beliefs because they are known to influence people's risk perceptions and judgments about their ability to cope with risks (Kouabenan, 2007). Indeed, in the area of protection motivation, such biased beliefs are just as likely to provoke a disinterest in prevention programs, as they are to prompt people to protect themselves (Janoff-Bulman and Frieze, 1983). Scheier et al. (1989), for example, pointed out the beneficial effects of optimism on the recovery of patients who had undergone surgery (coronary artery bypass); we also know that persons who generally expect to succeed in whatever they do apply more effort to attaining their goal than those to expect to fail (Carver et al., 1979). On the other hand, expectations that cause people to underestimate risks can lead to unsuitable behaviors because people do not seem to care much about protecting themselves against events they judge improbable (McKenna, 1993).

It appears in addition that individuals are more optimistic about a risk when they have a strong feeling of control over that risk. Along these lines, McKenna (1993) study of 99 participants (office workers, teachers, and students) showed that when the participants were put in situations where their perceived control was very low, their feeling of invulnerability tended to drop considerably. A meta-analysis by Klein and Helweg-Larsen (2002) of 27 studies conducted between 1980 and 1997 supports these conclusions. The data collected by these two authors showed, as a whole, that optimism was often strongly associated with a feeling of control (r = .31).

These findings suggest that a worker's feeling of invulnerability might be associated with the number of precautions he/she takes to avoid accidents, and led us to hypothesize that workers who take fewer precautions to avoid accidents feel more invulnerable to risks or see themselves as being less exposed than workers who do not (Hypothesis 1). In other words, a feeling of invulnerability may be a factor in failure to engage in EBA practices because it causes people to underestimate risks. We also hypothesized that risks directly related to the company's core production processes would be perceived as greater than risks related to ordinary, everyday accidents (Hypothesis 2).

Another point of interest in this study was whether and to what extent the feeling of invulnerability and the feeling of control have a different impact on motivation to engage in the EBA of accidents related to the agent's main activity or the industry's

core processes (chemical and radiation risks) versus motivation related to ordinary accidents. Given the substantial salience of risks linked to core processes, we expected the interaction between an agent's feeling of control and his/her feeling of invulnerability to have a greater effect on motivation for ordinary-accident EBA than for core-accident EBA. In other words, employees should be more interested in EBA for accidents linked to the core processes of their industry[1] than in EBA for everyday accidents (Hypothesis 3). We also expected the EBA motivation difference between ordinary accidents and core-process accidents to be due to workers' greater feeling of invulnerability to ordinary accidents than to chemical or radiation risks (Hypothesis 4).

In the sections that follow, we will describe the methodology of the study and then present and discuss the results obtained.

2. Methodology

2.1. Study sample

Three hundred and two persons participated in the study, 144 from the chemical industry (47.68% of the study sample) and 158 from the nuclear industry (52.32% of the study sample). All participants were volunteers. They were chosen so as to obtain a representative sample of the population at the sites studied. Their mean age was 41.8 years (*S.D.* = 9.70). The participants were from various occupational areas: 37% worked in maintenance, 32% in production, 17% in risk prevention, 9% in administration, and 6% in quality control. They belonged to various levels in the company hierarchy: 35% were technicians, 30% were foremen, 26% were blue-collar workers, and 8% were in management. The participants' gender was not taken into account due to the very small number of women with risky occupations in this type of industry.

2.2. Materials and procedure

We used a questionnaire derived from the one developed by Kouabenan et al. (2003, 2007) to assess risk perception.[2] The questionnaire had five parts. The four first parts measured the dimensions of risk perception via a list of 14 events (accidents, incidents, diseases) likely to occur at the two sites studied. The events were chosen on the basis of an analysis of the risk typology at each site (e.g., chemical risks: asphyxiation or poisoning; risk of radiation: contamination by radiation; ordinary accidents: injury with hand tool, projection of dust in eyes). The distinction of risk type (typology) is based on the risk classification of the French National Institute for Research and Security (2007). In this way we are able to distinguish risks related to: (1) manipulating chemicals (e.g., projection or inhalation of caustic soda, hydrogen, ammonia), (2) working in a radiological environment (e.g., work in the vicinity of equipment emitting radiation), and (3) doing activities nonspecific to these two industries (e.g., machining of pipes, handling of heavy loads, repairing electrical circuits).

Participants had to use a 6-point Likert-type of scale to rate:

(1) The probability that each of the events listed could happen to them at work, with a rating of 0 for no risk ("*My job doesn't expose me to this risk*"), 1 for "*minimal risk*", and so on up to 5 for "*maximal risk*".
(2) How serious it would be for them to experience each of these events, with a rating of 0 for "*not serious at all*", 1 for "*It wouldn't be very serious if that happened to me*", and so on up to 5 for "*It would be very serious if that happened to me*".
(3) How controllable they thought each event was for them, with a rating of 0 for "This event is totally uncontrollable for me", 1 for "This event is not very controllable for me", and so on up to 5 for "This event is highly controllable for me".
(4) The precautionary measures they took to reduce the probability of each event, with a rating of 0 for "*I take no precautions*", 1 for "*I take very few precautions*", and so on up to 5 for "*I take many precautions*".

The fifth part of the questionnaire measured the agent's feeling of control and feeling of invulnerability on the same scale. Participants had to rate their extent of agreement or disagreement with 12 statements, on a Likert-type scale ranging from 1 ("completely disagree") to 5 ("completely agree"). The scale included feeling-of-control items (e.g., "*I have good personal skills for controlling risks at my workstation*") and feeling-of-invulnerability items (e.g., "*I believe that nothing serious can happen to me at work*").

The questionnaire was administered individually or collectively during work hours. The researchers contacted the participants directly after having obtained the permission of their supervisors. The context and objectives of the study were explained to the employees before they were asked to take part. The participants filled out the questionnaire themselves. Whenever the questionnaire was administered in a group setting, a researcher was always present to prevent the agents from influencing each other. Individual administration was done in the presence of the researcher if the participant requested. Respondents were always debriefed afterwards to ensure that the instructions were well understood, and to talk about any subjects the participant wanted to address. Having this information (in addition to the answers given on the questionnaire) was useful for interpreting the results. The average time taken to fill out the questionnaire was 1 h.

3. Results

All data obtained was analyzed using SPSS version 14.0 software. We first checked the reliability of the scales used to measure risk perception and EBA motivation. Next we conducted correlation analyses to assess the link between the different dimensions of risk perception (probability, seriousness, controllability, precautions, feeling of invulnerability, and feeling of control). Then we compared the means on the risk-perception and EBA-motivation scales, by risk type and production sector. Lastly, we examined the differences between the effects of the feeling of invulnerability and the feeling of control on EBA motivation, by risk type.

3.1. Preliminary data analyses

The risk perception scales had a satisfactory level of internal validity (Cronbach's alpha between .87 and .93), as did the EBA motivation scale (Cronbach's alpha = .92).

Since we used the same scale to measure the feeling of control and the feeling of invulnerability, we conducted a data reduction technique based on Principal Components Analysis to distinguish the two dimensions. The analysis indicated that the scale had three

[1] Chemical accidents for the chemical industry, radiation accidents for the nuclear industry.

[2] In a study on perceived risk of contamination by methicillin-resistant staphylococcus aureus (MRSA) among healthcare personnel in a French university hospital, Kouabenan et al. (2003) designed a questionnaire aimed to grasp perceived risk and assessment of personal vulnerability and the vulnerability of others (co-workers) for a series of 13 hazards likely to occur in an hospital. The originality of this questionnaire is that the authors based their questionnaire of risk perception on risks relevant for the participants by selecting them on the basis of a preliminary analysis of the risks inherent in the worksite studied and then ask the participants to evaluate the probability that each of these hazards might affect them personally while at work, to rate their severity, frequency and assess their controllability and the efforts they made to reduce the occurrence of each risk.

components. The first included four feeling-of-control items and accounted for 20.08% of the variance; the second included four feeling-of-invulnerability items and accounted for 16.87%; the third included three items assumed to measure the feeling of vulnerability (the opposite of the feeling of invulnerability) and explained 11.27% of the variance (see Table 1). Concerning the third component, we realized after the fact that the items in question were more related to a feeling of fatalism (e.g., "*I don't believe one can do good work without ever taking risks*") than to a feeling of vulnerability.

After the Principal Components Analysis, we measured the reliability of the scales for the three components identified. The scale measuring the feeling of control had an acceptable internal reliability level (Cronbach's alpha = .68), as did the scale measuring the feeling of invulnerability (Cronbach's alpha = .60). However, the third component did not have a sufficiently high level of internal reliability (Cronbach's alpha = .33), so it was not included in the rest of the study.

The sections that follow will describe the relationships between these different variables and the validation of our hypotheses.

3.2. Perceived invulnerability and control, motivation to protect oneself, and motivation to participate in EBA

Pearson correlation analyses were conducted to assess the link between the different dimensions of risk perception (see Table 2). They showed that the feeling of control was positively correlated with the feeling of invulnerability ($r = .18$, $p = .001$). In other words, the more the agents thought the risks were controllable, the less vulnerable they felt. The results also showed that the relationship between the feeling of invulnerability and estimated precautions taken was negative ($r = -11$, $p = .055$), which means that the more invulnerable the agents felt they were, the fewer precautions they said they took. This validates Hypothesis 1.

In addition, it turned out that the feeling of control was negatively correlated with the perceived probability of risk ($r = -.12$, $p = .037$), while the relationship between the feeling of control and perceived risk seriousness was nonsignificant. The analyses also showed that the feeling of control was positively associated with perceived controllability ($r = .18$, $p = .002$) and precautions taken ($r = .23$, $p < .001$), and there was a strong correlation between perceived controllability and precautions taken ($r = .62$, $p < .001$). This means that the more the agents felt they were capable of avoiding the occurrence of an accident, the more precautions they said they took.

These findings support the idea that people's inclination to adopt self-protection behaviors is underlain by the feeling of control, while the feeling of invulnerability is negatively correlated with these behaviors. In other words, the greater an agent's feeling of invulnerability, the less motivated he/she is to engage in EBA ($r = -.16$, $p = .005$). By contrast, there was no significant relationship between EBA motivation and the feeling of control ($r = .07$, $p = .262$). We can see that EBA motivation was positively associated with perceived risk probability ($r = .23$, $p < .001$): the greater the perceived probability, the stronger the EBA motivation. The motivation variable was also positively correlated with perceived seriousness ($r = .28$, $p < .001$), perceived controllability ($r = .36$, $p < .001$), and estimated precautions taken ($r = .47$, $p < .001$).

3.3. Effect of risk type on risk perception

We compared the means using matched-group *t*-tests in order to determine whether there were perception differences that depended on the type of risk in each production sector (see Tables 3 and 4).

For the chemical sector, the analysis showed that the agents thought chemical accidents were more probable than ordinary ones ($t(143) = 4.56$, $p < .001$). They also perceived that it would be worst for them to experience a chemical accident than an ordinary accident ($t(143) = 13.13$, $p < .001$). Respondents reported taking more precautions to prevent chemical accidents than to prevent ordinary

Table 1
Data reduction technique based on principal components analysis with varimax rotation of the feeling-of-control and feeling-of-invulnerability scale.

Scale	Feeling of control	Feeling of invulnerability	Feeling of fatalism
I have enough experience to control the risks at my workstation	**.769**	.149	.029
My experience has allowed me to develop a good degree of control over risks at my workstation	**.763**	−.058	.129
I have good personal skills for controlling risks at my workstation	**.674**	−.105	.272
I believe that being careful is all it takes to control risks at one's workstation	**.564**	.128	−.164
I believe that all accidents can be prevented	−.323	.075	.282
I believe that nothing serious can happen to me at work	.101	**.730**	−.123
I've never had a problem so far, so I don't see why I'd have one in the future	−.022	**.691**	−.408
I seldom think about accidents that could happen to me at work	−.159	**.654**	.205
I rarely tell myself that something serious might happen to me at work	.130	**.604**	.070
I don't believe one can do good work without ever taking risks	−.026	−.080	**.706**
I never tell myself that what has to happen will happen	.060	−.049	**.649**
I feel I'm capable of controlling all risks at my workstation	.405	.210	.500

Note. Factor loadings >.50 are in boldface.

Table 2
Descriptive statistics, internal reliability and correlations between feeling of control, feeling of invulnerability, perceived probability, perceived seriousness, perceived controllability, estimated precautions taken, and experience-based analysis motivation.

Variables	*M*	*S.D.*	1	2	3	4	5	6	7
1. Perceived probability	1.86	.70	(.88)						
2. Perceived seriousness	3.25	.87	.28**	(.93)					
3. Perceived controllability	2.67	.89	.21**	.36**	(.90)				
4. Estimated precautions	3.07	.96	.30**	.41**	.62**	(.91)			
5. Feeling of control	3.59	.69	−.12*	.02	.18**	.23**	(.68)		
6. Feeling of invulnerability	2.69	.65	−.26**	−.16**	−.06	−.11*	.18**	(.60)	
7. EBA motivation	2.61	.98	.23**	.28**	.36**	.47**	.07	−.16**	(.92)

Note. Cronbach's Alpha of the different scales are in parentheses.
* $p < .055$.
** $p < .005$.

Table 3
Means, standard deviations and contrast of perceived risk dimensions for chemical sector agents by risk type.

Risk dimension	Chemical risk		Ordinary risk		$t(143)$	P	95% CI	
	M	*S.D.*	*M*	*S.D.*			*LL*	*UL*
Probability	2.49	1.47	2.02	.73	4.56	.001	.27	.68
Seriousness	3.90	1.10	2.91	.81	13.13	.001	−.84	1.14
Controllability	3.16	1.19	3.14	.84	.18	.856	−.15	.18
Precautions	3.86	1.22	3.24	.84	7.89	.001	.47	.78

Note. CI: confidence interval; *LL*: lower limit; *UL*: upper limit.

ones ($t(143) = 7.90$, $p < .001$). And they did not perceive chemical risks as being more controllable than ordinary risks ($t(143) = .18$, $p = .856$).

In the nuclear sector, the agents felt they were more likely to be confronted with a risk of radiation than with an ordinary risk ($t(157) = 9.34$, $p < .001$), which again obviously goes against statistical data. They perceived ordinary risks as being less serious than radiation risks ($t(157) = 7.18$, $p < .001$), which seems theoretically true for radiation catastrophes but is in fact false according to available statistics. The agents judged the risk of radiation to be more controllable than ordinary risks ($t(157) = 4.55$, $p < .001$), and they reported taking more precautions to avoid contamination by radiation than to avoid ordinary accidents ($t(157) = 11.89$, $p < .001$). In line with Hypothesis 2, risks directly linked to core processes were perceived as greater (more salient) than ordinary risks.

3.4. Effects of risk type and production sector on motivation to participate in EBA practices

We compared the scores of the actors in the chemical and nuclear sectors on the three scales measuring EBA motivation. The hypothesis was tested using a 2×3 design. The production sector was Factor A (independent variable 1); it had two categories, *a1* for the chemical sector and *a2* for the nuclear sector. The type of EBA was Factor B (independent variable 2); it had three categories, *b1* for EBA of chemical accidents, *b2* for EBA of radioactive contamination, and *b3* for EBA of ordinary accidents. The average amount of motivation to participate in the different types of EBA was the dependent variable. We conducted a *t*-test for dependent sample to analyze the effect of the "EBA type" on EBA motivation for each production sector, and an analysis of variance to test the effect of the "production sector" on the EBA motivation.

In the chemical sector, EBA of chemical accidents elicited more interest among agents than EBA of ordinary accidents ($t(143) = 9.45$, $p < .001$). In the nuclear sector, the difference of means was also significant: nuclear-plant agents were more motivated for EBA of radioactive contamination than for EBA of ordinary accidents ($t(157) = 9.23$, $p < .001$). Also, chemical workers were more motivated for EBA of chemical accidents than for EBA of radioactive contamination ($t(143) = 8.28$, $p < .001$), and nuclear workers were more interested in radioactive contamination EBA than in EBA of chemical accidents ($t(157) = 8.16$, $p < .001$). The results also indicated that chemical-sector agents were not more interested in radioactive-contamination EBA than in ordinary-accident EBA ($t(143) = 1.41$, $p = .161$), and nuclear-sector agents were not more motivated for chemical-accident EBA than for ordinary-accident EBA ($t(157) = .12$, $p = .908$). In line with Hypothesis 3, EBA motivation regarding accidents directly linked to core processes was significantly greater than motivation regarding the other types of EBA.

In order to further describe the production-sector effect on each type of EBA, we used an analysis of variance to compare the means obtained by each group on the different motivation scales (see Table 5). The comparisons indicated a production-sector effect on agent motivation only for EBA of contamination by radiation ($F(1,300) = 23.38$, $p < .001$, 95% CI [2.56, 2.93], $n^2 = .072$). The agents in the nuclear sector were more motivated than those in the chemical sector to participate in EBA of radioactive contamination. There is also an EBA motivation difference between the employees in the nuclear and chemical firms. The agents in the chemical sector were more motivated than those in the nuclear sector to participate in EBA of chemical accidents ($F(1,300) = 55.40$, $p < .001$, 95% CI [2.74, 3.05], $n^2 = .156$).

On the other hand, there was no difference in EBA motivation for ordinary accidents between the agents in the two sectors.

3.5. Effect of the feeling of invulnerability and the feeling of control on EBA motivation, by type of risk

Here we tested the hypothesis that the effects of the feeling of invulnerability and the feeling of control are greater on motivation to participate in EBA of ordinary accidents than in EBA of accidents linked to the core processes of the industry. To validate this hypothesis, we looked at the main effects and interactions of the factors "feeling of invulnerability" and "feeling of control" on each type of EBA, i.e., chemical-accident EBA, ordinary-accident EBA, and radioactive-contamination EBA. The independent variables were the mean scores on the feeling-of-invulnerability scale (Factor A) and on the feeling-of-control scale (Factor B). The dependent variables were the mean EBA motivation scores for chemical accidents, radioactive contamination, and ordinary accidents.

A multivariate analysis of variance was conducted to check for differences between the effects of Factors A and B on motivation to engage in the three types of EBA (see Table 6). The analysis indicated no main effect of the feeling of control on chemical-accident EBA motivation ($p = .419$). The main effects of the feeling of

Table 4
Means, standard deviations and contrast of perceived risk dimensions for nuclear sector agents by risk type.

Risk dimension	Risk type				$t(157)$	P	95% CI	
	Radiation		Ordinary				*LL*	*UL*
	M	*S.D.*	*M*	*S.D.*				
Probability	2.66	1.42	1.81	.68	9.34	.001	.67	1.03
Seriousness	3.38	1.38	2.75	.85	7.18	.001	.46	.81
Controllability	3.11	1.45	2.69	.94	4.55	.001	.24	.61
Precautions	4.02	1.36	2.84	.96	11.89	.001	.99	1.38

Note. CI: confidence interval; *LL*: lower limit; *UL*: upper limit.

Table 5
Comparison of means on the experience-based analysis motivation scales, by production sector.

EBA motivation	Chemical sector ($n = 144$)	Nuclear sector ($n = 158$)	F (1,300)	p	95% CI	n^2
	M (SD)	M (SD)				
Radiation accidents	2.28 (1.81)	3.20 (1.49)	23.38	.001	[2.56, 2.93]	.072
Chemical accidents	3.49 (1.39)	2.30 (1.40)	55.40	.001	[2.74, 2.93]	.156
Ordinary accidents	2.49 (.97)	2.29 (.97)	3.31	.070	[2.28, 2.50]	.011

Note. CI: confidence interval.

control on motivation for radioactive-contamination EBA ($p = .140$) and ordinary-accident EBA, ($p = .378$), were not significant either. Likewise, the feeling of invulnerability did not have a significant main effect on motivation for ordinary-accident EBA ($p = .692$). Nor was there a feeling-of-invulnerability effect on motivation for contamination-by-radiation EBA ($p = .358$). In contrast, the feeling of invulnerability did have a significant main effect on motivation for chemical-accident EBA ($F(15,176) = 2.51$, $p = .002$, 95% CI [2.51, 3.21], $n^2 = .116$), the agents were less inclined to engage in this type of EBA when their feeling of invulnerability was high than when it was low.

The analysis of the interaction between the feelings of invulnerability and control on motivation for EBA of chemical accidents showed that it was not significant ($p = .738$). The interaction between these two factors on motivation for EBA of contamination by radiation was also nonsignificant ($p = .714$). By contrast, the interaction between these two factors and motivation for ordinary-accident EBA was significant ($F(93,176) = 1.35$, $p = .046$, 95% CI [2.26, 2.52], $n^2 = .416$). In other words, the impact of the feeling of invulnerability on EBA motivation for ordinary accidents increased as the feeling of control over these risks increased. This finding validates Hypothesis 4 whereby the EBA motivation difference between ordinary accidents and core-process accidents is due to workers' greater feeling of invulnerability to ordinary accidents than to chemical and radioactive risks.

4. Discussion and conclusion

The results of the present study confirm the effect of risk type on workers' motivation to participate in EBA. They also point out just how salient occupational hazards are as compared to other sources of risk, which is a clear demonstration that people's perceptions and attitudes about risks are closely tied to the risks' subjective characteristics (Slovic et al., 1982). In addition, our results are consistent with Van der Schaaf and Kanse, 2004 study showing that risk acceptance in the case of events perceived as minor is one of the principal reasons mentioned by individuals to explain their lack of interest in incident reporting. What stands out from our study is that agents judge risks independently of their true frequency. Indeed, on both of the industrial sites studied, the most frequent accidents were not linked to risks the agents feared the most. For example, at the chemical factory, an analysis of the types of accidents that actually occurred within the past three years showed that out of 55 accidents reported to the employees' occupational health insurance, only one accident was related to the manipulation of chemicals while 27 were due to moving around in the plant (falls while walking, falls from height, and handling operations). During the same period at that same site, out of the 14 accidents that triggered a sick leave, none had anything to do with chemical products. Here again, more injuries occurred during moving around, which caused 11 sick-leave accidents out of a total of 14 reported accidents. In other words, the employees' attention, or more specifically their EBA motivation, was directed first at accidents that were rare but had dreaded consequences. Indeed, falls while walking and object-handling accidents were much more frequent and relatively less serious than accidental exposure to radioactivity and chemicals (sodium hydroxide burns, asphyxiation, and poisoning). Such perceptions could thus explain why EBA regarding these risks does not motivate employees as much.

These results are consistent with earlier studies on the social amplification of risks (Kasperson et al., 1988; Renn et al., 1992). Clearly, EBA brings into play not only the value systems of the agents in an organization but also the regulatory and technical measures constructed socially in view of modifying risk representations, and in the end, of changing their behavior. The process thus rests on the assumption that adoption of a metacognitive or reflective attitude about accident situations generates operating modes that are more in keeping with the requirements of the activity in question (Ivancic and Hesketh, 2000). In high-risk organizations like those in the nuclear-power and chemical industries, this approach has been introduced in order to create and maintain a very high degree of reliability (Rasmussen, 1990). The events generally taken into account are the ones linked to risks directly related to the core activities of the trade, which are an intrinsic source of

Table 6
Test for the effects of the feeling of control (FoC) and the feeling of invulnerability (FoI) on motivation to participate in the different types of experience-based analysis.

Source of variation	Dependent variable	Type III of sum of squares	df	Mean of squares	F	p	n^2
FoC	Chemical EBA motivation	40.29	17	2.37	1.04	.419	.058
	Radiation EBA motivation	67.72	17	3.98	1.39	.140	.077
	Ordinary EBA motivation	17.32	17	1.02	1.08	.378	.060
FoI	Chemical EBA motivation	80.24	15	5.35	2.51	.002	.116
	Radiation EBA motivation	48.01	15	3.20	1.10	.358	.054
	Ordinary EBA motivation	10.52	15	.70	.73	.757	.037
FoC × FoI	Chemical EBA motivation	179.16	93	1.92	.89	.738	.319
	Radiation EBA motivation	247.54	93	2.66	.90	.714	.322
	Ordinary EBA motivation	107.87	93	1.16	1.35	.046	.416
Error	Chemical EBA motivation	382.23	176	2.17			
	Radiation EBA motivation	521.23	176	2.96			
	Ordinary EBA motivation	151.53	176	.86			
Total	Chemical EBA motivation	3172.35	302				
	Radiation EBA motivation	3192.02	302				
	Ordinary EBA motivation	2004.48	302				

major catastrophes. Conversely, EBA of ordinary work accidents or incidents of everyday life looks more closely at events of a smaller scope, ones located within a given company that affect only those employees who are involved.

In this context, it is not surprising to find that accidents linked to a firm's core processes elicit more interest than ordinary accidents do. Accordingly, we think that the difference between interest in EBA of accidents directly linked to core processes and EBA of ordinary accidents reflects an imbalance between the "reliability culture" and the "safety culture" of these organizations. In this view, risk perception by employees in the nuclear and chemical sectors reflects the system of values reigning in their company in matters of safety. It follows that if we want employees to get as involved in ordinary-accident EBA as in core-process EBA, then these values must be readjusted to attain a better balance. One way to do so would be to make improving employees' perceptions of ordinary or everyday accidents a top priority in safety management, on a par with those of accidents linked to core processes. To begin, employees should be informed not only about whether such accidents are increasing in number, but also about the losses they will incur for the organization, for example, in terms of workdays lost due to temporary partial invalidity, disorganization of work and production, potential financial losses, etc. Mainly, statistical data of actual accidents in the companies would be useful to help demonstrate that this type of accidents is more frequent than workers imagine and that they could have severe consequences for their health as well. Indeed, to increase employees' involvement in ordinary-accident EBA, it would be helpful to inform them of the harmful consequences of this type of accident for themselves and for their co-coworkers. And knowing that people are more motivated to protect themselves when they feel vulnerable, employees' awareness of their vulnerability to these risks should be raised (Martin et al., 2009; Weinstein et al., 1986). In this direction, examples of such accidents and their causes should be given to employees to show them that such accidents could happen to anybody. Furthermore, a recent study by Fugas et al. (2012) showed that workers proactive safety behaviors, such as making suggestions to improve safety or acting to prevent the recurrence of previous incidents, are more influenced by supervisors' "descriptive safety norms" (e.g.: supervisors discuss with employees how to improve safety, teach them to identify safety problems, etc.) than by supervisors' "injunctive safety norms" ($r = .33$ versus $r = .18$). With respect to these results, it could be helpful for supervisors to share the underlying issues of common accidents with workers in order to allow them to gradually grasp the practical usefulness and necessity of EBA related to ordinary accidents.

Another important finding of the present study is the tight link observed between perceived vulnerability and motivation to take precautions on the job. We found, for instance, that the more invulnerable to risks the employees felt they were, the less inclined they were to take precautions. Fully consistent with this, we also noted that the feeling of invulnerability had a significant effect on EBA motivation, in such a way that the greater the agents' feeling of invulnerability, the less motivated they were to participate in EBA. Conversely, we saw that EBA motivation was usually positively linked to risk perception (perceived probability and seriousness), perceived controllability over risks, and precautions taken to avoid them. In addition, the feeling of invulnerability was found to have an increasingly greater effect on motivation for ordinary-accident EBA as the feeling of control over this type of accident rose. Moreover, not only was the feeling of control positively correlated with the feeling of invulnerability, both were negatively linked to risk perception. In other words, low involvement in ordinary-accident EBA might be due to low perceived vulnerability to these risks added to a very strong feeling of control over them, no doubt erroneously since these accidents continue to increase in number (illusion of control). It thus seems important in campaigns aimed at raising involvement in experience-based analysis of such accidents, both to insist on employees' perceived vulnerability to this type of risk, and to stress this illusion of control and its possible consequences in terms of safety. One way to achieve that could be to make employees aware of their own exposure to these risks and to show them ways to cope with or to prevent them.

As shown, the results of our study are of great importance for safety management in high risk industries like those investigated. But with regards to the low value of certain correlations between variables and the low effects of some of our results, we may be cautious regarding their generalizability. Indeed as can be seen, some correlations between the risk perception dimensions are low, although the scales had a satisfactory level of internal validity. This could be due to the diversity and numerous variables characterizing the people and activities of the two industries investigated even if most of them could be comparable. One way to solve this problem could be to replicate this kind of study separately in each industry by only considering the risks specific to this sector and better control the characteristics of the participants. In order to generalize these results, it also could be beneficial to replicate this study in other industrial sectors such as construction and transport where there are also a great number of specific and ordinary accidents.

Acknowledgements

This work was funded by the FonCSI (Foundation for a Culture of Industrial Safety).

References

Allen, J.A., Baran, B.E., Scott, C.W., 2010. After-action reviews: a venue for the promotion of safety climate. Accident Analysis and Prevention 42, 750–757.
Brewer, N.T., Gibbons, F.X., Gerrard, M., McCaul, K.D., Weinstein, N.D., 2007. Meta-analysis of the relationship between risk perception and health behavior: the example of vaccination. Health Psychology 26 (2), 136–145.
Carver, C.S., Blaney, P.H., Scheier, M.F., 1979. Focus of attention, chronic expectancy, and responses to a feared stimulus. Journal of Personality and Social Psychology 37 (7), 1186–1195.
Cuny, X., Gaillard, I., 2003. Les risques professionnels aujourd'hui: problèmes actuels, perspectives et orientations méthodologiques. In: Kouabenan, D.R., Dubois, M. (Eds.), Les Risques Professionnels: Evolution des Approches. Nouvelles Perspectives, Editions Octarès, Toulouse, pp. 25–36.
Dake, K., 1992. Myths of nature: culture and the social construction of risk. Journal of Social Issues 48 (4), 21–37.
Ellis, S., Davidi, I., 2005. After-event reviews: drawing lessons from successful and failed experience. Journal of Applied Psychology 90 (5), 857–871.
Fugas, C.S., Silva, S.A., Melia, J.L., 2012. Another look at safety climate and safety behavior: deepening the cognitive and social mediator mechanisms. Accident Analysis and Prevention 45, 468–477.
Herrnstein, R.J., Loewenstein, G.F., Prelec, D., Vaughan Jr., W., 1993. Utility maximization and melioration: internalities in individual choice. Journal of Behaviour Decision Making 6, 149–185.
Ivancic, K., Hesketh, B., 2000. Learning from errors in a driving simulation: effects on driving skill and self-confidence. Ergonomics 43 (12), 1966–1984.
Janoff-Bulman, R., Frieze, I.H., 1983. A theoretical perspective for understanding reactions to victimization. Journal of Social Issues 39 (2), 1–17.
Kahneman, D., Slovic, P., Tversky, A., 1982. Judgment Under Uncertainty: Heuristics and Biases. Cambridge University Press, Cambridge.
Kasperson, R.E., Renn, O., Slovic, P., Brown, H.S., Emel, J., Goble, R., Kasperson, J.X., Ratrick, S., 1988. The social amplification of risk: a conceptual framework. Risk Analysis 8 (2), 177–187.
Klein, C.T.F., Helweg-Larsen, M., 2002. Perceived control and the optimistic bias: a meta-analytic review. Psychology and Health 17 (4), 437–446.
Kouabenan, D.R., 2006. Des croyan ces aux comportements de protection – 2e Partie: Quels Apports des Etudes sur la Perception des Risques au Diagnostic de Sécurité et aux Actions de Prévention? In: Kouabenan, D.R., Cadet, B., Hermand, D., Muñoz Sastre, M.T. (Eds.), Psychologie du Risque: Identifier, Evaluer, Prévenir. De Boeck, Bruxelles, pp. 259–289.
Kouabenan, D.R., 2007. Décision, perception du risque et sécurité. In: Bernaud, J.L., Lemoine, C. (Eds.), Traité de Psychologie du Travail et des Organisations. Dunod, Paris, pp. 285–327.
Kouabenan, D.R., Cadet, B., 2005. Risk evaluation and accident analysis. Advanced Psychological Research 36, 61–80.
Kouabenan, D.R., Desrichard, O., Dubois, M., de Gaudemaris, R., Mallaret, M.R., Scarnato, F., 2003. Du diagnostic épidémiologique à la perception des risques de

contamination par le SAMR (staphylocoque doré) en milieu hospitalier. In: Kouabenan, D.R., Dubois, M. (Eds.), Les Risques Professionnels: Evolution des Approches. Nouvelles Perspectives, Editions Octarès, Toulouse, pp. 87–104.
Kouabenan, D.R., Dubois, M., Scarnato, F., De Gaudemaris, R., Mallaret, M.R., 2007. Methicillin-resistant *Staphylococcus aureus* risk perception by healthcare personnel in a public hospital. Social Behaviour and Personality 35 (1), 89–100.
Martin, W.E., Martin, I.M., Kent, B., 2009. The role of risk perceptions in the risk mitigation process: The case of wildfire in high risk communities. Journal of Environment Management 91 (2), 489–498.
McKenna, F.P., 1993. It won't happen to me: unrealistic optimism or illusion of control? British Journal of Psychology 84 (1), 39–50.
Nisbett, R., Ross, L., 1980. Human inference: strategies and shortcomings of social judgment. Prentice-Hall, Englewood Cliffs, New Jersey.
Institut National de Recherche et de Sécurité, (2007). Evaluation des risques professionnels. Retrieved from http://www.inrs.fr/actus/tableauMP84.html (15. 09. 07).
Rasmussen, J., 1990. Learning from experience? How? Some research issues in industrial risk management. In: Leplat, J., Terssac, G.D. (Eds.), Les Facteurs Humains de la Fiabilité dans les Systèmes Complexes. Edition Octarès Entreprise, Marseille, pp. 359–383.
Renn, O., Burns, W.J., Kasperson, J.X., Kasperson, R.E., Slovic, P., 1992. The social amplification of risk: theoretical foundations and empirical applications. Journal of Social Issues 48 (4), 137–160.
Rippl, S., 2002. Cultural theory and risk perception: a proposal for a better measurement. Journal of Risk Research. 5 (2), 147–165.
Rothman, A.J., Klein, W.M., Weinstein, N.D., 1996. Absolute and relative biases in estimations of personal risk. Journal of Applied Social Psychology 26 (14), 1213–1236.
Scheier, M.F., Magovern Sr., G.J., Abbott, R.A., Matthews, K.A., Owens, J.F., Lefebvre, R.C., Carver, C.S., 1989. Dispositional optimism and recovery from coronary artery bypass surgery: the beneficial effects on physical and psychological well-being. Journal of Personality and Social Psychology 57 (6), 1024–1040.
Slovic, P., 1987. Perception of risk. Science 236 (4799), 280–285.
Slovic, P., Fischhoff, B., Lichtenstein, S., 1982. Facts versus fears: understanding perceived risk. In: Kahneman, D., Slovic, P., Tversky, A. (Eds.), Judgment Under Uncertainty: Heuristics and Biases. Cambridge University Press, Cambridge, pp. 463–492.
Taylor, S.E., Brown, J.D., 1994. Positive illusions and well-being revisited: separating fact from fiction. Psychological Bulletin 116 (1), 21–27.
Van der Schaaf, T., Kanse, L., 2004. Biases in incident reporting databases: an empirical study in the chemical process industry. Saf. Sci. 42 (1), 57–67.
Weinstein, N.D., 1993. Testing four competing theories of Health-Protective Behavior. Health Psychology 12 (4), 333–424.
Weinstein, N.D., Grubb, P.D., Vautier, J.S., 1986. Increasing automobile seat belt use: an intervention emphasizing risk susceptibility. Journal of Applied Psychology 71 (2), 285–290.