The tragic 1996 Everest expedition: a tale of error culture

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Error occurrence cannot be fully eliminated. A strict differentiation between errors and their consequences is used to (a) discuss error prevention and error management, and (b) to show how organisations can promote an error mastery culture that combines the best of both. This article uses two 1996 Everest expeditions as an illustration of what can go wrong in complex high-risk systems. The point of this article, however, is not restricted to high-risk industries. A mastery error culture aims at control of negative error consequences – most relevant in high-risk industries – but also fosters positive error consequences needed for adaptation and innovation. The article discusses both general and recent empirical literature on safety, quality and error handling. (*Netherlands Journal of Psychology*, 65, 22-34.)

'I know the mountain [Everest] is an environment so extreme there is no room for mistakes.' (Breashears, 1997, p. 124)

Over the years, more than 150 climbers (one for every 30 attempting to climb it, or one for every five who have reached the summit) have died on Mount Everest. The leaders of the two expeditions that are discussed here – Adventure Consultant's founder Rob Hall and Mountain Madness's founder Scott Fischer (see Table 1 for an overview) – were both highly respected climbers. Yet, the summit bid of the two expeditions, both departing from Camp IV around midnight on 9/10 May 1996, had extremely tragic outcomes: after sunset 17 climbers were still somewhere high up the mountain. Both expedition leaders, a guide, and two clients died. Four narrowly escaped death.

This article discusses the importance of differentiating errors and related concepts. Doing so helps in raising awareness of the advantages and disadvantages of two dominant approaches to error: error prevention and error management. I then propose how organisations can benefit from the advantages of both. The case of Everest is illustrative here.

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Table 1	Composition of Adventure Consultants and Mountain Madness expeditions.	
Adventure Consultants		**Mountain Madness**
Rob Hall	Founder & leading guide	Scott Fischer
Mike Groom	Head guide	Anatoli Boukreev
Andy Harris	Guide	Neal Beidleman
Ang	Climbing sirdar (sherpa leader)	Lopsang
John Krakauer	Journalist/client	Sandy Hill Pittman
Doug Hansen	Client	Charlotte Fox
Beck Weathers	Client	Tim Madsen
Yasuko Namba	Client	Pete Schoening
Stuart Hutchison	Client	Klev Schoening
Frank Fischbeck	Client	Lene Gammelgaard
Lou Kasische	Client	Martin Adams
John Taske	Client	Dale Kruse
Belief system/Culture		
Legalist approach: emphasis on rules. Belief that rules can reduce bad decision making. Compliance to leader's decisions. Independent action discouraged.		Situationalist approach: belief that rules cannot cover every possible risky situation. Emphasis on adequate handling of problems as they arise. Emphasis on personal responsibility, self-reliance and dealing with consequences.
Yet, as it turned out, some important rules had not been discussed in the Adventure Consultants expedition.		Yet, in the Mountain Madness expedition, there were unrealistic ideas about the expedition's ability to prevent errors, resulting in nonchalance. In practice, self-reliance was not stimulated.
Illustrating quotes from expeditions		
'For safety's sake, the guide always calls the shots.'		'Personally I looked with concern upon the closely regimented expeditions where the clients performed as tin soldiers. [..] I felt it was important to encourage independent action.'
'We had been specifically indoctrinated not to question our guide's judgment.'		'[...] I'm gonna make all the right choices. When accidents happen, I think it's always human error. So that's what I want to eliminate.'

Complex systems and errors

Complex systems (e.g., air traffic control, nuclear power plants and Everest expeditions) are characterised by different elements that interact in ways that cannot be predicted beforehand, and where faults in one part cannot easily be isolated from the rest of the system (Roberto, 2002). A minor slip up in a complex system can therefore result in a domino effect where one faulty aspect triggers others. High Reliability Organisations (HROs) are organisations that have been able to operate accident-free in such systems. Research on HROs focuses on understanding the reasons why some organisations are able to avert accidents while others are not. A flexible, learning-oriented culture with an emphasis on communication is one of the characteristics of HROs (Pool, 1997; Roberts & Bea, 2001).

Culture is all the more important as safety does not linearly follow from design and maintenance. Adding safety measures and procedures

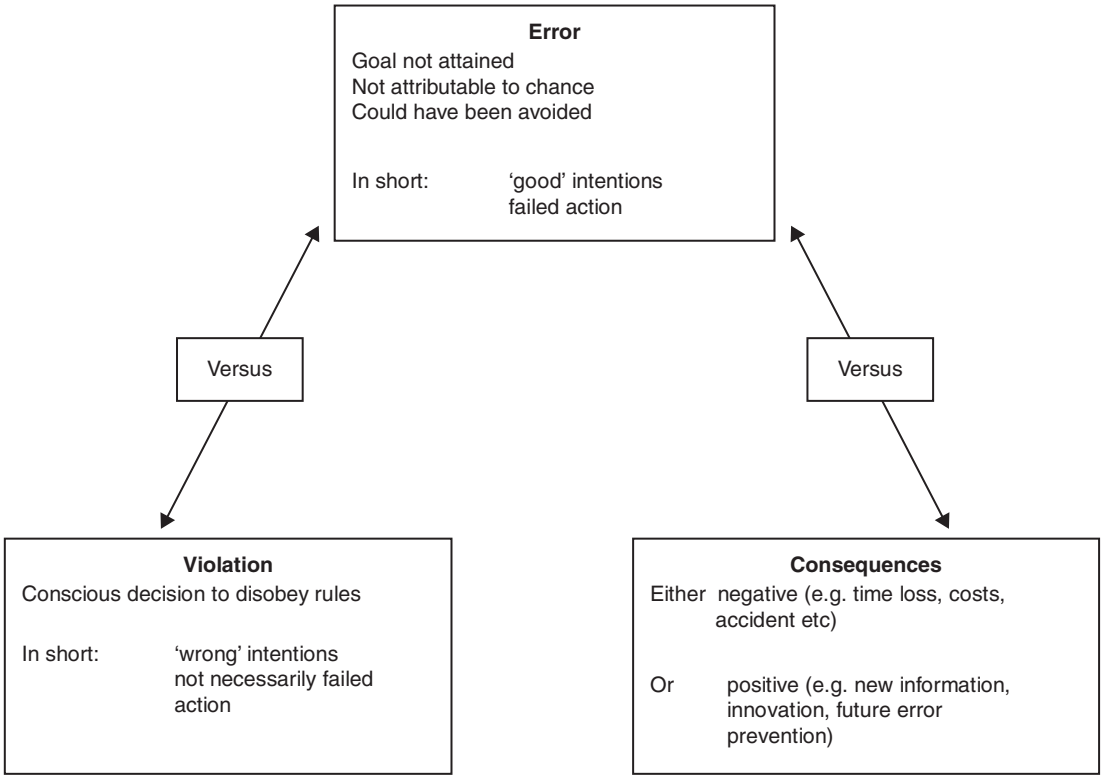

Figure 1
Errors and related concepts.

may seem like a good solution for dealing with complex systems, but this approach may actually backfire. It increases the system's complexity and creates more ways for something to go wrong (Perrow, 1999; Wildavsky, 1988). Organisation members have to be aware of the possibility of an accident. This means that they have to be trained in fault detection and handling. But training is not enough either. One of the key factors for reliability in complex, high-risk systems is the organisational culture (Klein, Bigley & Roberts, 1995; Weick, 1987). Beliefs, norms and assumptions form the core of organisational culture. This often tacit belief system directs reinforcement and thereby behaviour (Schein, 2004).

One of the problems with errors is that they are often confused with related concepts, such as error consequences and violations (Figure 1). If errors, consequences and violations are confused, the organisational belief system and other levels of culture will reflect this confusion. Below, I argue why that is undesirable for organisations. I argue how a clear distinction helps organisations to achieve a mastery error culture that allows them to both promote control of negative error consequences and foster positive consequences through learning (cf Sitkin, Sutcliffe, & Schroeder, 1994).

Whether or not errors have (severe) negative consequences tells us nothing about the severity of the error itself. As a matter of fact, there is no such thing as a severe error. The *same error* may have a variety of – minor or serious – *consequences*, depending on the situation, or system one is working in.[1] Turning a valve in the wrong direction may, when adjusting one's heating system at home, not even be considered worth mentioning. Consider the same error when a client of the Adventure Consultants expedition had to await ascending climbers before he himself could descend: 'Harris [one of Adventure Consultants guides], who had left the summit shortly after I did, soon pulled up behind me. Wanting to conserve whatever oxygen remained in my tank, I asked him to reach inside my backpack and turn off the valve of my regulator, which he did. For the next few minutes I felt surprisingly good. My head cleared. I actually seemed less tired than I had with the gas turned on. Then, abruptly, I sensed that I was suffocating. My vision dimmed and my head began to spin. I was on the brink of losing consciousness. Instead of turning my oxygen off, Harris [...] had mistakenly cranked the valve open to full flow, draining the tank.' (Krakauer, 1997, p. 8).

A second distinction is that between an error and a violation. In most – if not all – cases, disas-

1 That there is no such thing as a severe error does not imply that any one error is similar to the next. Actually, various error taxonomies exist that have helped researchers as well as practitioners to understand error-prone situations, and develop systems to prevent and/or correct errors (see for example Rasmussen, 1982; Zapf, Brodbeck, Frese, Peters, & Prümper, 1992).

ters are not caused by errors alone. Usually violations are important contributors as well. Errors and violations are similar in the sense that they both involve planned behaviour and goals. Yet, while an error implies a wrong plan or wrong implementation of a plan, a violation implies a conscious decision to ignore rules. Further, an error by definition implies the non-attainment of a (sub)goal (Frese & Zapf, 1994; Reason, 1990). This is not the case for violations. An action that is prohibited by rules may still result in goal attainment: Crossing a red traffic light may still be associated with the driver's goal of quickly going from A to B. Thus, while errors involve good intentions that were not executed properly, violations involve forbidden actions that may work out fine nonetheless.

The differentiation between errors and their consequences implies that we should not rate (lack of) company performance by the amount of errors. Rather, there should be a focus on control of negative consequences and learning. Edmondson, for example, demonstrated in a medical setting that the number of errors reported was positively associated with team performance (Edmonson, 1996). High performing teams were characterised by an open climate in which people felt safe enough to report errors. Reporting and discussing errors allows quick rectification and learning. Through these mechanisms, it is hypothesised, the teams outperform teams with a less open climate.

Similarly, high reliability is sometimes described as the absence of error occurrence.[2] Yet, from the same research it has become clear that errors occur even in HROs. What makes HROs highly reliable is not so much the absence of errors, but rather the absence of accidents. HROs are thus capable of averting negative error consequences. Pool (1997, p. 260-261) describes this focus on a highly reliable aircraft carrier: '[...] the crew members act as a team, each doing his job and watching what others are doing [...] [a] constant flow of communication helps catch mistakes before they have caused any damage.'

In a survey among 380 respondents from 65 Dutch organisations, and a replication including 47 German organisations, we assessed ways in which people within the organisation, rather than the individual respondent, typically react to error occurrence (Van Dyck, Frese, Baer & Sonnentag, 2005). In line with research findings in HROs, we found that open communication, error analysis, and emphasis on quick and effective error correction was associated with higher company performance. Similarly, Hofmann and Mark (2005) established that these constructive error handling behaviours were associated with lower levels of adverse outcomes in hospitals.

In both surveys (Van Dyck et al., 2005) we specifically assessed error management behaviour in organisations. Error management is based on the understanding that, no matter how hard one tries, one cannot prevent all errors (Garud, Nayyar & Shapira, 1999; Reason, 1997). Error management explicitly differentiates errors and their consequences (Frese, 1991). More important than avoiding error is avoiding its negative consequences. Error management is thus 'lenient' in the sense that it accepts error occurrence, yet the approach stresses the importance of taking errors seriously and dealing with them. Error management is aimed at avoiding or reducing negative error consequences, and at learning from errors. The latter is what conceptually links the approach to error prevention: Learning from errors that have occurred (error management) helps to prevent similar errors in the future.

The point is not so much that error management and error prevention are mutually exclusive, nor that one approach is superior to the other. Organisations need to focus on both prevention and management. This can only be achieved, however, if there is a shared understanding that error occurrence can not be eradicated, and that error occurrence does not *automatically* lead to severe consequences.

Error aversion and error mastery are two extremes of a continuum of error cultures. In an error aversion culture, there is so much fear of error occurrence that people do not even want to think about the possibility of errors. In such a culture errors are not discussed, or are even covered up, making it hard to correct and learn. In an error mastery culture it is accepted that error occurrence can not be eliminated, but at the same time errors are taken seriously and dealt with actively. There is a focus on detection, correction, communication and learning (Table 2).

In eight organisations from our survey we held additional in-depth interviews with 16 managers (Van Dyck et al., 2005). In organisations with an error mastery culture, the belief system was aligned with open communication, error analysis, correction and learning (e.g., 'We try to be open and discuss errors, because we believe that is the only way to control damage.' and 'I have spoken to the responsible manager, and have asked him to use this incident as a learning opportunity in his department.'). These interviewed managers expressed low emphasis on punishment and low fear of error occurrence. Managers offered notably more explicit viewpoints on why their organisation focussed on these values (e.g., '[otherwise] people will get frustrated and fearful, they will be less open [...] and therefore errors will be discovered later.'). Further, these managers specifically addressed the differentiation between errors, conse-

2 *E.g. Pool (1997, p. 258) where HROs defined as 'groups that seem to do the impossible: operate highly complex systems essentially without mistakes' and p. 258 'They must do their jobs without mistakes, or at least without the sort of mistakes that have catastrophic consequences' and 'they must try a high-stake strategy of 'trial without error.' See also Weick (1987).*

Table 2	The different layers of error aversion and error mastery culture.
Error aversion culture	**Error mastery culture**
Fear of errors Rigid focus on error prevention	Realistic focus on error prevention Combined with focus on error management
Deepest layer: examples of beliefs	
Errors are a sign of incompetence We don't make mistakes	To err is human The important thing is good error handling Errors offer learning opportunities
Middle layer: examples of reinforcements	
Punishment of error occurrence	Rewarding constructive error handling
Superficial layer: examples of error behaviour	
Strain caused by errors Covering up	Detection, correction, learning Open communication
Illustrating quotes from our research	
'But I don't want to discuss errors at great length. [...] I indicated that it shouldn't happen again and that was the end of it.'	'I have spoken to the responsible manager, and have asked him to use this incident as a learning opportunity in his department.'

quences, and violations (e.g., 'I told him that he shouldn't feel guilty that it went wrong. The point is that when something goes wrong, the mistake is dealt with as well as possible. And that's what he did very well. So I complimented him on that.'). The following quote from an error aversion culture, in contrast, shows how management treats people as if they purposely make mistakes, thus confusing errors with violations: 'The workers have to put a stamp with their identification code on their work [...]. But they're even smarter, they just don't put down their code, so that we don't know who made the mistake. [...] We're now thinking about installing cameras.' (Van Dyck et al., 2005).

The 1996 Everest expeditions offer a vivid example of a summation of errors in a complex system. I focus on the role of error culture in the expeditions. Several weaknesses can be identified in both expeditions. The two expeditions, their respective cultures and the unfolding of events on top of the world's highest mountain serve as concrete illustrations of theory relevant for high reliability. I generalise from control of severe negative consequences in high-risk activities to fostering positive error consequences, most relevant for activities that require adaptation and innovation. Recent empirical findings and practical implications are discussed.

Error culture on Everest

In the years preceding the 1996 spring expeditions, Everest had become increasingly popular. In 1996, some 300 people (climbers as well as supporting staff) resided at Base Camp. In total, no less than 15 expeditions, 12 non-commercial and three commercial expeditions, attempted to reach the summit. Commercial expeditions imply working with clients whose climbing expertise, physical health and ability to cope in extreme situations are unknown. Guiding clients up the mountain, some of whom substantively lack experience, therefore makes any prediction of the success rate nearly impossible.

The two expeditions considered in this article – Adventure Consultants and Mountain Madness – had quite different leadership styles and cultures (for an overview see Table 1). 'The differences between Hall's and Fischer's philosophies of guiding were emblematic of an ongoing debate between practitioners in the adventure travel industry. The camps of belief can be roughly divided between the so-called situationalists and legalists. The situationalists argue that in leading a risky adventure, no system of rules can adequately cover every situation that might arise, and they argue that rules on some occasions should be subordinated to unique demands that present themselves. The legalists, believing that rules can substantially reduce the possibility of bad decision making, ask that per-

sonal freedom take a backseat.' (Boukreev & De Walt, 1997, p.155).

I do not believe that Hall and Fischer were either legalists or situationalists in the strictest sense. Yet, Hall leaned more towards the legalist approach which implies, among other things, primarily a focus on error prevention. Fischer was closer to the situationalists approach, with more emphasis on error management. This approach of the Mountain Madness expedition was strengthened by the beliefs of one of its guides: 'As a Russian, Boukreev came from a tough, proud, hardscrabble climbing culture that did not believe in coddling the weak. He was quite outspoken in his belief that it was a mistake for guides to pamper their clients. 'If a client cannot climb Everest without big help from guide,' Boukreev told me, 'this client should not be on Everest. Otherwise there can be big problems up high.[sic]' (Krakauer, 1997, p.149-150). Yet, the following quote from expedition leader Fischer illustrates an unrealistic view with regard to error occurrence: '[...] I'm gonna make all the right choices. When accidents happen, I think it's always human error. So that's what I want to eliminate.' (Kraukaer, 1997, p. 65). As the following illustrates, this hubris was characteristic of the somewhat nonchalant error culture of the Mountain Madness expedition.

The summit attempt and what went wrong

The expeditions departed from Camp IV around midnight on 9/10 May. All members carried two oxygen canisters; a third canister for each of them was stashed at the South Summit to be picked up en route. With normal use, each canister provides oxygen for about six hours. This meant that no one was to return to Camp IV later than 18.00 hours. It is therefore common practice to set a strict turn-around time. Hall had lectured his clients repeatedly on the importance of a predetermined turn-around time: 'With enough determination, any bloody idiot can get up this hill. The trick is to get back down alive' (Rob Hall cited in Krakauer, 1997, p. 147). The turn-around time of the Adventure Consultants was going to be either 13.00 or 14.00 hours. Hall, according to Krakauer, never actually decided on the turn-around time: 'We were simply left with a vaguely articulated understanding that Hall would withhold making a final decision until summit day, after assessing the weather and other factors, and would then personally take responsibility for turning everyone around at the proper hour.' (Krakauer, 1997, p. 177).

Gammelgaard, a Mountain Madness client, said: 'I never heard anything whatsoever about a turn-around time on summit day.' (Boukreev & De Walt, 1997, p. 168). Indeed, Fischer never set a definite turn-around time either. 'Instead, he had worked out [...] a simple strategy, an adaptation of the tactic he'd been using throughout the expedition. His climbing sirdar, Lopsang [...], and his guides, Boukreev and Beidleman, would alternately lead; he would bring up the rear, and as he overtook stragglers, he would turn them around. If problems arose, he would establish radio contact with Lopsang [...], who, it was assumed, would always be at or near the front of the pack. Neither Beidleman nor Boukreev were issued with a radio.' (Boukreev & De Walt, 1997, p. 168). As it turned out, however, Lopsang was never at the front. For reasons that have not become fully clear even afterwards, he short-roped client Hill Pittman. This tactic, which is something like pulling someone up the mountain, drained his energy. It also meant that he was at the rear and not the front, unable to keep the agreement with Adventure Consultant's sirdar Ang on cooperatively roping the steeper sections above Camp IV. Ang, who was upset that he would have to make up for Lopsang's absence, refused to work on the ropes above the Balcony. Krakauer recalls: 'When Ang [...] and I first arrived at the Balcony at 05.30 hours, we were more than an hour in front of the rest of Hall's group. At that point we could have easily gone ahead to install the ropes. But Rob [Hall] had explicitly forbidden me to go ahead, and Lopsang was still far below, short-roping Pittman, so there was nobody to accompany Ang [...].' (Krakauer, 1997, p. 174-175). 'Whatever motivated him, Lopsang's decision to tow a client up the mountain didn't seem like a particularly serious mistake at the time. But it would end up being one of the many little things – a slow accrual, compounding steadily and imperceptibly toward critical mass.' (Krakauer, 1997, p. 170).

A bottleneck arose. Four of Hall's clients decided to turn around, figuring that with the fatigue they already experienced and the late hour, they would be unable to reach the summit and descend in time. Doug Hansen, also a client of Adventure Consultants, decided to turn around as well. 'Then Rob [Hall], who was bringing up the rear, caught up to Doug, and a brief conversation ensued. Nobody overheard the dialogue, so there is no way of knowing what was said, but the upshot was that Doug got back in line and continued his ascent.' (Krakauer, 1997, p. 165).

Just before the Hillary step – one of the most famous pitches in mountaineering, 40 feet of near-vertical ice and rock – further delays in rope fixing arose. Less than half of the intended route to be fixed was covered '[...] leaving [...] the most exposed part of the climb where the climbers had to perform a pretty precarious solo traverse where a slip could be fatal.' (Martin Adams cited in Boukreev & De Walt, 1997, p.170).

Finally, between ten to forty-five minutes after 13.00 hours, the first climbers (Boukreev, Krakauer, Harris, Beidleman, and Schoening) reached the summit. Other climbers were still going up well after 14.00 hours, some arriving at 14.15 but only descending after 15.10, some arriving even later than 15.30 or 16.00, thereby seri-

ously violating the turn-around times (had they been set). Most climbers had picked up, and started using, their third and last canister of oxygen on the way up, arriving at the summit with only a few hours of oxygen left. As guide Boukreev, then still on the way up, recalls: '[...] there on the South Summit, I began to wonder again where Scott [Fischer] was. Here, I thought, maybe it would be necessary to turn some clients around, but there was no Scott to do it. I felt I did not have the right to make this decision. The clients had paid big money and had given Scott that authority, not me.' (Boukreev & De Walt, 1997, p.167). As Boukreev was not issued a radio, he could not consult with Fischer.

Upon the mistake with the valve of the oxygen regulator, described earlier, Krakauer had to wait for an hour at the top of the Hillary step before he could descend. When he finally reached the South Summit, he was eager to screw on a new canister of oxygen. Guide Harris, however, stated that all canisters were empty. In reality they were not, it was (as Krakauer learned only after the expedition has ended) merely Harris's regulator that was frosted, due to which it registered all canisters to be empty. Harris, however, could not be convinced. 'In hindsight, Andy [Harris] was acting irrationally and had plainly slipped well beyond routine hypoxia, but I was so mentally impeded at the time myself that it simply didn't register. [...] Given what unfolded over the hours that followed, the ease with which I abdicated responsibility – my utter failure to consider that Andy might be in trouble – was a lapse that's likely to haunt me for the rest of my life.' (Krakauer, 1997, p. 188). Krakauer's description of events is indicative of low error awareness and detection as a manifestation of the expedition's culture as he says: 'My inability to discern the obvious was exaggerated to some degree by the guide-client protocol. Andy and I were very similar in terms of physical ability and technical expertise; had we been climbing together in a non-guided situation as equal partners, it's inconceivable to me that I would have neglected to recognise his plight. But on this expedition he had been cast in the role of invincible guide, there to look after me and the other clients; we had been specifically indoctrinated not to question our guide's judgement.' (Krakauer, 1997, p. 188).

Somewhat lower on the mountain, Krakauer ran into Adventure Consultants client Weathers, who had, due to eye surgery some years earlier, almost completely lost his vision in the low barometric pressure. Weathers had, several hours earlier, agreed that he would wait for Hall to return from the summit and descend with him. Krakauer offered to lead Weathers to Camp IV, but Weathers declined. A bad decision in retrospect. 'Beck [Weathers] was nearly persuaded when I made the mistake of mentioning that Mike Groom [a guide] was on his way down with Yasuko [Namba], a few minutes behind me. In a day of many mistakes, this would turn out one of the larger ones.' (Krakauer, 1997, p. 191).

Only Boukreev, Krakauer, Adams, and those who had turned around on the morning of 10 May, made it back to Camp IV before 19.00 hours. Daylight had gone and a fierce storm broke loose. At 16.30 Doug Hansen, the client who had been convinced by Hall to continue the ascent, had collapsed and was in need of oxygen above the South Summit. Hall stayed there to help Hansen. The night was setting in. Hall and Hansen were too high up on the mountain to be rescued, especially during the heavy storm that ensued. The people at Base Camp strongly urged Hall over the radio to descend, or to at least descend to the South Summit to pick up extra canisters of oxygen. Guide Andy Harris, however, repeatedly intervened with his own radio, stating his earlier conviction that all oxygen canisters were empty. This may well have contributed to Hall's decision not to move. At 16.45 hours on 11 May, Hall radioed that Hansen 'was gone' (leaving aside whether Hansen had wandered off or had died). By this time, Hall himself was unable to move. He died on the evening of 11 May.

Guide Harris was also somewhere high up on the mountain, as was Fischer. At 20.00 hours the batteries of the Mountain Madness radios ran out. It is unclear what exactly happened to Harris, he never returned. On 11 May, Lopsang attempted a courageous rescue of Fischer, but Fischer was too far-gone, not responding at all to the oxygen and tea offered.

Meanwhile, during the evening of 10 May, several members got lost not far from Camp IV. The storm severely reduced visibility, and the tracks from the ascent were erased by the wind. Groom, Namba, Adams, Beidleman, Schoening, Madsen, Fox, Hillman Pitt, Weathers and two Sherpa's mistakenly wandered east instead of west. The group lost all orientation and got onto the Tibetan (instead of Nepalese) side of the mountain.

Guide Boukreev had been, earlier that day, one of the first to leave the summit. When he met Fischer, who then was still ascending, Boukreev proposed that he would descend quickly, in order to regain strength possibly needed later. Fischer agreed. Several people have criticised Boukreev's decision to 'abandon' his clients. Boukreev's rationale, however, is persuasive. 'I said to Scott [Fischer] that the ascent seemed to be going slowly and that I was concerned that descending climbers could possibly run out of oxygen before their return to Camp IV. I explained I wanted to descend as quickly as possible to Camp IV in order to warm myself and gather a supply of hot drink and oxygen in the event I might need to go back up the mountain to assist descending climbers. Scott [Fischer], as had Rob Hall immediately before him, said 'OK' to this plan. I felt comfortable with the decision, knowing that four Sherpa's, Neal Beidleman (a guide like me), Rob Hall, and Scott Fischer would be bringing up the rear to sweep the cli-

ents to Camp IV.' (Boukreev & De Walt, 1997, p.249).

As it turned out, Boukreev was the only one who was able to rescue climbers. The clients that had returned were totally exhausted. Some Sherpa's, who had not summited in order to assist if an emergency were to arise, were incapacitated with carbon monoxide poisoning from cooking in a poorly ventilated tent.

Boukreev's first rescue attempt was fruitless. He could not locate the wandering climbers. Then, at 00.45 hours Beidleman, Groom, Gammelgaard, Schoening and two Sherpa's arrived at Camp IV. Being lost on the South Col, Schoening [a Mountain Madness client] had pulled himself together: '[...] his attitude was, 'Okay, no panic, no fear, no disaster. What can we do about the situation?'(Gammelgaard cited in Boukreev & De Walt, 1997, p. 206). Schoening was able to lead the stronger members of the lost group to Camp IV. Boukreev was given directions on where to find the others. At 04.30 Boukreev brought back Fox, Madsen and Hill Pittman to Camp IV. Namba and Weathers were (presumed) dead.

On the morning of May 11, after spending a night unconscious lying face-down in the snow, Weathers miraculously walked into Camp IV. '[...] I could see that his pile jacket was open down to his stomach, his eyes were swollen shut, and his arm was locked upright, parallel to his shoulder like a low-budget horror flick. His face was so badly frostbitten that he was unrecognisable. Then I realised it had to be Beck [Weathers].' (Henry Todd cited in Coburn, 1997, p. 176). The next day, at Camp IV, he is left for dead the second time, but again, revived. Upon treatment in a hospital Weathers lost an arm and several fingers, but survived. Looking back, he commented: 'I don't think the doctor who looked at me should be faulted for declaring me dead, or close to dead. It may not have been the best diagnosis, but we all make mistakes at times, even at sea level.' (Beck Weathers cited in Coburn, 1997 p. 200).

'What we can do now is contribute to a clearer understanding of what happened that day on Everest in the hope that the lessons to be learned will reduce the risk for others who, like us, take on the challenge of the mountains.'

(Letter written by Boukreev printed in Boukreev & De Walt, 1997, p. 251.)

The summit attempt and why it went wrong

A summation of errors and violations contributed to the 1996 Everest disaster. Roberto (2002) argues in his analysis of the Everest tragedy that besides cognitive biases and systems complexity (see above), the group climate was not optimal in either of the two expeditions. Self-reliance was discouraged, as was questioning the guides' decisions. In such a group climate it is hard to avert faulty decisions. Neither of the two expeditions had a very strong or very explicit error culture. Neither of the expeditions turned out to be optimally prepared to prevent problems or to avert their consequences. Adventure Consultant's inclination towards an error aversion culture, in combination with leader Hall's straying from his own rules, and the hypoxia of guide Harris, left the team with an inability to deal with the unexpected.

Hall focused on setting rules. He did not allow clients to go far ahead of the rest of the group. He was a leader who usually worked with a strict turn-around time. Referring to another expedition that had, earlier that spring, turned around just an hour before the summit, Hall had said: 'To turn around that close to the summit ... That showed incredibly good judgement [...]. I'm impressed – considerably more impressed, actually, than if he'd continued climbing and made the top.' (Rob Hall cited in Krakauer, 1997, p. 147) Yet, for the 1996 summit bid, he did not set a turn-around time, he expressed disappointment when some of his clients turned around before reaching the summit, and he even persuaded one client not to turn around but to continue for the summit. The reason for his uncharacteristic actions remains unclear. Possibly he wanted to bring more clients to the top than Fischer would. Possibly his thinking was impaired by hypoxia. Possibly both. In any event, his clients had, throughout the previous weeks, been conditioned to rely on rules and their guides rather than on their own judgement. On summit day, rules were not set, or were unclear, guides were absent or impaired with hypoxia. The clients were on their own.

A client of Mountain Madness ultimately led the stronger of the wandering clients from both expeditions (and an Adventure Consultant guide) back to Camp IV. A Mountain Madness guide — Boukreev — saved those who were left behind. The Mountain Madness sirdar — Lopsang — saved the leader of the Taiwanese expedition. Yet, the Mountain Madness culture, with its inclination towards the situationalist approach, was not perfect either. Both Fischer and Lopsang were already exhausted when the summit bid began. Only two radios were issued (to Fischer and Lopsang) leaving guides Boukreev and Beidleman without one. It was therefore impossible to make a proper assertion of the situation and the needs high on the mountain. There was no possibility to communicate strategies between the guides, leading guide and sirdar. Further, an informal, yet influential hierarchy between leader and guides inflated Boukreev's and especially Beidleman's authority to make crucial decisions (Roberto, 2002).

The most explicit choice for a mastery approach was Boukreev's harshly criticised decision to descend ahead of the others (Boukreev & De Walt, 1997; Krakauer, 1997). As described above, this enabled him to assist expedition members who were in trouble. When leading a

commercial Everest expedition one year later, he enforced a culture of self-reliance rather than obedience, and of coaching rather than leading. This successful 1997 expedition to Everest was organised in such a way that previous errors could be avoided and problems could be handled (Boukreev & De Walt, 1997, epilogue). He made it very clear that he was willing to serve as a guide, give advice, be a member of a rescue team if so needed, but he stressed that the clients would have to take some responsibility for the hubris of their ambition. Boukreev would act as a coach, not as an authoritarian leader. Research on HROs in army settings such as flight deck carriers shows that the organisation's ability to flexibly switch between strong hierarchy under normal conditions to encouragement of input by lower levels ('speaking up') under more risky circumstances (e.g., combat, launching and landing on the deck) is a crucial characteristic of HROs. This is in line with findings on team work in both aviation and the operating theatre. These settings are also characterised by a strong hierarchy, but the outstanding teams allow the juniors to speak up to the leader – if this enhances safety.

Further, radios were issued to all climbers and guides. Boukreev's successful approach in 1997 and the expedition's culture he explicitly enforced may have been the right answer. He may have been able to implement a true mastery error culture.

Errors and what can be learned: an update on the literature

The 1996 Everest tragedy shows that in spite of the quote at the kick-off of this article, errors occur even in high-risk situations. Several lines of research discussed above have offered insights on how high-risk environments can be dealt with. The role of organisational error culture is crucial here. But error culture is also important for organisations not active in a high-risk industries. It is important to note that errors are not only threatening, but offer opportunities as well. That is, besides the differentiation between errors and their consequences per se, it is important to keep in mind that errors can yield both negative and positive consequences. There are various examples of errors that have led to great innovations. The accidental development of penicillin is probably the most well-known example (for other examples see Jones & O'Brien, 1991). Especially in organisations where competitive advantage is gained by being innovative, a mastery error culture can help create positive error consequences.

The literature on learning organisations has defined learning as detection and correction of error (Argyris, 1992). In Argyris's view error should be embraced. That is exactly what is done in error training: Participants are encouraged to make mistakes during skill acquisition. It is stressed that error occurrence is not bad, nor is it something to be ashamed about. Rather, it is pointed out that errors can provide useful information and may help develop new ideas and strategies. Participants in error training outperform those in traditional and error avoidant training settings. This effect is even larger in more difficult tasks taken on after the training has ended (for a meta-analysis see Keith & Frese, 2008).

A recent study was explicitly aimed at investigating the independent roles of reward structure and error culture. This is important, as error culture and reward structure are intrinsically confounded in organisations. That is, an organisational focus on error prevention more easily elicits a reprimand upon error occurrence than praise for not having made an error. Conversely, constructive error handling is likely to be praised in an organisation that focuses on error management (Garud, Nayyar, & Shapira, 1999). In line with error management training studies, error approach was manipulated (error mastery versus error aversion). Half of participating groups were rewarded for desirable behaviour (prevention of errors/error handling), the other half were punished for undesirable behaviour (error occurrence/lack of error handling; Van Dyck & Van Hooft, 2009). The study revealed two independent effects of reinforcement and error approach. This means that for the first time it has been shown that besides well-known effects of positive reinforcements over punishment (see for example Kimble, 1961), the design allowed us to establish pure effects of error approach without any confound with operant principles reward and punishment. The study thereby rules out the thus far unexplored alternative hypothesis that error management culture effects should be understood in terms of positive reinforcement only (e.g., Podsakoff, Todor, & Skov, 1982; cf DeGrandpre, 2000).

From this study we further established some of the mechanisms that help groups perform better. Mastery oriented groups explored more, tried out various strategies and when they made mistakes they took responsibility for them. The latter contrasts error aversion groups, which blamed mistakes on time pressure, unclear instructions and other external causes. While mastery groups made more errors, they were also better at error correction and learning: about 80% of their mistakes were corrected, leaving them with a lower remaining amount of uncorrected mistakes than error aversion groups. As subsequent tasks got more difficult, it became clearer that these groups had learning advantages over the error aversion groups (Van Dyck & Van Hooft, 2009).

Homsma and colleagues (Homsma, Van Dyck, De Gilder, Koopman, & Elfring, 2007) showed that is was possible to manipulate error attributions in a two (internal *vs* external locus) by two

(instable *vs* stable causes) experimental design. The study extended the knowledge about the causal attribution mechanism by investigating the roles of causal ascription (stability and locus of causality) and causal interpretation (personal control and responsibility) after error occurrence (cf Van Dyck & Homsma, 2005). Internal unstable ascriptions lead to higher perceived control after error occurrence. Both control and responsibility, in turn, predict task behaviour. While causal interpretation predicts outcome measures, causal ascriptions are related to the same measures only indirectly. Participants who perceive more personal control and acknowledge more responsibility for the cause of the error have higher expectancies with regard to future success and propose higher quality strategies for future action.

Scholars have argued that learning from error is not possible in high-risk complex systems. Here, people should learn by 'trial without error' (Pool, 1997; Weick, 1987). But even these systems may offer opportunities for creating a consequence-free learning environment similar to that of error training settings. Think, for example, about flight simulators in aviation, or mountaineering where climbers can practice difficult transfers on special walls while a buddy is handling a rope attached to climber and ceiling, such that a fall can be stopped immediately. In such environments, trainees should not just learn the correct procedures, but could actually be encouraged to try out strategies and learn from their mistakes. In this way, they will be better equipped for error management when working in the real system.

In an emergency unit of a hospital and an innovative e-business corporation we investigated what happened with actual errors just after their occurrence as well as several weeks later (Van Dyck, 2009). The results confirm that an error mastery approach is positively related to control of error consequences. Communication and correction are associated with less severe consequences. Further, both single- and double-loop learning are predicted from an error mastery approach: The degree of communication about an error and analysis of its cause after occurrence, predict the amount of improvements pursued in subsequent weeks. Similarly, communication and analysis predict the amount of new ideas and insights the error has yielded later in time. Both communication and correction more often go together with long-term solutions rather than mere trouble-shooting.

A follow-up study investigated the influence of error incident characteristics on learning among operators in the chemical process industry. Operators were asked to describe error incidents that had recently occurred at Time 1. Six weeks later, measurements for learning followed. Operators learned more from error incidents when negative consequences were severe. Communication about errors mediated the relation between severity of error consequences and learning. When employees were confronted with severe error consequences, the willingness to talk about errors was higher which subsequently led to learning (Homsma, Van Dyck, De Gilder, Koopman, & Elfring, 2009). The findings suggest that employees do not automatically learn from their errors. Rather, employees communicate and learn from errors when consequences make it necessary for them to do so. This finding supports Cannon and Edmondson's (2005) and Sitkin's (1996) line of reasoning and Baumard and Starbuck's (2005) finding that small deviations from expected outcomes are often overlooked because they appear too insignificant to make use of their learning potential. Error incidents without imminent negative consequences, however, can also be a platform for learning.

Organisations that are guided by assumptions that reflect a tolerant, yet decisive orientation towards errors learn more from their errors than organisations guided by tolerant-indecisive, intolerant-decisive or intolerant-indecisive assumptions (Homsma, 2007). These findings extend research that focuses on non-punitive approaches towards error (Firth-Cozens, 2001, 2004; Helmreich & Merrit, 2000; Leape, Woods, Hatlie, Kizer, Schroeder, and Lundberg, 1998). Organisational tolerance is an essential condition for learning from error because it creates openness. Tolerance alone does not, however, lead to optimal error handling. Although tolerance is essential for openness, organisations also need to embrace assumptions that initiate an active investigation of the underlying causes of the error. Organisational decisiveness is needed to harvest the benefits of openness about errors.

While I believe that organisations active in high risk and low risk, innovative and conventional lines of industry can all benefit from an mastery error culture, each may do so in their own way. Emphasis can either lie on control of negative consequences or on promotion of positive consequences. Communication about errors and analysis of the underlying causes are regarded important for all, because they allow the development of shared knowledge (Carrol, 1998; Mathieu, Goodwin, Heffner, Salas, & Cannon-Bowers, 2000; Van Dyck et al., 2005).

Practical implications

The case study of the Everest disaster and our empirical work on error culture offer several suggestions for professionals (see also Table 3). I would suggest that leaders try to incite a tolerant, yet decisive culture that is high on communication, analysis, correction and learning, while low on covering up and strain. This can be achieved by a shared and reinforced recognition that errors in themselves are not a sign of incompetence. Errors cannot be eradicated fully, and error occurrence should therefore, to a certain

Table 3	Management do's and don't's for creating an error mastery culture
DO's:	
Be aware of the basic beliefs and assumptions of your error culture Make sure that practices, regulations and reinforcements are in line with the basic beliefs Pay attention to the difference between errors, error consequences and violations Be 'lenient' towards error occurrence (not violations), but take error handling seriously Create a safe climate for openness and responsibility Create a consequence-free environment for learning new, complex tasks through error training Focus on positive reinforcement of desired behaviour (rather than negative reinforcement of undesired behaviour) Walk the Talk: serve as a role model when error handling is concerned	
DON'T's:	
Focus on punishment Focus on checking up Assume wrongful intention (i.e., confuse errors and violations)	

extent, be accepted (error tolerance). Errors should, at the same time, be taken seriously, and handled quickly and effectively (decisiveness). A combined tolerant and decisive culture yields optimal results (Homsma, 2007).

In medicine, insights on leadership and team work developed in aviation, are taken to heart. Research on safe and constructive cooperation in multidisciplinary teams in which members differ in professional background, responsibilities and hierarchical positions suggest that a tolerant, decisive group climate can be achieved through so-called Team Resource Management (TRM) trainings (Firth-Cozens, 2001; Helmreich, 2000; Helmreich & Davies, 2004; Helmreich & Merrit, 2000; De Korne, Hiddema, Bleeker, & Van Dyck, 2007). TRM is a training that is aimed at increasing the use of non-technical skills to improve safety critical behaviours. TRM typically includes educating teams about the limitations of human performance. Furthermore, it requires participants to assess personal and peer behaviour. Operational concepts include inquiry, seeking relevant operational information, advocacy, communicating proposed actions, conflict resolution and decision making. Thus, TRM is directed at changing awareness of human limitations and behavioural changes in team work and communication in order to improve the management of errors and thus reduce adverse events.

It is important, as was argued earlier in this article, not to confuse errors with either error consequences or violations (see also Figure 1). While conducting my research I spoke with various leaders who had created hands-on practices in their organisations to reinforce a constructive error culture. A founder of a consultancy company, for example, held weekly error meetings. She would start these meetings by sharing a mistake she herself had made. By starting the meetings with her own mistake – which, because of her position, would generally hold more severe (potential) consequences than errors made by her employees – she created a non-threatening climate. The message was clear: It is okay to be open about errors. This message was further reinforced by specific praise of constructive error handling and propositions for improvements. Through these meetings, the team was able to analyse the causes of errors without laying blame, and to learn from them.

Quite in contrast with this example is the story of an employee in a different organisation. Here, every error would yield a fine, deducted from the employee's salary. This practice, of course, diminished all willingness to disclose errors. In fact, employees put a lot of time and effort in hiding errors. Both control of error consequences and learning become nearly impossible this way. A related approach was applied in a manufacturing company where management wanted to identify the individual employee if an error had occurred (see also above). They did so by obliging employee identification codes on every separate piece of work. This resulted in covert employee refusal and active frustration of the identification system. Management's next step was instalment of cameras, indicative of an ongoing cat and mouse game that certainly did not result in control of either errors or their consequences.

Culture and leadership are highly related, or two sides of the same coin (Schein, 2004). Leaders are not the only ones that influence and (re)-shape culture, but they do have an important impact on it. Research on error incident reporting and subsequent learning in the medical setting showed that mere espoused priority for safety is unrelated to both reporting and learning (Van Dyck, De Korne, Homsma, & Hiddema, 2009). The degree of incident reporting is positively related to learning. The relation between leaders' active reinforcement of safety and learning outcomes is mediated by the degree of incident reporting. Such a mediation is not found for leaders' espoused priority for safety. From

this, it follows that leaders should not just express their expectations, but in addition need to actively reinforce them by leading by example and complementing on desired error handling.

Leaders should be aware of the beliefs and assumptions that characterise the error culture. They should consider whether they are reinforcing these beliefs effectively. That is, are they rewarding desirable behaviour or punishing undesirable behaviour? Do praises and reprimands match what they want to convey and bring about? From our studies we have learned that although most managers in organisations have an opinion on the topic, only a small sample of these opinions and associated actions are in line with effective error handling and in support of error mastery culture yet. I hope the current paper will help in reconsidering the issue.

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References

Argyris, C. (1992). *On organizational learning*. Oxford: Blackwell.

Baumard, P., & Starbuck, W. H. (2005). Learning from failures: Why it may not happen. *Long Range Planning, 38*, 281-291.

Breashears, D. (1997). *Like running on a treadmill and breathing through a straw*. In B. Coburn (Ed.), *Everest: Mountain without Mercy.* Washington, DC: National Geographic Society.

Boukreev, A., & De Walt, G. W. (1997). *The Climb: Tragic Ambitions on Everest.* New York: St. Martin's.

Cannon, M. D., & Edmondson, A. C. (2005). Failing to learn and learning to fail (intelligently): How great organizations put failure to work to innovate and improve. *Long Range Planning, 38*, 299-319.

Carroll, J. S. (1998). Organizational learning activities in high-hazard industries: The logics of underlying self-analysis. *Journal of Management Studies, 35*, 87-137.

Coburn, B. (1997). *Everest: Mountain without Mercy.* Washington, DC: National Geographic Society.

DeGrandpre, R. J. (2000). A Science of Meaning. Can behaviorism bring meaning to psychological science? *American Psychologist, 55*, 721-739.

De Korne, D., Hiddema, U., Bleeker, F., & Van Dyck, C. (2007). *Versterking veiligheidscultuur door multidisciplinaire teamtraining [Enhanced safety culture through multidisciplinary team training]*. Kwaliteit in Beeld.

Edmondson, A. C. (1996). Learning from mistakes is easier said than done: Group and organizational influences on the detection and correction of human error. *Journal of Applied Behavioral Science, 32*, 5-28.

Firth-Cozens, J. (2001). Cultures for improving patient safety through learning: The role of team work. *Quality and Safety in Healthcare, 10*, 26-31.

Firth-Cozens, J. (2004). Organizational trust: The keystone to patient safety. *Quality and Safety in Healthcare, 13*, 56-61.

Frese, M. (1991). Error management or error prevention: Two strategies to deal with errors in software design. In H.-J. Bullinger (Ed.), *Human aspects in computing: Design and use of interactive systems and work with terminals.* Amsterdam: Elsevier.

Frese, M. & Zapf, D. (1994). Action as the core of work psychology: A German approach. In Harry C. Triandis, Marvin D. Dunette and Leatta M. Hough (Eds.), *Handbook of Industrial and Organizational Psychology*, *4*, 271-340. Palo Alto: Consulting Psychologists Press.

Garud, R., Nayyar, P. R., & Shapira, Z. (1999). Technological innovation: Oversights and foresights. Cambridge: University Press.

Helmreich, R. L. (2000). On error management: Lessons from aviation. *British Medical Journal, 320*, 781-785.

Helmreich, R. L., & Davies, J. M. (2004). Culture, threat and error: Lessons from aviation. *Canadian Journal of Anaesthesia, 51*, 333-361.

Helmreich, R. L., & Merrit, A. C. (2000). Safety and error management: The role of crew resource management. In B. J. Hayward & A. R. Lowe (Eds.), *Aviation resource management* (pp.107-109). Aldershot, UK: Ashgate.

Hofmann, D. A., & Mark, B. (2005). An investigation of the relationship between safety climate and medication errors as well as other nurse and patient outcomes. *Personnel Psychology, 59*, 847-869.

Homsma, G. J. (2007). *Making errors worthwhile: Determinants of constructive error handling*. Kurt Lewin Institute dissertation series. Amsterdam: VU University.

Homsma, G. J., Van Dyck, C., De Gilder, D., Koopman, P. L., & Elfring, T. (2009). Learning from error: The influence of error incident characteristics. Journal of Business Research, 62, 115-122.

Homsma, G. J., Van Dyck, C., De Gilder, D., Koopman, P. L., Elfring, T. (2007). Overcoming Errors: A Closer Look at the Attributional Mechanism. *Journal of Business and Psychology, 21*, 559-583.

Jones, C. F., & O'Brien, J. (1991). *Mistakes that worked*. New York: Bantam Doubleday.

Keith, N., & Frese, M. (2008). Effectiveness of error management training: A meta-analysis. *Journal of Applied Psychology, 93*, 59-69.

Kimble, G. A. (1961). *Hilgard and Marquis' Conditioning Revised.* (2nd edition). New York: Appleton.

Klein, R. L., Bigley, G. A., & Roberts, K. H. (1995). Organizational culture in high reliability organizations: An extension. *Human Relations, 48*, 771-793.

Krakauer, J. (1997). *Into Thin Air*. New York: Villiard.

Leape, L. L., Woods, D. D., Hatlie, M. J., Kizer, K. W., Schroeder, S. A., Lundberg, G. D. (1998). Promoting patient safety by preventing medical error. *Journal of the American Medical Association, 280*, 1444-1447.

Mathieu, J. E., Goodwin, G. F., Heffner, T. S., Salas, E., & Cannon-Bowers, J. A. (2000). The influence of shared mental models on team process and performance. *Journal of Applied Psychology, 85*, 273-283.

Perrow, C. (1999). *Normal accidents. Living with high risk technologies*. Princeton, NJ: Princeton University Press. (first published in 1984 by Basic Books).

Podsakoff, P. M., Todor, W. D. & Skov, R. (1982). Effects of leader contingent and noncontingent reward and punishment behaviors on subordinate performance and satisfaction. *Academy of Management Journal, 25,* 810-821.

Pool, R. (1997). *Beyond engineering*. New York: Oxford University Press.

Rasmussen, J. (1982). Human errors: A taxonomy for describing human malfunction in industrial installations. *Journal of Occupational Accidents, 4*, 311-335.

Reason, J. (1990). *Human Error*. Cambridge: Cambridge University Press.

Reason, J. (1997). *Managing the risks of organizational accidents*. Hampshire, UK: Ashgate.

Roberts, K. H., & Bea, R. (2001). Must accidents happen? Lessons from high-reliability organizations. *Academy of Management Review, 15*, 70-78.

Roberto, M. A. (2002). Lessons from Everest: The interaction of cognitive bias, psychological safety and system complexity. *California Management Review, 45*, 136-158.

Schein, E. H. (2004). *Organizational culture and leadership* (3rd edition). San Francisco, CA: Jossey-Bass.

Sitkin, S. B. (1996). Learning through failure: The strategy of small losses. In M. D. Cohen and U. S. Sproull (Eds.), *Organizational Learning*. Thousand Oaks: Sage.

Sitkin, S. B., Sutcliffe, K. M., & Schroeder, R. G. (1994). Distinguishing control from learning in total quality management: A contingency perspective. *Academy of Management Review, 19*, 537-564.

Van Dyck, C., De Korne, D. F., Homsma, G. J., Hiddema, F. (2009). *Walk the talk: Incident report systems as a tool through which leaders can enhance safety in hospital care.* Manuscript submitted for publication.

Van Dyck, C., Frese, M., Baer, M., & Sonnentag, S. (2005). Organizational error management culture and its impact on performance: A two study replication. Journal of Applied Psychology, 90, 1228-1240.

Van Dyck, C., & Homsma, G. J. (2005). 'Yes, it's my fault, but I couldn't help it.' How acknowledging control and responsibility can be just one bridge too far. In F. Avallone, H. K. Sinangil & A. Caetano (Eds.), *Convenience in organizations and society*. Milan: Guerini Studio. Pp. 119-124.

Van Dyck, C. (2009) *Mastering the dual challenges of errors: Risk and uncertainty as contingencies for control and learning*. Manuscript submitted for publication.

Van Dyck, C. & Van Hooft, E. A. J. (2009). *Error approach and performance: Causality and mediation*. Manuscript in preparation.

Weick, K. E. (1987). Organizational culture as the source of high reliability. *California Management Review, 14*, 112-127.

Wildavsky, A. (1988). *Searching for safety*. New Brunswick, NJ: Transaction Publishers.

Zapf, D., Brodbeck, F. C., Frese, M., Peters, H., & Prümper, J. (1992). Errors in working with office computers: A first validation of a taxonomy for observed errors in a field setting. *International Journal of Human-Computer Interaction, 4*, 311-339.