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Error management culture and organizational performance:

On mastering the challenges of errors¹

This paper examines organizational error culture in relation to organizational performance. We argue for the importance of an organizational culture that supports effective and productive error handling. We do so by drawing on the literature on errors in general (Reason, 1990), recent organizational approaches (e.g. Total Quality Management; Sitkin, Sutcliffe & Schroeder, 1994), operational safety and high reliability (Rochlin, 1999) and laboratory studies on error training (Frese, 1995). We gather survey and qualitative data on error culture in medium sized organizations and link these data to organizational performance measures.

Practically every organization is confronted with errors. Errors have been defined as “[...] all those occasions in which a planned sequence of mental or physical activities fails to achieve its intended outcome, and when these failures cannot be attributed to the intervention of some change agency” (Reason, 1990, p. 9).

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Errors have double implications. On the one hand, there is no doubt that errors can contribute to grave consequences — accidents like the one in Chernobyl or the Challenger disaster — on the other hand, most people readily agree that one can learn from errors. Thus, errors are the material that may lead to the insolvency of an organization (e.g. Barings Bank; Rawnsley, 1995) but they may also be the raw material for a learning organization (Argyris, 1992; Sitkin, 1996).

A similar duality has been recognized in Total Quality Management (Sitkin, Sutcliffe & Schroeder, 1994), exploitation versus exploration (March, 1991) and organizational learning (Argyris, 1992; Huber, 1991). Sitkin and colleagues (Sitkin, Sutcliffe, & Schroeder, 1994) have argued that Total Quality Management actually comprises two distinct goals resulting in distinct approaches; Total Quality *Control* and Total Quality *Learning*. On the one hand, organizations want to do ‘the things they do’ without errors (Total Quality Control). They want to exploit the methods that have proven their success (March, 1991), and improve them (single-loop learning; Argyris, 1992; March, 1991). This implies controlling and auditing known processes, and focussing on reliability and stability. On the other hand, organizations want to be adaptable and innovative (Total Quality Learning), and explore new ideas and methods (March, 1991), which implies second-loop learning (Argyris, 1992) rather than single-loop learning. In this respect, errors provide organizations with learning opportunities.

Both goals of control and learning are valid and important. It is, however, difficult for organizations to find an optimal balance between the two. A mere focus on exploration leaves an organization with many new ideas lacking necessary refinement. A mere focus on exploitation is likely to leave the organization with

well-developed, but sub-optimal methods (March, 1991). The two approaches require conflicting strategies (e.g. auditing versus risk taking and experimentation), which makes it hard to achieve an optimal balance. Yet, in order to keep competitive advantage, organizations need both reliability and stability associated with control, as well as adaptability and innovativeness associated with learning (March, 1991; Sitkin, 1996; Sitkin, Sutcliffe, & Schroeder, 1994).

Errors may result in both negative (e.g. loss of time, faulty products, accidents) and positive consequences (e.g. learning, innovation and resilience; Sitkin, 1996). The organizational goal of avoiding negative error consequences is conceptually associated with the more general goal of control. The organizational goal of fostering positive error consequences is similarly associated with the more general goal of learning. Organizations would gain most if they adopt a strategy that is able to take on the challenge of both goals of control (avoiding negative error consequences) and learning (fostering positive error consequences) simultaneously or in alignment.

A commonly used approach for avoiding negative error consequences is preventing the error itself (Argyris, 1992; Frese, 1991; Wilpert, 1995). With respect to the duality of errors (or rather their consequences), we propose that error prevention is a strategy not optimally suited for supporting both goals of control and learning.

Error prevention implies a focus on the goal of control. We propose that mere emphasis on error prevention has its limits: total elimination of errors is impossible. The advantages of the human cognitive apparatus (e.g. fast processing in uncertain environments) are the flipside of the fallibility of human reasoning (Reason, 1990). Further, error prevention may create negative side effects. An over-reliance on error

prevention may reduce error detection. When people are convinced that error prevention is successful, a sort of hubris develops which leads to a decrease of error anticipation which, in turn, makes it more difficult to detect those errors that occur nonetheless (Grefe, 1994; Dormann & Frese, 1994; Rochlin, 1999). Skills to deal with errors are affected (Argyris, 1992; Dormann & Frese, 1994; Rochlin, 1999), and an error occurring in spite of error prevention is then more likely to cause excessive damage (Reason, 1990; Frese, 1991). Further, a danger of organizational emphasis on error prevention is that errors are sanctioned severely. This may lead to strain, defensive reactions, covering up of errors, and thereby decrease the likelihood of error correction (Argyris, 1992; Johnston, 1996).

Error prevention does not necessarily allow learning. Organizational learning strategies such as experimentation (Huber, 1991) are in direct conflict with error prevention's goal of control: Errors are needed for learning from them. This dilemma is recognized in organizational learning strategies such as drawing from near-histories or hypothetical histories (March, Sproull & Tamuz, 1991), where the non-occurrence of errors is dealt with by trying to learn from errors that *might* have occurred. These strategies are in alliance with error prevention's goal of control and provide the learning material (hypothetical errors), but have drawbacks associated with artificiality and validity.

The error management approach (Frese, 1991) distinguishes between errors and their consequences. While error prevention aims at avoiding negative error consequences by avoiding the error altogether, the error management approach focuses on error consequences directly. It aims at avoidance of negative error consequences and the promotion of positive error consequences by means of early

error detection, quick and effective correction, error analysis, and long term learning from errors.

With respect to the duality of error consequences, we propose that error management is a strategy well suited for supporting both goals of control and learning. Error management overcomes the inherent conflict in allocating resources between the two. Both goals of control (avoiding negative error consequences) and learning (promoting positive error consequences) are embedded in the approach. Further, since error management does not imply error avoidance, the learning material — occurrence of errors — is available.

We now turn to the empirical evidence supporting the error management approach, which implies that negative error consequences can be avoided without avoiding the error itself (goal of control), and that positive error consequences can be promoted (goal of learning). Edmondson's (1996) research on errors in a medical setting revealed a positive relationship between the number of detected errors and team performance. It turned out that highly performing teams *reported* more errors (i.e. made more errors and/or were more willing to report them). Edmondson concluded that these teams had a better error climate, which allowed them to talk about errors, which in turn increased detection and correction. Thus, a distinction was made between an error (wrong medication order) and its negative consequence (harming a patient). Further, the open climate, characterized by a willingness to report and discuss errors, allows learning from errors, and thereby can affect team performance positively (Edmondson, 1996).

Learning from errors has been shown to occur in error training, which leads to higher performance compared to traditional and error-free forms of training (Dormann

& Frese, 1994; Frese, 1995; Frese, Brodbeck, Heinbokel, Mooser, Schleiffenbaum & Thieman, 1991; Gick & McGarry, 1992; Heimbeck, 1999). Errors allow and encourage exploration, which in turn seems to foster learning as well as a deeper understanding of the material involved (Frese, 1995; Kolb, 1984).

Edmondson's (1996) findings are in line with Rochlin's (1999) assertion that high performance should not be confused with the absence of errors. As Edmondson (1996, p. 25) has put it: "Given that human error will never disappear from organizational life, an important management issue thus becomes the design and nurture of work environments in which it is possible to learn from mistakes and to collectively avoid making the same ones in the future." Based on research in high reliability organizations, Rochlin reports the finding that high reliability organizations tend to reward the reporting of errors, and focus on organizational (i.e. shared) responsibility rather than on blaming the direct actor. The organization as a whole, not a single actor, should be the object under investigation. He further stresses that research be directed at the 'generic subjectivity' and organizational culture that provides meaning and purpose to the systems and processes that are operated and managed. Safety in high reliability organizations is more than the summation of actions of individual employees, but rather, entails a collective property that emerges from the interaction between parties, based on the social structure, beliefs, rituals and myths of the entire organization (Rochlin, 1999). Similarly, we propose that an error management approach be studied in terms of organizational culture dimensions. Thus, in line with Edmondson and Rochlin we argue that there is a cultural dimension to how organizations deal with errors.

Empirically, our study on error management culture builds on research on individual error management orientation (Rybowiak, Garst, Frese, & Batinic, 1999) where associations between this orientation and success of small-scale entrepreneurs have been established (Göbel, 1998; Göbel & Frese, 1999). Rybowiak et al. (1999) differentiated eight factors: communication about errors; analysis of errors; correction of errors; learning from errors; anticipation of errors; knowledge, acceptance and anticipation of risks; strain caused by errors (negative); and covering up errors (negative). In another study (Van Dyck, 1997; see also chapter 2) we tested whether these error orientation concepts could be translated to the team or organizational level. In the study of Van Dyck (1997; see also chapter 2), high intra-group consensus was found on the error culture scales. It turned out, however, that at the team level three dimensions were underlying the eight original scales used for individual error orientation. These dimensions were labeled mastery, awareness and error aversion.

The three dimensions refer to direct and indirect support and to impediment of error management. Error management is directly supported by a *mastery* orientation towards errors. We use the term mastery orientation in the sense of Dweck and her colleagues (Dweck & Legget; 1988; Diener & Dweck, 1978; 1980), that is, as an orientation toward developing ability, taking failure as a challenge to be mastered, generating effective strategies and maintaining effective striving under failure. Mastery orientation as an aspect of error culture is similarly focussed at overcoming difficulties associated with errors, and developing better strategies for the future. It entails that members of the organization communicate about errors, analyze errors' causes, deal with errors actively (i.e. quick and effective recovery), and attempt to learn from errors.

A general example comes from organizations that make errors, correct them in the best possible way and then share the relevant information among their employees, by means of an information system accessible and used by all.

Communication, analysis, correction and learning are all directly related to minimizing negative, and maximizing positive error consequences. As such, the mastery aspect of organizational error culture relates to a (long-term as well as short-term) orientation to overcome errors' problems and to take on the challenge that errors provide. Further, they entail what Rochlin (1999) labels a 'positive engagement', reflexive and interactive learning, and are in line with one of his key factors in high reliability organizations; the free flow of communication. The mastery aspect aims at both control (in the sense of eliminating or reducing negative error consequences) and learning (rendering positive error consequences). We, therefore, expect the mastery aspect of error culture to be positively related to organizational performance.

Anticipation of errors and knowledge, acceptance and anticipation of risks relate to a general *awareness* of errors. In calculated risk taking the organization accepts that it is sometimes necessary and useful to risk an error (see also Sitkin, 1996). Anticipation of errors is important because it aids the detection of errors. Only errors that are detected can be managed well. Negative error consequences tend to increase when the error remains undetected (Reason, 1990). Early detection can stop this dynamic process: The faster the detection, the better one is able to deal with the negative consequences (Grefe, 1994).

An example of the awareness aspect of error culture relates to recent preparations for the new millennium. The information technology sector had to

anticipate all aspects of their programming that related to the year 2000, read as 00 and misinterpreted as 1900. The organizations had to anticipate all problems related to this bug, as years are often used as variables that change other points in the program. Changing the programs necessitates an 'awareness' attitude in the information technology sector. Companies could not rely on simple solutions in their complex programs. They had to anticipate bugs that were overlooked, and test the effectiveness of their efforts in safe environments. A lot of companies organized 'dress rehearsals' where the date was artificially changed to 1-1-2000. On 'D-Day' the companies still had to be prepared for potential bugs to show up, even after extensive program adaptations and testing.

Error awareness thus relates to a preparedness for the unexpected, a continuous anticipation of future surprises (Rochlin, 1999). In sum, error awareness increases the likelihood of early error detection and prepares the organization for error handling. As such, error awareness indirectly supports error management. We thus expect a positive relationship with organizational performance.

Strain and covering up reflect a negative attitude towards errors, or *error aversion*. In organizations where employees are (severely) punished for their mistakes, employees are likely to experience strain, and may decide to cover up their errors. Strain and covering up diminish communication, analysis, correction, and learning, and thus, indirectly, hinder error management. Errors that are covered up remain undetected (at least to those who did not cover them up), and therefore run the risk of accumulating negative consequences (Reason, 1990).

An example is the Barings Bank disaster in 1993. Several sources indicate (e.g. Leeson, 1996; Rawnsley, 1995) that a major motivation for Leeson to produce an

unauthorized shadow account was that he was afraid to admit errors. He had been able to hide errors (and violations; cf. Reason, 1990) and their accumulating negative consequences for a long time, while attempting to make up for the errors and to look good without having to admit any of them. Employees who made mistakes or were not successful enough were fired quickly. Thus, the punishing culture of Barings Bank apparently reinforced this attitude (Rawnsley, 1995). Although there were obviously additional problems at Barings Bank, the accumulated consequences of Leeson's actions resulted in its fall.

With respect to error strain, a recent follow-up on the error training research (Heimbeck, 1999), revealed the crucial role of so-called heuristics (e.g. "Don't get upset with errors. Take them as a learning opportunity.") for the success of error training. This effect can be explained from the viewpoint of focussed attention: When errors are considered to be threatening, attention (i.e. cognitive resources) is directed to the self, rather than the task (Kluger & DeNisi, 1996). Translated to the domain at hand, error strain takes away resources needed for error handling. We therefore expect a negative relationship between error aversion and organizational performance.

We propose that error management culture refers to the aggregate incorporation of a mastery orientation, awareness and low error aversion within the organization. Avoiding negative error consequences and fostering positive error consequences should be associated with higher organizational outcomes.

Hypothesis 1: Mastery orientation is positively related to organizational performance.

Hypothesis 2: Error awareness is positively related to organizational performance.

Hypothesis 3: Error aversion is negatively related to organizational performance.

We use two methods to test our hypotheses. A survey is conducted using an adaptation of the error orientation questionnaire (Rybowiak et al., 1999) to measure error management culture and relate it to subjective and objective measures of organizational performance. In addition, interviews are conducted on a sub-sample of the investigated organizations. In these interviews emphasis lies on how errors are generally dealt with in the organization, how managers react to subordinates' errors, and organizational mission statements and visions with respect to errors. The qualitative data serve two purposes: First, to validate findings of the survey data; second, to explore additional organizational culture dimensions that are not measured by our questionnaire.

Methods

Sample. To minimize the risk of disintegration into several different sub-company sites with their own culture, we sampled mid-sized commercial organizations. We worked with a database from a commercial agency. This organization specializes in setting up and maintaining databases containing addresses of Dutch companies and names of functionaries within them. For our database we requested addresses of a total of 1,000 companies with one hundred to five hundred employees working in the same plant, office or site, and names of two functionaries within them. From this database we approached three hundred organizations. To work against a possible post-hoc explanation that associations between error culture and organizational performance would be restricted to certain sectors (e.g. with low risk activities), we included various sectors in our sample: automation (IT), retail trade, construction,

publishing, wholesale, machine and appliances, transport, insurance, consultancy and banks. Within broad categories for line of industry (see below), the approached companies were randomly selected. The approached companies do not differ from the non-approached companies with respect to the control variables (see below), nor do the participating companies (of those approached) differ from the non-participating companies.

Either one or two managers per company were selected from the database and received ten questionnaires on organizational error management culture. We asked these contact persons to give the questionnaire to their colleague-managers with a view to including as representative a cross-section of management as possible. If necessary - that is if a company had returned some, but not enough questionnaires - we wrote and/or telephoned the contact person asking whether it was possible to attain further participation. Our threshold for including a company in our analyses was three or more returned questionnaires. In exchange for participation, each company received a report with all relevant information and results with respect to their company as well as anonymous comparison data of the other companies.

In all, contact persons from 85 companies participated (producing a 28.3% response rate). In terms of individual participants, 380 questionnaires were returned. Since only organizations with three or more respondents were included in our analyses, this produced a sample of 65 organizations (25% of approached organizations). Of these, eleven organizations returned three completed questionnaires, fifteen organizations sent in four, fifteen sent in five, and twenty-four organizations sent in six to ten questionnaires. The average number of participating managers per organization in our sample is 5.4 (SD = 2.0). In total 297 male and 43

female managers participated, 10 managers did not reveal their gender. On average the participating managers had a position just above mid-level management.

Measures. Our questionnaire contained three scales on organizational error management culture, and a self-reported measure of organizational performance. Furthermore, for twenty-four of the organizations we were able to obtain an objective measure of organizational success. All measures other than the control variables form 5-point scales ranging from 1 (not at all / very unsuccessful) to 5 (completely / very successful). More details are given below.

Error management culture. Our measure of error management culture was based on the Error Orientation Questionnaire (EOQ) developed and validated for individuals (Rybowiak et al., 1999). We adapted the thirty-seven items of the EOQ in such a way that all items referred to the organizational level (“To which degree does this statement apply to *people in your organization in general?*”; see appendix for specific items).

In another study (Van Dyck, 1997; see also chapter 2) we specifically tested the generalizability of the error orientation questionnaire to higher levels (i.e. the team level in that case). It turned out that at the team level three dimensions were underlying the eight original scales. In the current study the same three dimensions surfaced. We entered the thirty-seven items in a factor analysis: Three factors had eigenvalues higher than two. Consistent with the other study, items of communication (k=4), analysis (k=5), correction (k=4) and learning (k=4) loaded on the first factor (mastery), items of anticipation (k=5) and risk taking (k=4) loaded on the second factor (awareness). Items of error strain (k=5) and covering up (k=6)

loaded on the third factor (error aversion). For all but three items loadings were .20 or more higher on their respective factor than they were on the other two factors. Thus, three error culture dimensions are formed: Mastery (Chronbach's alpha = .92), Awareness (Chronbach's alpha = .71), and Error Aversion (Chronbach's alpha = .88).

Subjective organizational performance. To avoid common method variance, survey data of the respondent with the highest position in a company were used to establish a subjective measure of company performance. In all analyses with subjective measure of organizational performance, only data of the remaining respondents were used to assess error management culture.

We designed the measure of subjective organizational performance in such a way that comparisons between organizations in different industry characteristics were possible. That is, the measure comprises three items on success of the organization *relative to its competitors in the same line of business*. The items are: "How successful is your organization in comparison to other companies in the same line of industry and of (about) the same size?"; "To what degree has your organization achieved its most important goal in the last year?"; and "How innovative is your organization in comparison to other companies in the same line of industry and of (about) the same size?" (Cronbach's alpha = .76).

Objective organizational performance. Relying on only one type of economic value (e.g. profit) has serious drawbacks. Preferably, we wanted to work with an economic measure that takes into account several general economic values, and that makes comparability over different lines of industry possible. We used a yearly-published

book by a Dutch consultancy agency that describes the performance of a large number of Dutch companies to obtain objective data on company success (De Breed & Partners, 1996). The method for developing these scores is based on Altman's (1968) model. The model has been refined over the years, and specific (annually updated) models have been developed and updated for separate lines of industry. The nature of annual financial reports is in part dependent on the nature of company activities (line of industry). By developing prediction models separately for each sector this is taken into account and corrected for.

With the use of multiple discriminant analysis, a set of financial ratios was developed that distinguished between annual reports of solvent and insolvent companies (De Breed & Partners, 1996). For each line of business, separate regression models were developed, based on recent data on insolvency in that particular industry. These regression models took into account commonly used economic data, such as profit rate, cash flow, added value and resulted in a score between one (very poor) and five (excellent). A low score meant a high resemblance to companies that had become insolvent in the previous years, while a high score meant a high resemblance to companies that had been successful in the previous years. An advantage of this measure is that it is comparable across lines of business and that it is based on several economic indicators of success.

Only larger Dutch Incorporated companies that had filed recent and detailed annual reports were included in the analyses of De Breed & Partners. Companies active in banking or insurances were not included. These restrictions have consequences for availability of data for the companies in our sample. We were able

to obtain these objective data of organizational performance for twenty-four companies in our sample.

Control variables. We used age ($M = 49.39$, $SD = 41.34$ years) of the organization (based on founding year of the first office in The Netherlands) and number of employees of the participating office ($M = 227.69$, $SD = 101.95$) as control variables in our analyses to test against liability of newness (Brüderl & Schüssler, 1990; Sighn & Lumsden, 1990; Singh, Tucker & House, 1986) and liability of smallness hypotheses (Brüderl, Preisendörfer & Ziegler, 1992; Sighn & Lumsden, 1990).

In addition, line of industry served as a control variable. For this purpose, four broad categories were developed based on industry codes of the participating organization. The first category, 'production & construction', comprises nineteen organizations active in production (doors (1), plastics (1), cigarettes (1), wood (1), machines (2), engines (1), and newspapers (2)), and construction (10). The second category, 'business services', comprises sixteen organizations (consultancy (3), information technology (6), administration (3), public relations (1), marketing research (2), and transportation (1)). The third category, 'finances & insurances', comprises ten organizations of which six are active in insurances, and four are banks. The fourth and final category, 'trade', comprises twenty organizations of which eight are active in retail trade and twelve in wholesale. The industry categories are included as three dummy variables in our regression analyses.

Level of Analysis

All our measures referred to the organization as a whole, rather than individual behaviors or attitudes. Eta² values - a measure of intragroup consensus (James, 1982) — as well as ICC values (Kenny & La Voie, 1985) — a comparison of within and between variance on group measures - were calculated to determine whether aggregation of data to the organizational level was justifiable on methodological grounds. In our study the eta² values ranged from .24 to .38 (.33 ($p < .01$) for mastery, .24 (n.s.) for awareness, .38 ($p < .01$) for error aversion. ICC values are satisfactory for two of the three culture measures (.37 ($p < .01$) for mastery, .05 (n.s.) for awareness, .51 ($p < .01$) for error aversion). Due to the low intra-group consensus values for the awareness dimension, aggregation of data on this dimension is not justified. The awareness dimension is therefore excluded from the analyses².

Qualitative Data

We conducted in-depth interviews with sixteen managers from eight companies of our sample; one was active in automation, one in administration, one in retail trade, one in construction, two in wholesale, one in insurance, and one in technical consultancy. We used a critical incident approach (Flanagan, 1954), taking into account at least two occurrences of errors. Examples of errors mentioned by the interviewees are: (calculation) errors in offerings for clients, errors in employment contracts, wrong

² Our analyses as described in the result section yield identical results regardless of whether awareness is included or excluded.

planning and not meeting the deadline for a product presentation, errors in purchases, not being alert on wrong and insufficient information from clients, faulty products, the printing of three million letters, of which the address headings did not fit the envelope windows, and the hiring of seventeen temporary employees from two agencies, where both sent seventeen temps, so that the organization had the double amount of what they needed.

The focus of the interviews was on espoused and enacted (Siehl & Martin, 1990) aspects of the error management culture and on ways in which managers reacted to, and dealt with subordinate's errors. Further, it was assessed whether an organization had a clear vision and/or mission statement regarding errors. All interviews were administered 'face-to-face', audio-recorded and transcribed.

In the first step of the coding process, raters 1 and 2 (other than the authors, but familiar with the theory) independently developed six categories (mastery, awareness and error aversion, as is consistent with survey data; blame, punishment and empathy as new dimensions) from their readings of the transcripts. In the second step, raters 3 and 4 (unfamiliar with hypotheses and theory) independently indicated all those parts of the transcripts related to error culture (Cohen's Kappa = .86). About half of the total number of words was included in error culture segments, to be further analyzed. The remaining half of transcribed interviews contained general information about the organization, its main activity, responsibilities of the interviewed manager, the manager's department, and the questions of the interviewer. Before starting the next step in the rating process, the raters 3 and 4 discussed the differences, and decided together on those parts of the transcripts that were indicative of the

organization's error culture. This resulted in 261 segments to be categorized and scored.

Only in the third step (their second step) were rater 3 and 4 provided with the six categories. They were asked to assign the error culture segments of the transcripts to the six categories (Cohen's Kappa = .69). The two raters discussed the differences, and decided together on those categories they initially differed on.

Raters 3 and 4 were then asked to assign a score between 1 (low) and 5 (high) to each categorized segment of the transcripts (Cohen's Kappa = .76). The two raters discussed the differences, and decided on those scores they initially differed on.

On average, 16.1 segments were categorized and scored per interview. Per interview, scores in the same category were averaged, resulting in an overall score on each of the six categories, for each of the interviews. Further, at the end of each interview managers were asked about specific mission statements of their organization regarding errors. Since this entailed a simple and standard question, we did not further code these parts of the interviews. An additional rater (number 5, unfamiliar with our hypotheses) selected illustrating quotes from the interviews.

For each of the six dimensions, correlations between scores of two managers of one company were calculated. These are; .28 for Mastery, .18 for Awareness, .32 for Error Aversion, -.16 for Blame, .48 for Punishment, and .79 for Empathy. Based on these correlations we decided to exclude the Blame variable, and the Awareness (for which we had also found insufficiently high intra-group agreement values for the survey data, see Methods section) from further analyses.

Results

Table 1 shows means, standard deviations, and inter-correlations. Mastery orientation and error aversion have a small and marginally significant correlation with each other. Size was negatively related with mastery orientation and positively with error aversion. Apparently, larger organizations have lower mastery orientation and higher error aversion scores. The correlation between the subjective and objective measures of organizational performance was non-significant, suggesting that the two measures tap different aspects of performance: The subjective measure is related to the achievement of goal developed within the organization, while the objective measure relates to economic indicators.

We tested our hypotheses using correlational (Table 1) and hierarchical (or sequential) regression analyses (Table 2). We entered the control variables size, age, and three dummies for the four industry categories in the first step of a hierarchical regression analysis with the subjective measure of organizational performance as the dependent variable. A similar hierarchical regression analysis was conducted with the objective measure of organizational performance as the dependent variable. In this second analysis, however, only one dummy (industry category trade) was entered in the first step, since only data on the objective performance variable were available for two of the industry categories (trade and production)³. Table 2 shows that the control

³ The data loss on the objective measure of performance is not random, but relates to line of business (banks and insurance companies are not included), type of organization (“incorporated”) and size of the company (in terms of turnover). This led to data loss due to the fact that we had quite a number of banks and insurance companies in our sample, and because our sample included organizations that were not ‘big’ enough for the De Breed and Partners’ index to have included them. To test for size and

variables did not affect either of the two dependent variables. The two error culture dimensions were entered in the second step. Hypothesis 1 predicted a positive relationship between mastery orientation and organizational performance. As can be seen in Tables 1 and 2, mastery orientation was positively related to both subjective and objective organizational performance. In Table 2, the significant change in explained variance in the subjective measure of organizational performance in the second step was due to the mastery dimension. With the objective measure of organizational performance a marginally significant change in explained variance ($p = .08$) was found in the second step.

industry effects (apart from our use of control variables for the full sample) we have conducted our analyses on the subjective measure of performance separately for the two parts of the sample we do and that we do not have objective data for. These analyses yield identical results.

Table 1
Means, Standard Deviations, and Correlations for Error Management Climate, and Organizational Size, Age, and Performance

Variables	Mean	s.d.	1	2	3	4	5a	5b	5c	6
1. Mastery Orientation	3.23	.46								
2. Error Aversion	2.64	.53	-.20#							
3. Size	227.69	101.95	-.23*	.21*						
4. Age	49.39	41.34	-.02	-.04	-.10					
5. Industry Category										
a. Trade (dummy)	n.a.	n.a.	-.06	.10	.07	.11				
b. Business Services (dummy)	n.a.	n.a.	.05	-.07	-.05	-.31*	.38**			
c. Production (dummy)	n.a.	n.a.	.16	-.14	-.08	.15	-.43**	-.37**		
6. Subjective Performance	3.50	.42	.33**	.09	.16	-.10	-.24#	-.13	-.09	
7. Objective Performance	4.08	1.02	.46*	-.00	-.17	.13	-.26	n.a.	.11	.20

All measures form 5-point scales ranging from 1 (not at all / very unsuccessful) to 5 (completely / very successful), with the exception of the control variables; size (number of employees) and age (in years) of the company, and the dummies for industry category. The number of organizations is sixty-five, except for the objective measure of organizational performance where we only have data on twenty-four of the organizations. n.a. = not applicable; # $p < .10$; * $p < .05$; ** $p < .01$, all two-tailed tests.

Table 2
Results of Hierarchical Regression Analyses

Dependent variable:	Subjective organizational performance			Objective organizational performance		
	ΔR^2	F Δ	β	ΔR^2	F Δ	β
<i>Step 1: Control variables:</i>	.10	1.29 (5, 59)		.07	.45 (3, 18)	
Size			.13			-.11
Age			-.14			.14
Industry Category (dummies)						
Trade			.21			-.12
Business Services			-.10			n.a.
Production			-.01			n.a.
<i>Step 2: Error management culture:</i>	.15**	5.62 (7, 57)		.26 ^a	3.02 (5, 16)	
Mastery orientation			.40**			.51*
Error Aversion			.11			.31

All measures form 5-point scales ranging from 1 (not at all / very unsuccessful) to 5 (completely / very successful), with the exception of the control variables; size (number of employees) and age (in years) of the company, and the dummies for industry category. The number of organizations is sixty-five, except for the objective measure of organizational performance where we only have data on twenty-four of the organizations. n.a. = not applicable; ^a $p = .08$; * $p < .05$; ** $p < .01$.

The beta for mastery was significant⁴. Thus, hypothesis 1 was supported.

Hypothesis 2 could not be tested since we found no justification to aggregate the awareness dimension. As discussed in the methods section, this variable was excluded from further analyses. Error aversion was not significantly correlated with either measure of organizational performance (see Tables 1 and 2). Thus, we did not find support for Hypothesis 3.

Qualitative Findings

A striking finding of our qualitative analyses was the absence of mission statements and organizational vision concerning errors. Only one of the sixteen managers indicated that their organization had an explicit error approach, which focused on error prevention. Ten other managers indicated that their organization did not have any specific vision regarding errors. The remaining five managers indicated that errors had never been discussed at the organizational level. Statements were, for example: “Errors have never been explicitly discussed at the organizational level. We do, however, have a quality system, which implies a focus on prevention of errors,

⁴ We also tested for two-way interactions between the error culture dimensions and the industry categories to investigate whether relationships between error culture dimensions and organizational performance measures differed over industry categories. This was done in an equivalent way as described in Table 2 with control variables and error culture dimensions being entered in step 1 and 2 respectively. The interaction terms being entered in the third step. For each of the interaction terms a separate analysis was performed (note that using separate analyses for each of the interaction terms allows us to find non-expected significant effects more easily, therefore this procedure is more conservative than entering all interaction terms together in the third step). No significant effects were

procedures for dealing with specific errors, and registration of customer complaints aimed at improvement.” and “Yes, we do have a very precise procedure for the registration of errors, deviations and accidents.” This sounds as if there were a clear procedure, but it was only related to the *registration*, and not to the handling of errors.

For validation purposes and for further exploration of important error culture issues, we calculated correlations between survey and interview dimensions (see Table 3). Note that these correlations are based on very few cases and should only be taken as suggestive. Moderate to high positive correlations appeared between the survey dimensions mastery orientation and error aversion and their counterparts in the interview. Due to the small sample size for the qualitative data, these correlations were non-significant. They suggest that both procedures — the survey and qualitative approach — tended to tap the same dimensions. The correlation between the mastery dimension in the interview and the subjective measure of organizational performance was of similar size (albeit not significant) as in the survey data. There was also a negative correlation between the error aversion dimension in the interview and the subjective measure of organizational performance (although, again, not significant due to the small N). We had hypothesized such a relationship but did not find it in the survey.

The other correlations suggest further issues for error culture research. Mastery orientation, as measured in the survey, was significantly negatively correlated with error aversion (interviews), and negatively (non-significantly)

found for any of the interactions. This leads to the conclusion that there was no moderator effect of line of industry on error culture and performance relationships.

correlated with punishment (interviews), and positively (marginally significant) correlated with empathy (interviews).

Table 3
Correlations between survey and interview dimensions

Survey dimensions:	Mastery	Error Aversion	Subj. Performance
Interview dimensions:			
Mastery	.51	.22	.34
Error Aversion	-.71*	.40	-.52
Punishment	-.38	-.17	-.31
Empathy	.68#	.23	.23

$N = 8$ organizations, * $p < .05$, # $p < .10$, two-tailed tests.

Another way to look at the qualitative data is a consideration of quotes that illustrate our error culture dimensions. In Table 4a and 4b an overview is given of organizations which' managers participated in the interviews, scores on mastery orientation, error aversion, punishment and empathy (lower scores in Table 4a, higher scores in Table 4b) and one or two illustrating quotes for each dimension. The organizations whose quotes are given had the following scores in the survey; an organization active in automation with mastery score 3.34, error aversion score 2.73, subjective performance score 4.08; administration (3.23; 3.00; 3.61); retail trade (3.09; 2.73; 3.50); construction (3.32; 2.55; 3.58); wholesale (1) (3.67; 2.22; 3.73); wholesale (2) (3.43; 2.99; 4.21); insurance (3.46; 2.73; 3.33); and technical consultancy (3.27; 2.71; 2.93).

Table 4a
Illustrating Quotes for the Four Error Culture Dimensions (Interview): Low Scores

Organization	Score	Quotes
		Mastery Orientation
Consultancy	2.73	“In this organization, we don’t talk about errors”
Retail	2.85	“But I don’t want to discuss errors at great length. [...] I indicated that this shouldn’t happen again. And that was the end of it.”
Wholesale (1)	1.00	“We specifically don’t want to disguise our own mistakes. We want them out in the open.”
		Error Aversion
		Punishment
Administration	1.25	“When I first started as a supervisor, I used to get angry at people when they made a mistake. That is very easy and seems forceful. But you have to get used to the fact that it simply does not work. People will get frustrated, fearful, they will be less open about their mistakes and therefore errors will be discovered later.”
Wholesale (1)	1.75	“Don’t keep matters bottled up. People shouldn’t be given hell about their errors. People have to learn from their errors. I make errors myself.”
Wholesale (2)	2.00	“[...] Learning from errors. I see them as positive, as free feedback. I always see them as positive. If people report their errors to me I thank them for that. I don’t complain, I regard it as an opportunity to improve things. That’s how I see errors.”
		Empathy
Retail	2.00	“I said to her: ‘tell him.’ ‘But,’ she responded, ‘I have already informed him [that a certain person would get a raise].’ ‘Well, that’s your problem,’ I replied.”

Table 4b
Illustrating Quotes for the Four Error Culture Dimensions (Interview): High Scores

Organization	Score	Quotes
		Mastery Orientation
Administration	4.75	"I try to create an open atmosphere and tell people they should inform me if they have made a mistake, so that we can do something about it. We try to be open and discuss errors, because we believe that is the only way to control damage."
Wholesale (2)	4.50	"I have spoken to the responsible manager, and have asked him to use this incident as a learning opportunity in his department."
Wholesale (1)	4.35	"I try to create an open atmosphere and tell people they should inform me if they have made a mistake, so that we can do something about it. We try to be open and discuss errors, because we believe that is the only way to control damage."
Automation	3.90	"I try to create an open atmosphere and tell people they should inform me if they have made a mistake, so that we can do something about it. We try to be open and discuss errors, because we believe that is the only way to control damage."
		Error Aversion
Consultancy	4.30	"The funny thing was that I got an evasive reaction at first, like 'don't worry, nothing's wrong.' And then when I started digging a bit deeper, I found a chain of things that indicated people were protecting each other."
Retail	3.15	"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 identification code, so that we don't know who made the mistake."
		Punishment
Construction	3.80	"Errors... Well, I accept errors in the sense that when a person makes too many, they're fired." "It will be fatal for him [the employee who made a mistake] if the customer finds out."
		Empathy
Wholesale (2)	5.00	"The way I go around is that I try to empathize. I take the circumstances onto account. Including the social aspects."
Administration	4.50	"If I would have said to that guy, 'You idiot, how could you have done that?', he would have felt really small, while 'why don't you come up with something that will prevent this error in the future' will make him feel like a hero."

The quotes in Tables 4a and 4b illustrate the central aspect of mastery orientation; open, free, and constructive communication, analysis, a focus on error recovery and learning. The quotes on error aversion suggest that fear of being caught while making a mistake is an important issue. The quotes on punishment suggest that managers can be readily differentiated on whether they do or do not punish errors. The same holds for showing empathy. What can further be seen in these quotes, is that with higher scores on mastery and empathy and lower scores on error aversion and punishment, managers more often offer a rationale for their approach (e.g. “We believe that is the only way to control damage”, and “[otherwise] people will get frustrated, fearful, they will be less open [...] and therefore errors will be discovered later”). Conversely, with lower scores on mastery and empathy, and higher scores on error aversion and punishment, managers tend to merely state their approach (e.g. “[...] this shouldn’t happen again. And that was the end of it.”). More important, these rationales directly relate to the mastery and error aversion dimensions. That is, rationales given for not punishing subordinates for their errors relate to the fear that punishment will reinforce error aversion, and impede error detection (manager from administration company), that punishment will impede learning (manager from second wholesale company), and that showing empathy will serve the goal of error correction (manager from insurance company).

Discussion

The most interesting finding of our study is that mastery orientation correlated positively with both the subjective and objective measures of organizational

performance. This effect was upheld when we controlled for age and size of the organization, and line of industry the organization is active in. This is in line with our first hypothesis. Unfortunately, our second hypothesis could not be tested, since aggregation of the awareness dimension was not legitimate due to low values of intra-group consensus. No significant negative association was found between error aversion and the organizational performance measures. Thus, there was no support for our third hypothesis.

It makes sense that mastery orientation showed the clearest association with organizational performance because it is at the core of what error management is about. Communication, error analysis, correction of errors and learning from errors all are directly aimed at avoiding negative error consequences and determining better strategies for the future. The importance of the mastery dimension is in line with two of Rochlin's (1999) central constructs in high reliability organizations and their safety culture; a free flow of communication, the rewarding of reporting of errors and a continuous reflexive and interactive learning approach. Our qualitative data give further support to these ideas. Validation for our two error culture survey dimensions is inferred from positive correlations between these two survey dimensions and their counterparts in the interview data. Further, a similar positive correlation between the interview mastery dimension with the subjective measure of success (survey) was found as in the survey data.

A selection of quotes from our qualitative data illustrates the essence of the error culture dimensions. The reactions to subordinates' errors (punishment and empathy) can be seen as managers' reinforcement of the organizational error culture

in lower levels of the organization, and as an expression of the error culture at higher (management) levels of the organization.

A clear limitation of our study is its cross-sectional design. We therefore were unable to test for causality. Our results are consistent with two opposing hypotheses: Either error management culture leads to increased organizational performance, or high organizational performance enables or encourages an error management approach. The interpretation of the latter would be that high performance, or a good position of the company, would make management and employees more relaxed so that they feel free to discuss errors and learn from them, rather than get upset and hide errors. The experimental design of error training research (Dormann & Frese, 1994; Frese, 1995; Frese et al., 1991; Heimbeck, 1999) gives a clear indication that the way people perceive errors and handle them, influences performance. We would argue that these findings on causality on the individual level would also be true at the organizational level. It is, however, plausible that there is a mutual reinforcement of error culture and organizational performance: Error culture influences organizational performance and performance influences error culture. In either event, the causality issue needs to be addressed in future empirical research.

Another problem might lie in self-selection of participating organizations and respondents within them. Organizations that have already developed an interest in the topic of dealing with errors, and that have already given the topic some thought, are more likely to participate. Within these organizations, managers who think they deal with errors well (which does not necessarily conform to our ideas) are more likely to participate. We think, however, that this mechanism is not a very likely explanation of our results. First, our sample displayed enough variation in both error management

culture and organizational performance in the survey data, as well as variation between participants as assessed in the qualitative data. Second, self-selection should decrease variance, and therefore, reduce correlations. Third, the absence of mission statements and organizational visions with respect to dealing with errors in the interviews suggests that no bias is operative.

One other weakness of our study is the low correlation between the subjective and objective measures of organizational performance. This suggests that the two measures tap different aspects of organizational performance. Our subjective measure of performance refers to organizational goals and to what degree they were attained, and to how well the organization is doing in comparison to direct competitors. The objective measure comprises several economic indicators weighted according to their prediction of organizational survival in that line of industry. It makes sense that these two measures of performance are different. It attests to the robustness of the results that mastery orientation is significantly related to both measures.

A strength of our study is that our analyses do not use the same sources of information for the 'dependent' and 'independent' variables. The subjective measure of organizational performance was based on the highest manager who was left out of the measures of the culture variables. The objective measure of organizational performance was developed for a different purpose by a commercial firm, unrelated to our research effort.

We think that the most important mechanism that links error culture and organizational performance, relates to both issues of control (avoiding negative error consequences) and learning (promoting positive error consequences). Specific issues in this respect would be related to learning new approaches, dangerous areas, and

boundary lines of routine approaches. Research in a related area (Wall, Jackson & Davids, 1992) showed that the reason why operators produced performance gains after the introduction of a new payment system was that they optimized fault management. Further research is needed to empirically establish the precise mechanisms by which error management culture influences organizational performance. One suggestion derived from our qualitative analyses would be to focus on interpersonal aspects of error handling such as punishment, and showing empathy with people that err. It is noteworthy in this respect that a similar trend can be observed in the aviation industry, where policies are designed to encourage the reporting of errors without sanctions (Johnston, 1996), thus creating an environment where errors are not punished. Related to the aspect of punishment is that of taking responsibility. Rochlin (1999) reports that highly reliable organizations tend to attribute error to the organization as a whole rather than displacing responsibility to the erring task group or individual.

Up to this point, error management culture with its core of mastery orientation, has been discussed to be useful for all companies. Although we did not find any moderator effect of industry on the mastery orientation - organizational performance relationships, we think that (other) contingencies may affect the relationship. We would argue that all companies benefit from an error management culture, but do so in different ways. In line with the contingency argument presented by Sitkin et al. (1994), for some organizations the advantages of an error management culture would be associated with issues of control, while for others they may be associated with issues of learning. This would then depend on the line of industry, or on whether or not an organization is going through a period of change.

It is important to differentiate between errors and error consequences. People sometimes argue against our error management idea that companies cannot afford to produce faulty products of low quality. This is obviously correct. However, a faulty product is an error *consequence* and is not necessarily related to error management per se. In fact, a faulty product may be the result of lack of error management. Error management culture may be of central importance to companies. Actually, part of the debate on Taylorism versus Anti-Taylorism can be understood in terms of organizational approaches to errors. Taylor's (1911) approach was strong, because it entailed an ingenious method to eradicate errors (and inefficiencies) by reducing the complexity of work, by giving the worker exact instructions of what to do under which circumstances, by a high division of labor, and by using tools and machines that made errors unlikely. Taylorism thus leads to an organizational error culture that optimizes error prevention. Tayloristic approaches, however, have serious drawbacks. They reduce responsibility, initiative and internal motivation (Fay & Kamps, 1998). Therefore, alternative approaches to job design have become prominent. These non-Tayloristic approaches, have had to deal with the argument that their approaches lead to a higher degree of errors (Wall & Jackson, 1995). This implies that organizations with non-Tayloristic approaches are forced to develop some strategy for dealing with errors. We think that error management is a useful concept for these non-Tayloristic approaches.

Error management culture should be a matter of high concern for managers as well as an issue of high conceptual importance for studies on organizational change and organizational learning. Errors will appear whenever companies reduce the number of routines people can rely on. Change processes are, therefore, frequently

associated with a higher degree of errors. Moreover, people will more likely participate actively in change processes if their errors are not punished. When companies attempt to be superior to other companies we would advise them to focus on a culture that fosters the open discussion of errors, the analysis and efficient correction of errors, and learning from errors. Managers should realize that errors are not always avoidable and errors should therefore be tolerated to a certain degree. This does not mean that they should not be taken seriously. As a matter of fact, we suggest that errors should be taken more seriously than is often done. In this respect it is important to note the absence of organizational visions or mission statements in the companies of which we interviewed managers. While errors traditionally are discussed only when the consequences are high or even disastrous, we suggest that errors with small consequences should also be taken as chances to learn. In line with Rochlin (1999), we suggest that organizations should be encouraged to take responsibility for their errors. Error management culture may be an important, and up to this point unexplored, element for many if not most companies to gain competitive advantage.

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Appendix: Items Organizational Error Management Culture

Mastery orientation

Error correction:

When an error has occurred we usually know how to rectify it.

When an error is made, it is corrected right away.

If an error is restorable, we usually know how to do it.

Although we make mistakes, we don't let go of the final goal.

Learning from errors:

For us, errors are very useful for improving the work process.

An error provides important information for the continuation of the work.

Our errors point us to what we can improve.

In mastering a task, people can learn a lot from their mistakes.

Analyzing errors:

After making a mistake, people try to analyze what caused it.

In this organization, people think a lot about how errors could have been avoided.

If something went wrong, people take the time to think it through.

After an error people think through how to correct it.

After an error has occurred it is analyzed thoroughly.

Communication:

When someone makes an error, (s)he shares it with others so that they won't make the same mistake.

When people are unable to correct an error, they turn to their colleagues.

If people are unable to continue their work after an error, they can rely on others.

When people do something wrong they can ask others for advice on how to continue.

Awareness

Anticipation:

It is very likely that people will make errors in the process of mastering their task.

When people start to work on something, they are aware that mistakes can occur.

In this organization, people are often amazed by their mistakes.

In this organization we take the occurrence of errors into account.

In this organization, we take into account that things will go wrong from time to time.

Risk taking:

For an organization to achieve something, it has to risk the occurrence of errors.

It's fine to risk an error every once in a while.

To get better in what we do, we don't mind that something can go wrong in the process.

We would rather make mistakes than do nothing.

Fear of errors

Error strain:

In this organization, people feel aggravated when making mistakes.

People in this organization are often afraid of making errors.

In general, people feel embarrassed after making a mistake.

If an error occurs, people get upset and irritated.

During their work, people are often concerned that errors could be made.

Covering up:

Our motto is; "Why admit an error when no one will find out?"

It can be harmful to make your errors known to others.

There is no point in discussing errors with others.

There are advantages in covering up one's errors.

People in this organization prefer to keep their errors to themselves.

Employees that own up to their errors are asking for trouble.
