The introductory chapter of this dissertation began with Erma Rorrek's error incident as an illustration of how learning from error can take form. In order to learn from error, employees need to understand the underlying causes of the occurrence of errors. Communication about and the analysis of errors are considered essential in reaching a better understanding of errors (Carroll, 1998; Edmondson, 1996; Mathieu, Goodwin, Salas, & Cannon-Bowers, 2000; Van Dyck, Frese, Baer, & Sonnentag, 2005). Erma’s department, for example, engaged in a discussion to identify the underlying causes of error occurrence. As a result of this discussion, concrete plans were developed to prevent a similar error from occurring in the future.

Figure 1. Overview of the research model.
The behavioral practices displayed by Erma and her department are, however, not very common in everyday practice. In reality, learning from error is the exception to the rule in most organizations (Carroll, 1998; Carroll, Rudolf, & Hatakenaka, 2002; Edmondson, 1996; Tucker, 2004; Van Dyck, 2000; Van Dyck et al., 2005). My aim was, therefore, to advance theory on the underlying factors that encourage or obstruct adequate error handling and learning in organizational contexts. To gain a better understanding as to why most organizations find it so difficult to learn from error, we took a look at the influence of processes at the organizational and individual level, as well as characteristics of the error on learning (see Figure 1).

In Chapter 2, we examined impact of the factor organizational culture. In Chapters 3 and 4, we assessed the predictive value of attribution processes on subsequent behavior. In Chapters 4 and 5, we reported on the influence of error incident characteristics on subsequent learning. In this chapter, an overview of the research presented in the earlier chapters is provided. Subsequently, the results are discussed and suggestions for future research offered. We conclude by discussing some implications for practice.

The Main Findings
An overview

Although scholars have argued that the underlying assumptions of organizational culture influence error handling and learning practices, this relationship has not been empirically established (Edmondson, 1996; Van Dyck et al., 2005). In this dissertation this gap is addressed through the development and validation of the error assumption framework. Organizations that are guided by assumptions that reflect a tolerant yet decisive orientation towards errors learn more from their errors than organizations guided by tolerant-indecisive, intolerant-decisive and intolerant-decisive assumptions about error (Chapter 2).

In Chapter 3, causal attribution has been identified as an important antecedent of behavior after error occurrence. The results show that perceived personal control and responsibility are better predictors of learning than the attribution dimensions ‘locus of causality’ and ‘stability’. When people perceive more personal control or acknowledge more responsibility over the cause of an error, they have higher expectancies with regard to future success and propose higher quality strategies for future action.

The study presented in Chapters 4 and 5 demonstrated that learning depends on certain aspects of the error incident. Errors in complex tasks lead to more learning than errors that are made in routine actions. Moreover, the severity of the consequences influences learning from error. Employees communicate and learn from their errors when negative consequences make
it necessary for them to do so. In the following paragraphs the findings are discussed in greater detail.

Organizational culture
In the outline of the dissertation described in Chapter 1, we argued that the sales department described in the hypothetical error incident may have shared a cultural error assumption that enabled optimal error handling and learning. After the consequences of the error were minimized, the department learned from the error by discussing and analyzing the incident.

The study presented in Chapter 2, reported on the development of a framework for the identification of organizational error assumptions. Interpretation of the data suggests an error assumption framework with two dimensions – organizational tolerance towards errors and organizational decisiveness towards errors –. Results show that organizations that are guided by types of assumptions that reflect a tolerant yet decisive orientation towards errors learn more from their errors than do organizations guided by tolerant-indecisive, intolerant-decisive and intolerant-indecisive assumptions about error (see Figure 1). The study shows that organizational tolerance towards errors is an essential condition for learning from error because it creates openness about error. As illustrated by Erma's incident, new insights at the departmental level can only develop when people disclose their errors. In organizations that are characterized by assumptions reflecting tolerance, employees were quite open about their errors. In organizations that are characterized by assumptions reflecting intolerance towards errors, however, people had a tendency to be less forthcoming. Intolerant views led to covering up rather than openness, to avoid potential blame or punishment.

Tolerance towards errors alone, however, does not lead to optimal error handling. Although tolerance is essential to create openness about errors, organizations also need to embrace assumptions that initiate an active investigation of the underlying causes of error. The study presented in Chapter 2 revealed that, although tolerance towards errors led to openness, it did not necessarily result in initiatives aimed at learning from error. In other words, employees like Erma do not automatically take the floor at work meetings to find ways to prevent errors from reoccurring. For such initiatives, employees have to be prompted by assumptions that reflect tolerance and decisiveness about error. Whereas organizations with tolerant and indecisive views primarily engaged in activities aimed at minimizing negative consequences, organizations with a tolerant and decisive view towards errors managed to learn from their errors.
Attribution processes
In the hypothetical error incident, Erma blamed herself for not being up to date with the latest negotiation outcomes. However, she might just as easily have engaged in self-irrelevant attributions by blaming the people in charge of the transfer of negotiation outcomes. Moreover, she could have attributed her error to flat-out undesirable causes, such as a lack of ability. In literature on failure attribution, causes are seen as desirable when they maintain an individual’s belief in his or her capabilities and the expectancy to perform the erroneous action correctly remains unaffected (Weiner, 1985; Bandura, 1982). Perceived causes are considered undesirable when they weaken an individual’s belief in his or her own capabilities. Illustrated by Erma’s causal reasoning, we argued that error handling can be affected by attribution processes after an error occurs.

The laboratory study presented in Chapter 3 supported the proposition that causal attribution influences subsequent error handling and learning behavior (see Figure 1). Perceived personal control and the acknowledgement of responsibility are valuable predictors of expectancy of success and quality of strategy after error occurrence. The more personal control and responsibility individuals perceive, the higher the expectancy with regards to future success and the higher the quality of strategies for future action. Moreover, the results suggest that perceived personal control and acknowledged responsibility are better predictors of learning (i.e., the development of strategies to overcome the error) than the attribution of errors to changeable and self-relevant causes (internal-unstable causes). Perceptions of personal control and responsibility over the cause of an error predict expectancy of success and learning above and beyond locus of causality and stability.

The empirical field study conducted in the chemical process industry casts a different light on the predictive value of perceived personal control on learning from error (Chapter 4). Employees generated more insights and ideas when they perceived low personal control, whereas in the laboratory study participants developed better strategies when they perceived high personal control over the error cause. The laboratory study and the field study thus yielded different results concerning the predictive value of perceived personal control with regard to learning from error. After the presentation of the main results, the theoretical implications of these two findings are discussed.

Error Incident Characteristics
Chapters 4 and 5 show that certain aspects of the error incident influence error handling and learning (see Figure 1). In Chapter 1, we asked the question whether Erma and her department would have learned from her error if she had made a minor spelling error rather than a calculation error in the tender. The results presented in Chapter 5 show that not every error
offers the same learning opportunities. It depends on the complexity of the error. Errors that occur in actions at the intellectual level of regulation lead to more learning than errors in actions at the flexible level of regulation. That is to say, errors in complex tasks lead to more learning than those made in routine actions. An explanation might be that compared to errors occurring in complex actions, learning from error during routine actions may not be considered all that crucial. This may be the case because for routine tasks employees do not perceive the need to learn, because they have knowledge on how to reach the goal without errors.

Research concerning the predictive value of the severity of the consequences of an error on learning from error emphasizes the hypothetical nature of Erma's error incident (Chapters 4 and 5). Erma discussed the error incident in front of her department for a second time to find ways to prevent similar errors from reoccurring. There seemed, however, no urgent reason for Erma to engage in such behavior, because her earlier actions had already made sure that the damage had been minimized. Findings from the empirical field study show that employees learn more from errors when negative consequences appear. Employees communicate and learn more from errors when the consequences are more severe. When the consequences are more severe, there is higher generation of new insights and ideas and higher implementation of improvements in the weeks following the error incident. The findings suggest that employees do not automatically learn from their errors. Rather, employees communicate and learn from errors when the negative consequences make it necessary for them to do so. This finding supports Cannon and Edmondson's (2005) line of reasoning, that small deviations from expected outcomes are often overlooked because they appear too insignificant to make use of their learning potential.

Theoretical Implications and Directions for Future Research

In line with Schein's (1992, 1993) theoretical work on organizational culture, this dissertation demonstrates that underlying levels of organizational culture can be a significant barrier or stimulant for learning in organizational contexts. Research into the error assumption framework shows that an optimal learning culture requires specific types of assumptions. An optimal environment for learning from error calls for assumptions that reflect tolerance as well as decisiveness towards errors. The finding that shared tolerance towards errors alone is not sufficient for the creation of an optimal learning culture extends research that focuses on non-punitive approaches towards error (Firth-Cozens, 2001, 2004; Helmreich & Meritt, 2000; Leape et al., 1998). Although tolerance towards errors is an essential prerequisite for learning, employees do not learn from error on a structural basis unless organizational assumptions
prompt them to do so. Organizational decisiveness towards errors is needed to harvest the benefits of openness about errors.

This conclusion is strengthened by the findings reported in Chapters 4 and 5. Results showed that an error in itself in not automatically grasped as a learning opportunity. Instead the degree of negative consequences that results from the error is a major stimulant for employees to learn. Similarly, in research into organizational failure, it is argued and demonstrated that 'smaller failures' often do not lead to learning (Baumard & Starbuck, 2005; Cannon & Edmondson, 2005; Sitkin, 1992). Baumard and Starbuck, for example, showed that small and moderate failures did not stimulate people to try and identify potential problems. Severity of consequences, however, is not an appropriate criterion for learning because the same error may result in a variety of consequences, depending on the context in which the error occurs. Employees thus need to be guided by organizational assumptions that facilitate learning from errors that do not necessitate learning at first sight.

After the occurrence of Erma's error, for example, additional action to learn from the error may not have seemed crucial. The action patterns involved when drawing up tenders were in principle well-known to Erma. Learning from error was thus, in principle, not necessary for her to perform the same action correctly in the future. Furthermore, the negative consequences did not trigger a learning effect because they were minimized successfully. Nonetheless, Erma decided to talk about and learn from her error to find a way to prevent the same error from reoccurring.

Now that the relationships between organizational culture and learning from error have been established, the focus needs to move towards research that increases our understanding as to why assumptions reflecting tolerance and decisiveness lead to optimal learning. The knowledge-sharing process should be considered when unraveling the relationship between the error assumption framework and learning from error. In Erma's case, for example, there was no instant way of eradicating calculation errors from health insurance tenders. Discussion about Erma's error during the work meeting led to an exchange of information from which plans were developed to prevent similar errors from happening in the future.

There is theoretical support for the proposition that the predictive power of the error assumption framework on learning can be clarified by including the knowledge-sharing process as a mediator. Organizational culture is recognized as an important predictor of knowledge sharing (O'Dell & Grayson, 1998). They argue that, unless an organizational culture provides a supportive climate for knowledge transfer, knowledge sharing will be limited. Communication about errors and error analysis are considered practices that contribute to the development of shared knowledge about errors (Carroll, 1998; Edmondson,
1996; Van Dyck et al., 2005). In Chapters 4 and 5, it was shown that the two concepts were significantly related to learning over time. A promising direction for future research would, therefore, be to investigate whether the process of knowledge sharing explains the relationship between the error assumption framework and learning from error. Such a study has the potential to clarify and strengthen the theoretical argument as to why certain types of error assumptions lead to optimal learning. Moreover, a better understanding of the underlying process that leads to learning will facilitate the development of effective strategies to meet the challenge of creating optimal learning cultures.

A first step could be to establish knowledge sharing as a mediator in a controlled setting. To conduct such an experiment, one could form small workgroups. In the following steps, one could (1) manipulate the group's error culture (organizational tolerance × organizational decisiveness) comparable to the one used in Chapter 2, followed by (2) individual, error-prone subtasks; after which there is (3) a possibility for an exchange of knowledge with the group about the errors they made during their individual tasks. This discussion could be video-taped and rated for the degree and quality of knowledge sharing. The experiment could be concluded by (4) a sub-task comparable to the one the participants performed earlier to measure learning from error.

It would also be of interest to continue research into the relationship between attribution processes and learning from error. As far as we know, ours is one of the first studies in which the predictive value of attribution processes on error handling and learning has been investigated. From a theoretical perspective, it is appealing to continue research into error attribution, because this process may influence behavior after errors occur at the organizational level. Scholars have argued that socialization with the organizational culture may lead to shared attribution styles (Furnham, Sadka & Brewin, 1994).

Given the sparseness of research into the relationship between attribution processes and learning from error, and the intriguing results of perceived personal control on learning, we would recommend taking a closer look at the findings concerning perceived personal control in this dissertation (Chapters 3 and 4). In Chapter 3, we showed that the positive effects of perceived personal control after failure (for an overview see Försterling, 1985) also generalize to behavioral practices after error occurrence. Perceived personal control after error occurrence was positively related to learning practices. The perception of personal control was positively related to the quality of the proposed strategies for future action. In the empirical field study (Chapter 4), however, employees generated more insights and ideas when perceived personal control was low.

Both the positive as well as the negative relationship between perceived personal control and learning findings are supported by the literature. In literature on success and
failure attribution (theory of motivation and emotion, Weiner, 1985; theory on self efficacy, Bandura, 1982; theory of learned helplessness, Abramson, Seligman & Teasdale, 1978) perceptions of control are seen as desirable, because they lead to functional task behavior after error occurrence (Chapin & Dyck, 1976; Fowler & Peterson, 1981; Schunk, 1981, 1982). Similarly, Van Dyck (2007a) found that making suggestions for improvement after error occurrence which were under the control of the participant led to enhanced learning and performance.

In literature on organizational learning, on the other hand, lack of control is considered to be a prerequisite for learning (Fiol & Lyles, 1985). The suggestion is that learning is triggered by events that cannot be tackled within the customary framework of doing things. It is argued that ambiguity and insufficiency of solutions make learning more likely (Miller & Friesen, 1980). Similarly, Cannon and Edmondson (2005) argue that people have a basic desire to believe that they have control over unsuccessful actions. This illusory perception of control may discourage rather than encourage people from learning, as it implies that people feel they are able to prevent the same error from reoccurring without additional learning.

Each of the two findings is thus supported by a different school of thought. Together, the findings concerning perceived personal control do not suggest a dominance of one theory over the other. Additional research into the juxtaposition of these findings would be valuable, as it would help extend the theoretical understanding of the influence of perceived personal control on learning as well as of the applicability of the underlying theories.

Future research into the predictive value of perceived personal control on learning should be aimed at preventing a potential confound that may have influenced the current findings. The setting of the laboratory made close control over the attribution process possible. The experiment was designed in such a way that variance in severity of consequences between participants was minimized. Moreover, in the laboratory experiment, participants were asked to play levels of a video game. The worst thing that could happen after error occurrence was engaging in a new attempt to finish a level of the computer game. Severe error consequences were therefore not possible in the experiment.

In contrast to the experimental study, variance in the degree of negative consequences could not be controlled for in the field sample. Moreover, it was possible that errors in the field study led to quite severe consequences. Although the participants were asked explicitly to engage in causal attribution of error causes in the field study, we were unable to determine whether they actually did so. Therefore, it is possible that participants engaged in attribution over the negative outcomes of the error (i.e., the severity of consequences) rather than error causes. The significant relation would then relate to a lack of perceived personal control over
the negative outcomes of the error, rather than to a lack of perceived personal control over the error cause.

In Chapters 4 and 5, the results indicated that the severity of the consequences had considerable impact on learning from error. Severity of consequences is positively related to communication, analysis and learning from error. At first sight, these results allow room for rather pessimistic thoughts about learning from error in organizational contexts. It would be a shame if employees only learn from error when consequences are severe. The positive relationship between severity of consequences and learning from error may suggest that opportunities to learn from similar errors without negative consequences are not seized. The severity of consequences of similar errors is highly variable, depending on the situation in which they occur (Van Dyck, 2000). Moreover, error incidents without negative consequences occur much more frequently than errors with severe consequences (Ramanujam & Goodman, 2003).

These results, however, could be idiosyncratic, because the research focused on a single organization. It would be interesting to include both the error assumption framework and severity of consequences in a study, to see how the two interrelate and influence subsequent error handling and learning from error. In Chapter 2, we argued that a tolerant yet decisive mindset towards errors promotes *minimization* of negative error consequences and *maximization* of learning from error. In organizations that are characterized by a tolerant yet decisive mindset towards errors, the impact of severity of consequences on error handling and learning may thus not be all that prominent when compared to the other three culture typologies. It seems likely that organizations that are characterized by types of assumptions that reflect tolerance and decisiveness also learn from those errors that form the 'early warning signs' that should be taken seriously if similar incidents with highly severe consequences are to be avoided (Cannon & Edmondson, 2005; Sitkin, 1992). In organizations in which less constructive mindsets towards error prevail (e.g., an intolerant and indecisive mindset towards error) learning from errors can be absent, unless severe consequences convince people that existing routines need to be improved or modified.

However, it should not be ruled out that severity of consequences may have an independent effect on learning from error. Research conducted by graduate students at the VU University of Amsterdam yields additional support to the relationship between severity of consequences and communication about error, and learning from error. Research conducted at a waste-disposal facility, local tax authority and three health care institutions consistently showed a considerable impact of severity of consequences on subsequent communication and learning from error (De Vrij, 2006; Harkema, 2006; Ter Laak, 2007; Schutte-Van Rijsinge, 2006).
In this dissertation, evidence was found in support of the proposition that learning depends on the nature of the error. Errors that are made in relative complex or new tasks led to higher learning than errors that occur during routine actions. Learning from error is thus dependent on the level of intellectual exertion invested in the erroneous actions. Future research into the nature of the error could offer a valuable extension as to clarify under what circumstances employees learn. A better understanding of the relationship between the nature of an error and learning can lead to the development of custom-made strategies to utilize the positive function of various types of errors successfully.

In my opinion, future research should incorporate additional genotype characteristics that may interplay and influence behavior after error occurrence. Reason's (1990) slips-lapses-mistakes categorization differentiates errors at the level of regulation as well as in various phases in the action process. Based on this categorization, Reason argues that certain errors are likely to have more far-reaching consequences than others, "mistakes are likely to be more subtle, more complex and less well understood than slips. … [and] constitute a far greater danger" (p. 9). He argues that a mistake is an error type that can be categorized at the intellectual level of regulation and is related to deficiencies involving the selection of plans to attain a certain goal. Mistakes are thus categorized in the planning phase of the action process. Slips and lapses, on the other hand, are considered lower regulation level activities associated with storage and execution stages of the selected action plan.

Incorporation of the classification of errors in various phases of the action process can be a fruitful way of further investigating the effect of the genotype characteristics on subsequent learning. Exploration of the assumed interplay between level of regulation and action process on subsequent behavioral practices is best performed in a controlled setting, because the nature of the error may depend on the organizational setting. The study to which we referred in Chapter 5 revealed an uneven distribution of errors at the level of regulation. An experimental design renders the opportunity to control the type of task and likely error types which could prevent unequal distribution on the level of regulation and action process.

To carry out such an experiment, four conditions could be created by developing tasks that vary in the level of regulation (flexible versus intellectual) and are error-prone in different phases of the action process (planning stage versus storage and execution phase). Subsequently, learning could be measured by allowing participants to share knowledge after error occurrence with a collaborator who supposedly works on the same task.

Practical Implications
We would argue that learning from error is valuable for all organizations. Organizations in which a single error do not immediately prompt catastrophes can also benefit from error. The
Dutch construction business, for example, loses 20 percent of its annual turnover due to errors (USP Marketing Consultancy, 2005). Errors varying from flaws in architectural designs to the purchase of the wrong colored kitchen tiles lead to an annual debit of € 5 billion. A reduction of as little as one percent through learning from error would lead to an annual cost reduction € 50 million.

This statement is supported by viewpoints expressed by employees who are engaged in managerial practice. In the past four years, we were involved in numerous project-related conversations with organizational staff, executives and supervisors. One thing that became clear during those conversations is that every single executive we met recognized the importance of learning from error. Whether they were active in garbage disposal units, tax authorities, health care or in the chemical process industry, every executive valued learning from error.

Leaders, however, vary in their approach to learning from error. Managers of "Insur" and "Sale", for example, explicitly signaled to their subordinates that errors were not tolerated, whereas managers of "Tech" and "Admin" valued tolerance towards errors (See Chapter 2). The findings presented in Chapter 2 suggest that an optimal environment for learning from error includes assumptions that reflect tolerance as well as decisiveness towards errors. Leaders should stimulate tolerance and decisiveness towards errors, because they have an exemplary function when it comes to creating a culture that encourages people to learn from their errors. The reactions from leaders are powerful signals that serve as a guide for subordinates in their everyday practices (Schein, 1992). The in-depth study at the health care institution (Chapter 2) provided a clear example of this. The manager of the 'isolated' location successfully anchored a mindset that enabled learning from error by prioritizing tolerance and decisiveness about errors. By consistently acting upon the assumption that "an error means that there still is something to be learnt", he presented a clear guideline for his subordinates on how to act whenever an error occurred.

Although we acknowledge that it is not easy to change certain aspects of an organization’s culture, the example presented above indicates that it is possible. We would argue that the error assumption framework forms a tangible tool for organizational members to start thinking about their enacted mindset towards errors. The creation of conditions under which people can openly share their perspectives about errors may constitute an important step towards a mindset that promotes learning. Groups that are able to reflect upon and communicate about their objectives and strategies become aware of the underlying reasons for their actions and are able to learn (Schön, 1983; West, 2000).

Another important implication deals with the importance of learning from errors that do not lead to negative consequences. In the introductory chapter, Erma's error incident
provided an example of the best way to deal with errors. Based on Erma's error incident we argued that learning from error is essential because similar errors can differ in their degree of consequences depending on the situation in which they occur. In Erma's case the error incident did not lead to permanent damage, but the consequences could have been severe if the context or handling of the error had been slightly different. In this dissertation, the results showed that it is especially those errors with severe consequences that stimulate learning (Chapters 4 and 5). We would argue that leaders should create awareness among their subordinates that the degree of negative consequences is not a valid standard for learning from error. Rather, leaders should emphasize that errors with insignificant negative consequences may form the early warning signs that should be taken seriously if future catastrophic incidents are to be avoided (see Sitkin, 1992).

Managers should create opportunities for their employees to engage in structural communication regarding errors. This dissertation shows that communication is one of the most important requisites for learning from error. The results also suggest, however, that employees do not automatically share knowledge about errors (see Chapter 4). Motivating employees to interact and discuss errors openly may promote new ideas that lead to the future prevention of errors or even pave the way for innovational activities.