SELF-REGULATORY PROCESSES IN ERROR MANAGEMENT TRAINING

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Abstract

Error management training is an active training approach. In contrast to traditional error avoidant trainings that provide detailed tasks instructions in order to prevent errors during training, error management training encourages participants to make errors and to learn from them. Although many studies have shown error management training to lead to better performance than error avoidant training, several issues concerning the effectiveness of error management training remain unsolved. The present dissertation compiles three studies that aimed to illuminate the psychological processes underlying the effectiveness of error management training and the conditions that promote or restrict its effectiveness.

Study 1 tested the notion that self-regulatory processes (emotion control and metacognitive activity) mediate the effectiveness of error management training. It further explored whether a new variant of error management training designed to enhance metacognitive activity leads to a performance increment. Fifty-five volunteer students learned a computer program under 1 of 3 conditions: error avoidant training, error management training, or a variant of error management training that included a metacognitive module. As predicted, both forms of error management training lead to better transfer performance than error avoidant training (d=0.75), but the two error management training groups did not differ. Mediation hypotheses were fully supported: Emotion control (assessed with a self-report questionnaire) and metacognitive activity (assessed with a measure derived from verbal protocol analysis) mediated performance differences. These findings highlight the potential of promoting self-regulatory processing during training.

Study 2 compared error management training and error avoidant training, with a focus on interactions between cognitive ability and training condition. It also explicitly distinguished training from transfer performance. Participants were 110 volunteer university students who learned a computer program in 1 of the 2 conditions. As predicted, error avoidant training led to better immediate training performance than error management training, but this effect was reversed for novel transfer tasks. Further, interactions of training and cognitive ability emerged as expected: Cognitive ability predicted training performance in both error management and error avoidant training, but it predicted transfer performance only in the error avoidant training group. This pattern of results is consistent with resource allocation models which suggest that with practice, tasks become less dependent on cognitive ability.

Study 3 meta-analyzed 23 studies (N=1981) that evaluated error management training against alternative trainings. The overall mean effect size was positive (Cohen's d=0.44). As hypothesized, effect sizes tended to be larger for tasks with clear feedback (d=0.57) and were significantly larger for test than for training performance (test performance: d=0.58), for transfer tasks that were dissimilar from training tasks (d=0.80), and when guided trainings were the alternative training (d=0.65). Error management training was also more effective than unguided trainings without error management instructions (d=0.21). To maximize benefits, these moderating factors should be considered when designing error management training.

The present studies demonstrate that integrating errors explicitly into training rather than avoiding them can be a fruitful approach to promote performance on novel transfer tasks. Elements of error management training may be incorporated into existing training forms such as behavior modeling, because learning from errors possibly leads to more flexible and adaptable behavior than practicing only correct behaviors. Future research could also examine whether participants of error management training apply the self-regulatory skills learned in training (emotion control and metacognitive activity) to work tasks that are seemingly unrelated to the particular training content.

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1 INTRODUCTION

Much has been written and said about the changing nature of work. Both the popular media and scientific papers have embraced topics such as globalization, rapid technological advancement, mergers/acquisitions and organizational restructuring, and the putative consequences of these phenomena for individuals and organizations. One major consequence seems to be agreed upon: Work requirements are constantly changing, and today's workforce is faced with the necessity to flexibly adapt to these changing demands (e.g., Frese, 1997; Hesketh, 1997; Hesketh & Ivancic, 2002; Ilgen & Pulakos, 1999; Kraiger, 2002; Pulakos, Arad, Donovan, & Plamondon, 2000; Quinones & Ehrenstein, 1997; Sonnentag & Frese, 2002; Wexley & Latham, 2002). Accordingly, training research has begun to turn its attention to training forms that seem most qualified for promoting adaptability in trainees. Active learning approaches have been proposed as training forms that may be particularly well suited to promote adaptability (Hesketh & Ivancic, 2002; Smith, Ford, & Kozlowski, 1997). The present dissertation deals with one particular active learning approach, namely with error management training.

Active learning approaches regard trainees as active participants of the learning process rather than as passive recipients of instruction (Bruner, 1966; Frese & Zapf, 1994; Greif & Janikowski, 1987; Hesketh & Ivancic, 2002). Correspondingly, direct instruction is reduced to a minimum. In contrast, participants are encouraged to explore and experiment with the task in order to learn its principles and strategies for effective performance. Error management training differs from other active learning approaches as it places a greater emphasis on errors during training. Errors are regarded as informative feedback that helps to improve one's knowledge and skills. In line with this positive view of errors, participants of error management training are encouraged to use their errors as learning devices while they work on difficult training tasks (Dormann & Frese, 1994; Frese, 1995; Frese et al., 1991; Heimbeck, Frese, Sonnentag, & Keith, 2003; Ivancic & Hesketh, 1995/1996; Wood, Kakebeeke, Debowski, & Frese, 2000).

The positive view of errors adopted in error management training is rather unusual in the training literature. Most training approaches are silent on the subject of errors, and some scholars even take an explicitly negative view of errors. They assume that errors lead to inefficiencies, wrong habits, and emotional frustration. A famous example is Skinner (1953) who equated errors with aversive stimuli that do not contribute to learning and should therefore be avoided during training. Many traditionally oriented training forms aim to eliminate the possibility of errors, for example, by means of a tight training structure and detailed instructions on task solution – an error avoidant approach that stands in contrast to principles of error management training (Ivancic & Hesketh, 1995/1996).

Error management training on the one hand and error avoidant training on the other hand represent two general strategies of dealing with errors that can be adopted during training (Figure 1; Frese, 1995): The *error prevention* approach aims to reduce the number of errors; error prevention tries to erect a barrier between the action and the potential error. The *error management* approach argues that errors are ubiquitous and cannot be completely avoided, even by experts (Prümper, Zapf, Brodbeck, & Frese, 1992). Furthermore, error management implies that the error itself needs to be distinguished from potential negative consequences of the error: The error itself does not have to be avoided at all costs but the negative consequences that may occur if errors are not effectively dealt with. Thus, error management attempts to erect a barrier between the error and its negative consequences.

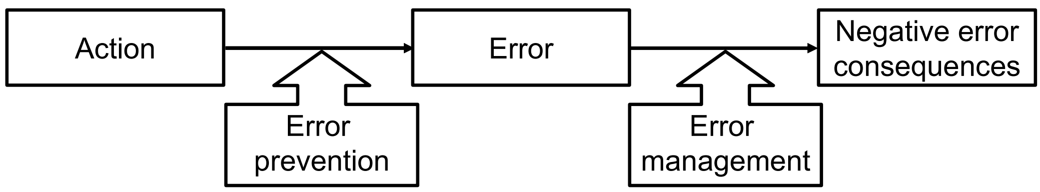

Figure 1. Two strategies to deal with errors: Error prevention and error management (adopted from Frese, 1995).

It should be noted that the concept of error management does not deny the importance of error prevention at the workplace – errors can lead to negative consequences for individuals and organizations and should therefore be avoided. Yet, because not all errors can be avoided, error management emphasizes the importance of dealing effectively with errors *after* they have occurred (van Dyck, Frese, Baer, & Sonnentag, in press). Particularly during training, when knowledge and skills are not well developed, errors are almost inevitable. Additionally, errors during training are informative, because they show what part of one's knowledge and skills still needs to be improved (Fisher & Lipson, 1986). Thus, the error management approach does not gloss over errors but takes them seriously.

Error management training is expected to promote adaptability, because it offers participants – to a higher extent than traditional trainings – the opportunity to practice strategies that are helpful for solving novel transfer tasks (Frese, 1995; Heimbeck et al., 2003; Hesketh, 1997; Ivancic & Hesketh, 1995/1996). The transfer environment opens up the possibility to make errors, because trainees often have to work on novel tasks without additional external guidance. For participants of traditional error avoidant training, this transfer situation imposes new demands compared with the training situation, because they have been protected from making errors during training. Participants of error management training, however, who had the opportunity to make errors during training and to develop effective strategies to deal with them, may be better equipped to master the novel transfer tasks.

In line with these arguments in favor of error management training, several studies have shown error management training to lead to better performance than error avoidant approaches in moderately to highly difficult transfer tasks (Chillarege, Nordstrom & Williams, 2003; Dormann & Frese, 1994; Frese et al., 1991; Heimbeck et al., 2003; Ivancic & Hesketh, 2000; Nordstrom, Wendland & Williams,, 1998; Wood et al., 2000). Yet, several issues concerning the effectiveness of error management training remain unsolved. For example, what are the psychological mechanisms underlying the effectiveness of error management training? How does cognitive ability of participants relate to performance in error management training? What are the boundary conditions for the effectiveness of error management training? This dissertation addresses these and further questions in three empirical studies which are reported in the chapters that follow.

Overview of the following chapters

The present dissertation comprises three empirical studies that focus on different aspects of error management training. These studies are reported in the following three chapters (Chapters 2-4). They can be read independently from each other (i.e., the chapters contain separate theoretical introductions and discussions).

Study 1 (Chapter 2) is concerned with the processes in error management training that are crucial for its effectiveness. The main line of argument is that error management training, more than traditional training approaches, fosters the acquisition of self-regulatory skills during training that are useful when participants are confronted with difficult and novel transfer tasks. These self-regulatory skills comprise both emotional control aimed at reducing potential negative emotions, and cognitive control (i.e., metacognitive activity) aimed at inducing mindful planning, monitoring, and evaluation processes while working on the tasks. This proposition is tested in a training experiment that compares traditional error avoidant training with error management training in which participants learn a new computer program. Study 1 also explores whether a new variant of error management training which includes additional instructions to enhance metacognitive activity leads to incremental performance effects.

Study 2 (Chapter 3) also deals with processes during training but in a more indirect manner. It proposes that the cognitive processes that participants engage in during error management training (but not during traditional error avoidant training) resemble the processes during transfer, and that, therefore, performance on transfer tasks becomes less dependent on cognitive-attentional resources. In line with this theoretical proposition, cognitive ability is expected to lose its predictive power for participants of error management training (but not of traditional error avoidant training) for performance on transfer tasks. In other words, this study predicts an interaction of cognitive ability and training form on transfer performance. Furthermore, this chapter is explicit about the distinction between training and transfer performance – a distinction that is often neglected in studies dealing with error management training. Like Study 1, Study 2 is a training experiment that compares error management and error avoidant training. The training content and material are adopted from Study 1.

The third study (Chapter 4) is a meta-analysis based on all available published and unpublished studies that compared error management training with an alternative training (including the two studies from Chapters 2 and 3 of this dissertation). The aim of this meta-analysis is to arrive at an estimate for the overall effectiveness of error management training and to identify moderators that affect the magnitude of the effect sizes. The potential moderators that are examined include the type of performance assessed in the studies (e.g., training vs. transfer performance), the similarity of training and transfer tasks, the feedback provided in tasks, and the type of training that error management training is compared with.

Chapter 5 summarizes the results and major conclusion drawn from the empirical studies, and it discusses further implications for theory and practice as well as directions for future research.

2 Self-Regulation in Error Management Training: Emotion Control and Metacognition as Mediators of Performance Effects

"Errors are great because you learn so much from them!" – Such a statement stressing the positive function of errors may sound quite ironic for many of us, given the rather negative view of errors generally held in society. Early in school we learn that errors are punished by poor grades, and workplace errors can have severe consequences for individuals and organizations, and may even lead to catastrophes such as the Chernobyl meltdown. From this point of view, there is nothing good about errors. From a psychological perspective, however, errors make it possible to learn (Fisher & Lipson, 1986). This is the perspective taken by proponents of error management training: Errors provide informative feedback and should, therefore, be explicitly incorporated into the training process (Heimbeck et al., 2003). Consequently, training participants are exposed to many errors during the training situation and are encouraged to use these errors as a learning device by means of positive error statements such as the one in the opening sentence.

Error management training studies have shown that error management training leads to better performance by participants than error avoidant training, which is designed to prevent participants from making errors, when learning new computer programs (Chillarege et al., 2003; Dormann & Frese, 1994; Frese, 1995; Frese et al., 1991; Heimbeck et al., 2003; Nordstrom et al., 1998). Others have added to these findings, for example, by applying error management training to driving simulation training (Ivancic & Hesketh, 2000), by comparing error management training with behavior modeling (Debowski, Wood, & Bandura, 2001; Wood et al., 2000), and by testing aptitude-treatment interactions of training condition and person characteristics (Gully, Payne, Koles, & Whiteman, 2002; Heimbeck et al., 2003). Despite the growing body of research dealing with error management training, evidence illuminating the psychological mechanisms underlying its effectiveness remains scarce. Only a few studies explicitly looked at potentially mediating processes (Debowski et al., 2001; Wood et al., 2000), and none of these arrived at conclusive results. Our study aims to fill this gap by using both questionnaire and verbal protocol data to identify mediating processes in error management training.

The present study contributes to the existing research in the following ways: First, it replicates existing error management training studies. Second, the major focus of our study is on processes mediating the effects of error management training on task performance. More specifically, we argue that error management training – but not error avoidant training – stimulates self-regulation of emotions (i.e., emotion control) and self-regulation of cognitions (i.e., metacognition) during skill acquisition. We further propose that the quality of these self-regulatory processes determines later task performance. This argument is consistent with educational theory stressing the importance of metacognition in self-regulated learning (e.g., Schunk & Zimmerman, 1994) and with Kanfer and colleagues' resource allocation perspective in skill acquisition (e.g., Kanfer & Ackerman, 1989). Third, we present and test a new variant of error management training specifically designed to enhance metacognitive activity. To our knowledge, no study has explicitly tried to systematically change elements of error management training in order to improve its effectiveness. In the following, we will briefly describe the basic concepts underlying error management training. Then, we will discuss processes that potentially mediate the effectiveness of error management training.

2.1 The Concept of Error Management Training

The basic principle of error management training is that participants are given opportunities to make errors during training. Participants are provided with only minimal information (e.g., information about the functions of the computer program to be learned) and are then given the opportunity to individually explore the system. It can be generally stated that errors occur during goal oriented behaviour, that they imply that a goal has not been reached, and that they could have been potentially avoidable (Zapf, Brodbeck, Frese, Peters, & Prümper, 1992; Frese & Zapf, 1994; Reason, 1990). In error management training, for example, if the goal of a participant is to enlarge an object that is visible on the computer screen, and if he or she instead moves this object, this would be an error. Errors can, in principle, be distinguished from inefficient actions, because inefficient actions still lead to the goal. However, inefficient actions can be conceived as erroneous when it is assumed that most people hold a standard of efficiency. In error management training, inefficient actions can occur as well. For example, if the task was to insert three additional columns into an existing table, and if the participant first deleted the whole table and then inserted a new table with the desired number of columns, this would be inefficient and considered an error although the goal has been reached.

Error management training is similar to exploratory learning (Bruner, 1966) which emphasizes the importance of allowing the learner to actively explore ideas and to test them (e.g., Greif & Keller, 1990). There are two characteristics of error management training, however, that show its greater emphasis on making errors and using them as a learning device, compared with classical approaches to exploratory learning. First, in contrast to exploratory training, error management training tasks are quite difficult right from the start, thereby exposing participants to many error situations (Heimbeck et al., 2003; Hesketh & Ivancic, 2002). Since explicit training tasks are given, participants have clear external objectives during training, whereas pure discovery methods often lack this kind of structure (Mayer, 2004). The second characteristic of error management training is that participants are explicitly informed about the positive function of errors during training and are presented error management instructions to reduce potential frustration in the face of errors (Dormann & Frese, 1994; Frese, 1995). Error management instructions are brief statements such as "Errors are a natural part of the learning process!" or "The more errors you make, the more you learn!", designed to frame errors positively (Frese et al., 1991). Error avoidant training, on the other hand, mimics many conventional tutorials adopting a negative attitude toward errors: Step-by-step instructions are provided to prevent errors from occurring, and participants are not informed about the positive functions of errors (Frese, 1995).

In several training experiments, error management training that included error management instructions proved superior to error avoidant training across diverse participant samples (students as well as employees), training contents (e.g., computer training, driving simulator training) and training lengths (1-hour training to 3-day training sessions). These training experiments comprised one or more training phases and subsequent test phases which assessed performance in terms of number of correct task solutions (Chillarege et al., 2003; Debowski et al., 2001; Nordstrom et al., 1998; Wood et al., 2000), ratings of correctness, efficiency, and speed of solutions in difficult tasks (Dormann & Frese, 1994; Frese et al., 1991), or number of errors in transfer tasks (Ivancic & Hesketh, 2000). A recent study by Heimbeck et al. (2003) highlighted the crucial role of error management instructions in error management training: Error management training was superior not only to error avoidant training but also to pure exploratory training without error management instructions. Thus, according to this study, only the combination of providing participants (1) with ample opportunities to make errors, and (2) explicit encouragement to learn from their errors by means of error management instructions improved task performance.

Error management training is not expected to affect all types of learning outcomes at any time. First, error management training aims at improving performance *after* (as opposed to *during*) training. That is, most error management training studies differentiate one or more *training* phases from later *test* phases. During training, participants are encouraged to make errors. During the test phase, however, participants are aware that their performance is being assessed (e.g., Wood et al., 2000). This distinction is crucial, given that manipulations positively affecting training performance may negatively affect performance in the long run and vice versa (Goodman, 1998; Hesketh, 1997; Schmidt & Bjork, 1992). In other words, error management training aims to improve transfer performance, not training performance. In fact, training performance may be worse in error management training in terms of error rate, efficiency, or training time because participants are not directly guided to correct solutions; rather they experiment, explore, make errors, and sometimes arrive at wrong solutions.

Second, error management training should affect different types of transfer tasks differentially. Transfer implies that "knowledge, skills and attitudes" are "transferred from one task or job to another" (Hesketh, 1997, p. 318). Two types of transfer can be distinguished (Ivancic & Hesketh, 2000): (1) *Analogical transfer* refers to problem solutions that are familiar or analogous. (2) *Adaptive transfer* entails "using one's existing knowledge base to change a learned procedure, or to generate a solution to a completely new problem" (Ivancic & Hesketh, 2000, p. 1968). From a practical perspective, adaptive transfer is most relevant, because not all potential work-related problems and solutions can be taught during training (Hesketh, 1997; Kozlowski et al., 2001). For example, not all functions of a new word processing program can be explained during a one-day training. Back on the job, however, training participants may encounter unexpected problems while working with the word processing program and, in contrast to the protected training situation, might not have any assistance at all. In this respect, error management training resembles the transfer situation more than error avoidant training – an issue that is captured in the principle of transfer appropriate processing which postulates that those processes required on transfer tasks should be practiced in training (Morris, Bransford, & Franks, 1977).

We expect error management training to be particularly effective in promoting adaptive transfer, because participants learn to deal with unexpected problems during training. For analogical transfer, the prediction is less clear. As outlined by Ivancic and Hesketh (2000), errors made during training may facilitate the retrieval of similar problems and their solutions, thereby promoting analogical transfer. On the other hand, error avoidant training might be as successful for analogical transfer as error management training: In order to solve analogical problems, participants of error avoidant training only need to apply the correct strategies they learned during training to the new (but analogous) problem. Therefore, we expect analogical transfer to be the same in both error management training and error avoidant training. This prediction is consistent with the results of prior error management training studies. For example, Heimbeck et al. (2003) predicted and found group differences only for difficult tasks but not for easy tasks (cf. Dormann & Frese, 1994; Frese, 1995). They argued that performance in easy tasks should not benefit from error management training, because easy tasks require only a low degree of skill and do not lead to many errors. In sum, we expect to replicate the group difference in adaptive transfer that has been found in earlier studies.

Hypothesis 1: Error management training leads to better adaptive transfer than error avoidant training.

2.2 Processes in Error Management Training

Several mechanisms for the effectiveness of error management training have been proposed in the literature, although only few studies have attempted to directly test these potential mechanisms. Two groups of mechanisms have been proposed: (1) Cognition-based approaches highlight the function of exploration and associated deeper level processing during training (Dormann & Frese, 1994; Heimbeck et al., 2003). Additionally, other authors suggest that metacognition is important (Ivancic & Hesketh, 2000). (2) Emotion/motivation-based approaches investigate the emotional or motivational processes potentially facilitating or debilitating learning during training, such as intrinsic motivation (Debowski et al., 2001; Wood et al., 2000) or frustration (Chillarege et al., 2003; Nordstom et al., 1998).

We do not reject the proposed mechanisms but suggest that these can be integrated in a self-regulatory perspective that acknowledges the significance of both cognitive and emotional processes in error management training. Self-regulation refers to processes "that enable an individual to guide his/her goal-directed activities over time", comprising "modulation of thought, affect, behavior, or attention" (Karoly, 1993, p. 25). In error management training, self-regulatory processes are particularly important due to the low degree of structure and the lack of external guidance (Schmidt & Ford, 2003). We argue that participants in error management training learn to use self-regulatory skills that prove valuable when confronted with new problems not practiced in training – problems that require adaptive transfer (Ivancic & Hesketh, 2000). In the following, we will refer to emotion control and metacognition as two self-regulatory skills mediating error management training effectiveness.

2.2.1 Emotion Control in Error Management Training

Emotion control is a skill involving "the use of self-regulatory processes to keep performance anxiety and other negative emotional reactions (e.g., worry) at bay during task engagement" (Kanfer, Ackerman, & Heggestad, 1996, p. 186). Emotion control is expected to and has been shown to be particularly important for learning in early phases of skill acquisition where errors and setbacks are most likely to occur. Failures in emotion control result in impaired learning and performance, because negative emotions divert attentional resources to the self and away from the task at hand (Kanfer &

Ackerman, 1989; Kanfer et al., 1996; Kluger & DeNisi, 1996). Not all types of emotion control processes, however, can be expected to be equally beneficial. For example, mere suppression of negative emotions drains resources (Muraven & Baumeister, 2000) and can result in cognitive deficits, whereas reappraisal of the emotional event, modifying emotions before they unfold, does not (Richards & Gross, 2000). We propose that error management training helps participants to develop and practice beneficial skills of emotion control early on in training because error management instructions frame errors positively and thereby encourage participants to adopt a positive perspective on errors. In error avoidant training, however, participants are prevented from making errors, and this does not prepare them to handle their negative emotional reactions to errors. As a result, when they are confronted with new tasks in the test phase without guidance, they are more likely to encounter negative emotions debilitating their performance. In sum, we expect a mediation effect of emotion control.

> *Hypothesis 2*: Emotion control mediates the effect of training conditions on adaptive transfer in that (a) error management training leads to higher emotion control than error avoidant training, and (b) emotion control positively affects adaptive transfer.

2.2.2 Metacognition in Error Management Training

Notwithstanding the critical role of emotional control processes during skill acquisition, cognitive control processes should also be considered because the mere absence of negative emotions does not quite ensure learning. Rather, the free attentional resources at one's disposal need to be devoted to task-related activities that maximize task learning (Kanfer & Ackerman, 1989). Following theorizing by Ivancic and Hesketh (2000; Hesketh & Ivancic, 2002), we propose that metacognition is powerful in promoting transfer and that error management training fosters metacognitive activity.

Metacognition implies that an individual exerts self-regulatory "control over his or her cognitions" (Ford, Smith, Weissbein, Gully, & Salas, 1998, p. 220), and involves skills of planning and monitoring as well as evaluation of one's progress during task completion (Brown, Bransford, Ferrara, & Campione, 1983; Schraw & Moshman, 1995). Metacognition has been shown to be related to academic achievement (e.g., Pintrich & De Groot, 1990; Schunk & Zimmermann, 1994) and to problem-solving performance (Berardi-Coletta, Buyer, Dominowski, & Rellinger, 1995; Davidson & Sternberg, 1998), and is assumed to be particularly useful in learning environments that provide little external structure or guidance (Schmidt & Ford, 2003). In error management training, metacognitive activities are encouraged because "errors prompt learners to stop and think about the causes of the error" (Ivancic & Hesketh, 2000, p. 1968). Participants then need to come up with solutions to the impasse, implement them, and monitor their effectiveness (Ivancic & Hesketh, 2000). These metacognitive activities can be conceived as higher-order strategies (Ford et al., 1998) that help participants to master new tasks on their own. Error avoidant training, however, does not necessarily offer the opportunity to engage in metacognitive activities because participants are provided with the correct task solutions and do not need to explore the system on their own. In sum, we expect a mediation effect of metacognitive activity.

> *Hypothesis 3*: Metacognitive activity mediates the effect of training conditions on adaptive transfer in that (a) error management training leads to higher metacognitive activity during training than error avoidant-training, and (b) metacognitive activity positively affects adaptive transfer.

The proposed mediation effects of emotion control and metacognitive activity are depicted in Figure 2.

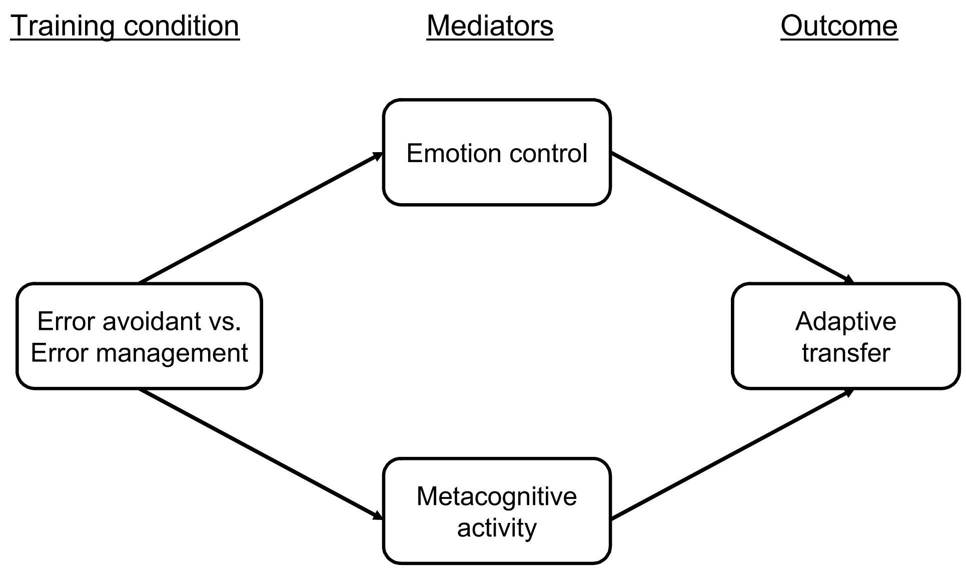

Figure 2. Emotion control and metacognitive activity mediating effects of training condition on adaptive transfer (conceptual model).

In addition, our study aimed to explore whether the effect of error management training could be improved by supplementing error management instructions with additional instructions specifically designed to enhance metacognitive activity. Although we assume that error management promotes both emotion control and metacognitive activity and that these two processes enhance performance, supplementary instructions could be even more powerful: If not all participants spontaneously engage in emotion control or metacognitive activity, additional instructions specifically designed to improve one of these processes may be more effective than error management instructions alone. For emotion control, we would not expect a strong effect of supplemental instructions aimed at improving emotion control because standard error management instructions already have a component of emotional relief (e.g., "There is always a way to get out of an error situation!"), and because prior studies suggest that error management training alone can have an effect on emotional outcomes (Frese et al., 1991; Nordstrom et al., 1998). Thus, an additional effect on the regulation of emotions may be less likely. For instructions specifically designed to enhance metacognitive activity, however, an additional effect seems more likely: When left without further guidance in error management training, some participants may rely on less effective strategies such as unsystematic trial-and-error (van der Linden, Sonnentag, Frese, & van Dyck, 2001). Similarly, Mayer (2004) argues that exploratory training methods can be improved by providing help in guiding participants' cognitive activity in productive directions (cf. Bell & Kozlowski, 2002). Consequently, additional instructions highlighting the benefits of and explaining how to make use of metacognitive activity may direct the participants' attention to more effective strategies and, therefore, be more successful than error management instructions alone. On the other hand, it may be argued that since error management training already is powerful in promoting metacognitive activity, there might not be any more room for an add-on effect of any supplementary instructions. Because of these conflicting expectations on the role of metacognitive instructions, we put forth an open research question:

> Does error management training supplemented by metacognitive instructions lead to better adaptive transfer than error management training alone?

2.3 Method

2.3.1 Participants

Participants were 55 volunteer university students with majoring in education (i.e., primary and secondary education). As an incentive, participants took part in a lottery that was conducted after completion of the study where they could win 1 of 3 monetary prizes (equivalent to about 50, 30, and 20 dollars). The sample was composed of 53 women (94%). Mean age was 23.1 years (*SD* = 5.2). Most participants reported having had work experience (86%), with 27% having worked regularly before they started attending the university and 70% working on regular basis while studying (*M* = 11.6 hours per week, *SD* = 9.2). Participants' experience with computers differed broadly, but none of them had ever worked with the specific software used in this study. This was a prerequisite for participation. Accordingly, when making the appointment for the training session and again directly before the training started, we asked participants whether they had used the program before. Participants were randomly assigned to training conditions.

2.3.2 Experimental Design and Procedure

Participants were trained to create overhead slides with a presentation program (PowerPoint 2000 for Windows) in 1 of 3 training conditions. Sessions were run individually for each participant and lasted two and a half hours (including a 10-minute break). As depicted in Figure 3, sessions comprised (1) an introductory phase (identical for all participants), (2) the actual training phase where the experimental manipulation took place, and (3) a test phase (identical for all participants). The training material and instructions are provided in Appendix A.

Introductory phase. In the beginning, all participants received a 2-page manual containing general information about the program. This manual briefly explained the menu and toolbars, how specific functions can be activated to create objects (e.g., a rectangle), and how existing objects can be modified (e.g., enlarging a rectangle). Also, participants were informed about the undo function of the program. All participants received the same manual so that task information was held constant across training conditions. Reading time was approximately five minutes. Participants were allowed to refer to their manuals during the entire training session (but not during the test phase).

After reading the manual and before the actual training started, participants first worked on a simple slide. In this way they could get accustomed to handling the mouse for creating objects and to thinking aloud while working ("warm-up" exercise for verbalization, Taylor & Dionne, 2000, p. 415). This introductory task included creating and modifying a circle, a rectangle, a text box, and an arrow while following written instructions. The experimenter demonstrated the first few steps. She read the written instructions out loud (e.g., "Click on the icon 'rectangle' in the drawing toolbar.") and then carried out the described actions while verbalizing them. Participants were asked to complete the task following the written instructions while thinking aloud (for instructions on thinking aloud, see below). No time limit was given for the introductory task. Mean time for task completion was 16.80 minutes (SD = 5.04) and did not differ between experimental groups, F (2,52) = 0.21, p = .81.

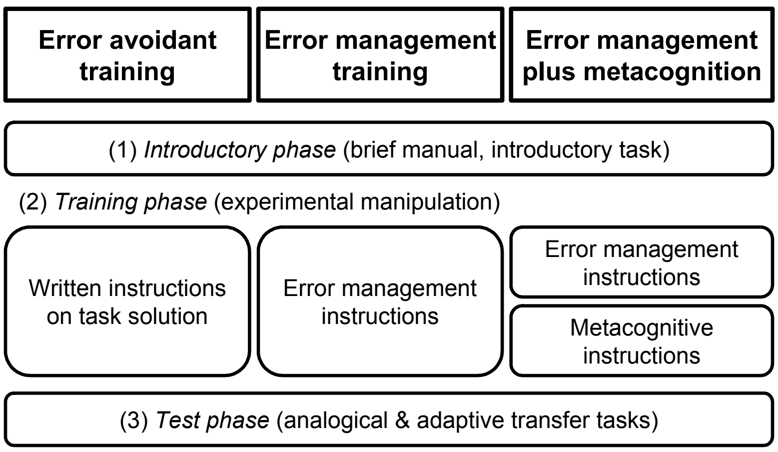

Figure 3. Course of the experiment (Study 1).

Training phase. After the introductory phase, the actual training began in which the training condition was experimentally manipulated. Participants were consecutively given copies of two slides printed on paper. The task was to reproduce these slides as closely as possible. The first slide required creating, moving, and modifying (e.g., coloring) diverse objects such as rectangles, triangles, textboxes, and stars. The second slide involved creating and modifying a table by simple formatting such as coloring cells and centering cell entries. To complete each slide, participants were given 15 minutes, resulting in a training time of 30 minutes. Those participants who finished the two slides before the training time was up received a third slide to work on during the remaining time. This third slide looked different than the former ones but required program functions similar to those already used. The number of participants who worked on the third slide did not differ between experimental groups, F (2,52) = 1.14, p = .33.

Participants completed the training tasks in 1 of 3 training conditions: error avoidant training, error management training, or error management training supplemented with a metacognitive module. In the *error avoidant training* (n = 18), participants received detailed written instructions (similar to those in the introductory practice phase) explaining task solution in a step-by-step manner. This training condition resembled commercially available software tutorials. Participants were asked to follow the instructions closely. They were told that these instructions would enable them to learn the most important program functions in the shortest time, and that by following the instructions participants would become familiar with the correct functions from the very beginning.

In the *error management training* condition (n = 17), participants were not provided with any information on task solution. They received instructions emphasizing the positive function of errors during training and were encouraged to make errors and learn from them. Additionally, the following error management instructions derived from earlier error management training studies were presented (cf. Heimbeck et al., 2003; Debowski et al., 2001; Dormann & Frese, 1994; Wood et al., 2000): "Errors are a natural part of the learning process!", "There is always a way to leave the error situation!", "Errors inform you about what you still can learn!", and "The more errors you make, the more you learn!". During training, the error management instructions were prominently displayed on a poster and verbally repeated by the experimenter.

Participants in the *error management training plus metacognition* (n = 20) condition initially received exactly the same treatment as participants in the error management training condition. That is, before they worked on the first training slide, they were not provided with any information about the task solution but were given instructions emphasizing the positive function of errors and error management instructions. When the participants worked on the second training slide, however, treatment differed in that participants received additional instructions designed to enhance metacognitive activity. These metacognitive instructions were derived from a study conducted by King (1991; cf. also McInerney, McInerney, & Marsh, 1997; Schmidt & Ford, 2003) in which pairs of children were trained in strategic questioning while solving problems. In King's study, the children were provided with an index card listing questions concerning metacognitive planning, monitoring, and evaluation (e.g., "Are we getting closer to our goal?", "What worked? What didn't work?"). In the present study, these questions were adopted and slightly modified. Participants were first given brief written instructions explaining the benefits of strategic questioning while working on the training tasks. They were then told to pose and answer these questions to themselves whenever appropriate while working on the task. For example, when they did not know what to do next, participants were told to analyze the problem and develop a strategy by asking and answering questions like "What is my problem? What am I trying to achieve?" or "What do I know about the program so far that can be useful now?". Finally, the list of questions to be posed was prominently displayed on a poster during training and verbally repeated by the experimenter. To make sure that participants followed instructions on strategic questioning during training, they were told that the questions they posed and answered would be tape-recorded and counted later on (which was actually the case, since the method of thinking aloud was used during training; see below).

Participants in all three groups were informed about the undo-function of the program and the delete key before the training started. This was done to keep knowledge about these error correction options constant. No further help was provided during training. Only in the few cases where participants could not continue with the task, did the experimenter intervene (e.g., one participant accidentally closed the working file; another participant accidentally "lost" a toolbar that was essential for task completion). The number of interventions by the experimenter did not differ between training conditions, F (2,52) = 0.86, p = .43.

During the entire training, the method of thinking aloud was used. Instructions for thinking aloud were carefully constructed following recommendations by Ericsson and Simon (1993). Instructions were: "While you are working on the slide, please verbalize all your thoughts. Just speak out whatever comes into your mind, no matter what it is". When participants stopped verbalizing for more than 10 seconds, they were prompted to continue ("Please keep on talking."). Empirical evidence suggests that this type of verbalization instruction is least obtrusive to participants' cognitive processing (Ericsson & Simon, 1993; Taylor & Dionne, 2000). The number of prompts for continuing verbalization did not differ between training conditions, F (2,52) = 1.97, p = .15.

Test phase. Tasks and instructions in the test phase were identical for all participants. Participants were handed printed copies of three slides. As in the training phase, the task was to reproduce these slides as closely as possible. The test slides, however, were more difficult than the training slides (cf. Dormann & Frese, 1994; Heimbeck et al., 2003). The first test slide comprised bullet points with text items and a figure consisting of several framed and colored text boxes and arrows. The main task of the second test slide was to produce and to format a table. For the third slide, a vertical bar chart had to be created and edited with the diagram function of the program. Additionally, all three test phase slides involved picking a specific design template and predefined layouts of the program. Since pilot testing had indicated that these were extremely difficult tasks, all participants were informed about the menu options where they would find the required functions. Participants were given 12 minutes to complete each slide, resulting in an overall testing time of 36 minutes. Before testing started, participants were told that this was the test phase in which they were to demonstrate what they had learned during the training session (cf. Wood et al., 2000).

2.3.3 Measures

Performance. Performance ratings were conducted on the basis of the slides the participants had created during the training and the test phase. Each task was divided into meaningful observable subtasks. For example, the task to create a figure consisting of several textboxes and arrows was divided into seven subtasks: "at least one textbox present", "all textboxes present", "position of text within textbox correct", "at least one arrow present", "all arrows present", "format of arrows correct", and "relative positions of textboxes and arrows correct". The subtasks served as coding units and were rated as either correctly completed or not (dichotomous rating; cf. Heimbeck et al., 2003). A second rater coded a randomly chosen subset of training and test slides. The two raters were the first author and a graduate student who was trained to use the coding system. Both raters were blind to the experimental condition. For the training phase slides, Cohen's kappa was .87 (based on a subset of 270 coding units). To arrive at a measure for overall *training performance*, the number of completed subtasks was computed for each participant.

For the ratings of the test phase slides, Cohen's kappa was .89 (based on a subset of 768 coding units). We further divided the subtasks of the test phase into tasks of low and high distinctiveness from training slides. A subtask was rated as low in distinctiveness if it required mere repetitions of program functions used in training (e.g., creating a textbox, changing the color of a rectangle), or if a program function used in training had to be applied in a similar though not exactly identical manner as in training (e.g., inserting a 4 x 4 table when the training task was to insert a 3 x 3 table). A subtask was rated as high in distinctiveness if a completely new function had to be applied for task completion (e.g., complex formatting of a table, inserting and editing a diagram). Inter-rater agreement on this distinction of high-low distinctiveness for the 64 subtasks of the test slides was high (Cohen's kappa = .84). Cases where the ratings of both raters differed were resolved by discussion. Low-distinctiveness subtasks solved were summed to represent *analogical transfer*; high-distinctiveness subtasks solved were summed to represent *adaptive transfer* (cf. Ivancic & Hesketh, 2000). All analyses are based on these sum scores. As outlined in the introduction, we expected performance differences between experimental groups only for adaptive transfer but not for analogical transfer.

Verbal protocol data. Participants' thinking-aloud during training was transcribed verbatim and segmented with each phrase (either complete or incomplete) constituting a segment (cf. Sonnentag, 1998). Mere expressive utterances (e.g., "Hum", "Okay", "Yup") were coded as such and excluded from further analyses. Due to technical problems (microphone dysfunctions and broken videotapes), audio data of six participants was lost, resulting in a sample size of n = 49 for all analyses comprising verbal protocol data (error avoidant group: n = 14, error management training group: n = 16, error management training plus metacognition group: n = 19).

The second half of the training phase, in which participants created and formatted a table, was critical for the present research question. Only in this phase did all three training conditions differ (the first training phase was identical for the error management training and the error management training plus metacognition group). Also, the task in this phase was rather difficult and, therefore, required deliberate and conscious processing, which is a prerequisite for verbal protocols to "generate rich and valid data" (Taylor & Dionne, 2000, p. 415). We therefore based our analyses on the verbal data of the second training phase. Another potential threat to the validity of verbal protocol data are general verbalization tendencies of participants (as a person characteristic) influencing critical verbalizations. Thus, we counted the verbalizations of participants during the introductory phase in which no experimental manipulation had occurred. The general verbalization tendencies of participants (as indicated by number of phrases per minute) did not differ between the experimental groups, F (2,43) = 0.20, p = .82. Protocols of the critical training phase comprised an average number of 166.9 segments (SD = 57.3) and did not differ in length between experimental conditions, F(2,46) = 1.78, p = .18.

Each segment was classified into 1 of 2 major categories and into a more specific subcategory within the major category (cf. Berardi-Coletta et al., 1995; Sonnentag, 1998). The first major category, which was the focal category in our study, was metacognitive statements; statements reflecting metacognitive control of planning, monitoring and evaluation were categorized here. The second major category, which we called task-focused statements, subsumed statements that indicated task-orientation but lacked the cognitive control characteristic for metacognitive processing. Only very few segments did not fit into either category (M = 2.31, SD = 2.05) and were deleted from further analyses. The number of nonclassifiable segments did not differ between experimental conditions, F (2,46) = 0.40, p = .67. The two major categories of metacognitive versus task-focused statements map the distinction made by Berardi-Coletta et al. (1995) between processing level (i.e., metacognition) and problem level as two general levels of cognitive-attentional focus during problem solving. The most frequent subcategories of metacognitive statements and task-focused statements along with sample statements are listed in Table 1. The two most frequent categories in task-focused statements refer to mere descriptions by participants on what action step they were just performing (Category 2a) or what action step they were about to perform (Category 2b). These categories may appear similar to the second metacognitive category listed, "Monitoring – observing changes" (Category 1b). The difference is that statements coded in the latter category reflected more detailed and attentive observations by participants that did not refer to the performed action itself (as in Categories 2a and 2b) but to the visible changes on the computer screen that were the *result* of an action performed.

Table 1

Two Major Categories and Most Frequent Subcategories in Verbal Protocol Analysis

(1) Metacognitive statements
a. Planning – generation of hypotheses (e.g., "It must be possible to select these cells separately.", "If I mark the whole thing right here, I should be able to do the frame.")
b. Monitoring – observing changes (e.g., "Now I have these dotted lines again.", "And if I pull the mouse across them, these turn blue.")
c. Evaluation – derivation of general rules (e.g., "I first have to click on this thing here, then I get these dots and I can move it.", "I cannot do this until I have inserted the line.")
d. Evaluation – explicit explanation (e.g., "That's because I have clicked on this pen here.", "No, because I have to activate it first.")
(2) Task-focused statements
a. Description of present step (e.g., "I click on textbox.", "Now I pull this.", "And I center this one, too.")
b. Description of next step (e.g., "Now I will enter the text.", "Now I will center it again.", "I will make this more evenly spread.")
c. Negative evaluation without explanation (e.g., "No, that's wrong.", "No, I don't like that.", "I didn't want that.")
d. Spelling out while typing (text or numbers to be entered into the table)
e. Reading out or repeating instructions (error avoidant group only)

The statements were classified by the first author and a graduate student who was trained to use the coding system. Cohen's kappa was .80 for the distinction between the two major categories (based on a subsample of 2,000 segments). Although inter-rater agreement remained acceptable on the level of subcategories (Cohen's kappa = .69), we based our main analyses on the broader level because our hypotheses did not refer to specific metacognitive subprocesses but to overall metacognitive activity of participants. If a statement was categorized as metacognitive and the same statement was then merely repeated by the participant, these repetitions were counted as such and excluded from further analyses. We then calculated the percentage of metacognitive statements relative to the number of all statements to represent *metacognitive activity* during training.

Emotion control. Emotion control during task engagement was assessed shortly after the test phase using a self-developed 8-item scale (see Appendix B) . Items were subject to a pilot test involving an independent sample (N = 79), while closely following definitions of the construct as outlined by Kanfer and colleagues (e.g., Kanfer & Ackerman, 1989; Kanfer et al., 1996). We used this self-developed scale in our study because existing measures of emotion control or related constructs did not seem to fit our purposes. Although Kanfer and colleagues have used a measure for emotion control in a study dealing with job search activities (Wanberg, Kanfer, & Rotundo, 1999), there are two reasons why their items did not seem suitable for our study. First, their items are mostly specific to their research question (e.g., "I get anxious even thinking about a job interview"). Second, their items appear to measure emotion control only indirectly by measuring negative emotions (i.e., anxiety in the sample item) as an indicator of *lack* of emotion control. The items we developed were designed to capture strategies for *regulation* of negative emotions that participants actively engage in, rather than negative emotions per se. In this respect, our scale resembled coping questionnaires (e.g., Carver, Scheier, & Weintraub, 1989; Folkman & Lazarus, 1985) or more recently published scales on emotion regulation at work in service employees (e.g., Grandey, Dickter, & Sin, 2004; Totterdell & Holman, 2003), where items directly refer to regulatory strategies one might use when experiencing a stressful encounter. However, in line with Kanfer's conceptualization of emotion control that our research was based on, our scale's emphasis was on controlling emotions and sustaining attention during completion of a specific task. We used a modified version of Wanberg et al.'s (1999) item instruction: Participants were asked to rate their reaction to problems they faced during task completion. All items began with the root "When difficulties arose" with various stems following including "I purposely continued to focus myself on the task" and "I calmly considered how I could continue the task". Items were answered on a 5-point Likert scale ranging from 0 (*does not apply*) to 4 (*applies*). Cronbach's alphas were .82 in the pilot sample and .80 in the present sample.

Error orientation. As a manipulation check, error orientation during task completion was assessed using two subscales of the Error Orientation Questionnaire (EOQ; Rybowiak, Garst, Frese, & Batinic, 1999; see Appendix B). The original questionnaire is designed to measure "attitudes to and … coping with errors at work" (Rybowiak et al., 1999, p. 527) of individuals or groups. For the present study, we chose 2 of the 8 EOQ subscales covering important individual error orientations which we expected to be affected by error management instructions (EOQ subscale *error strain*) and by metacognitive instructions (EOQ subscale *learning from errors*). In order to fit the present research question, we slightly modified the instructions and items to capture error orientations during task completion (rather than general orientations at work). The subscale *error strain* consisted of five items involving negative emotional reactions to errors and being afraid of making errors (e.g., EOQ item "I feel embarrassed when I make an error" was changed to "I felt embarrassed when I made an error"). Cronbach's alpha was .81 for this scale. The subscale *learning from errors* comprised four items covering the extent to which people used errors to learn (e.g., EOQ item "Errors help me to improve my work" was changed to " Errors helped me to improve my work"). Cronbach's alpha was .82 for this scale.

Computer experience. Before the onset of the study, participants were asked how many years they had been using a computer and which computer applications they used (e.g., word processing programs, spreadsheet programs). We used *years of computer usage* and *number of applications* as two indicators of computer experience and included these variables as covariates in all analyses. There were no pre-experimental differences between training conditions in years of computer usage, F (2,52) = 0.25, p = .78, and in number of applications, F (2,52) = 0.51, p = .67.

All participants had worked with text processing programs before (such as Word for Windows). We asked participants which functions of text processing programs they employed, because the presentation program taught in this study shares many features with common text processing programs. For example, participants were asked whether they regularly formatted texts, used bullets, or created and formatted tables. We used the *number of functions* regularly employed by participants as a third indicator of computer experience and included this variable as another covariate in all analyses. There was a pre-experimental difference between training conditions in number of functions: Before the study began, participants of error avoidant training knew more computer functions relevant to the program taught, *F* (1,52) = 4.61, $p < .05$, $\eta^2 = .08$ (for the descriptive statistics, see Table 2).

2.4 Results

2.4.1 Intercorrelations of Study Variables

Descriptive statistics and intercorrelations of the study variables are displayed in Table 2. As expected, intercorrelations between computer experience and performance variables were in the middle range with all but one coefficient being significant. We included all three computer experience variables as statistical controls in further analyses.

2.4.2 Manipulation Checks

To assure that participants had interpreted the error management instructions and the metacognitive instructions in the intended way, error orientation of participants during task completion were compared. We expected *error strain* to be lower in both error management training groups than in the error avoidant group because error management instructions frame errors positively, and errors should, therefore, be perceived as less threatening. Planned contrasts revealed that this was the case: Error strain was significantly higher in the error avoidant group compared to the error management training groups, *F* (1,49) = 5.81, $p < .05$, $\eta^2 = .11$, but did not differ between error management training groups, *F* (1,49) = 0.03, $p = .86$. We further expected *learning from errors* to be particularly high in the error management training plus metacognition condition because the metacognitive instruction given to this group stressed the usefulness of metacognitive planning, monitoring, and evaluation for learning over and above the rather general positive framing of errors in the error management instructions. Again, this was the case. Learning from errors was significantly higher in both error management training groups compared to the error avoidant group, *F* (1,49) = 8.11, $p < .01$, $\eta^2 = .14$, and a direct comparison of the two error management groups revealed that it was highest in the error management condition with the metacognitive instructions, *F* (1,49) = 4.17, $p < .05$, $\eta^2 = .08$. Taken together, these results suggest that both the error management instructions and the metacognitive instructions worked in the intended way.

Table 2

Means, Standard Deviations, and Intercorrelations of the Study Variables

Variable		1	2	3	4	5	6	7	8	9	10	11	12
Training conditions[a]													
1. Contrast 1		--											
2. Contrast 2		.05	--										
Computer experience													
3. Years of computer usage		.08	-.05	--									
4. Number of applications		-.16	-.02	.27*	--								
5. Number of functions		-.28*	.11	.34*	.44**	--							
Performance variables													
6. Training performance		-.15	-.15	.30*	.25	.38**	--						
7. Analogical transfer		.00	-.01	.42**	.41**	.46**	.70**	--					
8. Adaptive transfer		.18	.15	.49**	.41**	.49**	.63**	.77**	--				
Mediators													
9. Emotion control		.42**	.15	.07	-.25	-.02	.12	.20	.30*	(.80)			
10. Metacognitive activity		.63**	.31*	.14	-.16	-.13	-.04	.10	.32*	.38**	--		
Manipulation checks													
11. Error strain		-.31*	-.02	-.15	.17	-.08	-.13	-.24	-.24	-.68**	-.18	(.81)	
12. Learning from errors		.34*	.30*	.07	-.07	.12	-.07	.09	.19	.48**	.44**	-.28*	(.82)
Total	*M*	0.35	0.05	5.10	1.95	4.36	25.95	24.73	10.87	2.97	4.88	0.85	2.60
	SD	0.95	0.83	3.02	1.22	2.03	9.00	4.89	5.35	0.61	3.52	0.72	0.70
Error avoidant group	*M*	-2.00	0.00	4.75	2.22	5.17	27.89	24.72	9.50	2.60	1.40	1.17	2.26
	SD	0.00	0.00	2.59	1.22	1.89	7.84	5.11	4.59	0.66	1.81	0.75	0.68
Error management group	*M*	1.00	-1.00	5.49	1.82	3.65	26.65	24.82	10.53	3.04	5.01	0.69	2.50
	SD	0.00	0.00	3.19	1.63	1.87	10.31	5.15	6.07	0.59	1.74	0.69	0.71
Plus metacognition group	*M*	1.00	1.00	5.07	1.80	4.25	23.60	24.65	12.40	3.24	7.35	0.69	2.99
	SD	0.00	0.00	3.35	0.77	2.12	8.71	4.70	5.20	0.41	3.49	0.65	0.52

Note. N = 55 (error avoidant group: n = 18, error management training group: n = 17, error management training plus metacognition group: n = 20). For all analyses involving metacognitive activity: n = 49. Alpha coefficients are shown in parentheses on the diagonal when applicable. Plus metacognition group = Error management training plus metacognition group.

[a] Contrast 1 compares error avoidant training with error management training groups (error avoidant training = -2, both error management training groups = +1), Contrast 2 compares error management training groups (error avoidant training = 0, error management training = -1, error management training plus metacognition = +1).

* p < .05, two-tailed. ** p < .01, two-tailed.

To assess whether participants in the error management training plus metacognition group followed instructions to pose and answer questions related to metacognitive planning, monitoring, and evaluation during training, we counted how often participants of all training groups posed questions similar to those listed in the metacognitive instructions (Cohen's kappa = .71 based on 2,000 segments). As expected, the number of questions was largest in the verbal protocols of the error management training plus metacognition condition, F (1,43) = 23.30, p < .01, η^2 = .35, indicating that participants had followed metacognitive instructions.

We also used the verbal protocol data to further illuminate whether participants in error management training had in fact made more errors during training than participants in error avoidant training who received detailed instructions on the task solution (note that despite these instructions participants in this condition could still make errors; e.g, because they did not read the instructions correctly). Although not an exact count, the category "Negative evaluation without explanation" can serve as an indicator of errors in training, because statements subsumed under this category imply that participants' preceding action did not lead to the desired outcome (category 2c in Table 1). As expected, the statements in this category were much more frequent in the error management training groups (M = 20.91, SD = 9.23) compared to the error avoidant group (M = 8.79, SD = 4.68), F (1,43) = 15.68, p < .01, η^2 = .27.

Finally, to get a better picture of what exactly happened in the training conditions, we inspected the frequency of task-focused statements in the training groups. In the error avoidant training group, about one third of the statements comprised reading or repeating the written instructions on task solution (category 2e in Table 1; M = 31.31, SD = 11.71; numbers refer to percentage relative to all statements). Participants in this condition also frequently described what they were currently doing (category 2a; M = 19.37, SD = 6.65) or what they were about to do (category 2b; M = 11.56, SD = 5.39). In error management training, too, participants frequently described the present step (category 2a; M = 24.92, SD = 10.30) or the next step (category 2b; M = 20.79, SD = 5.46), but the third most frequent category was the error category (category 2c; M = 12.36, SD = 4.48). Taken together, these analyses suggest that the experimental manipulation was successful: Participants in error avoidant training worked along the lines of the written instructions during training, and participants in error management training frequently made errors while working on their own.

2.4.3 Main Effects of Training Condition on Transfer Performance

Hypothesis 1 predicted adaptive transfer performance to be superior in both error management trainings than in error avoidant training. In an open research question, we further explored whether participants in the error management training plus metacognition condition (i.e., with additional metacognitive instructions) would perform better than those in classical error management training without additional metacognitive instructions. For performance in analogical transfer, we did not expect any differences between training groups. We first tested this with a repeated measures ANCOVA with training structure as the between-factor, transfer type (i.e., analogical and adaptive transfer) as the within-factor, and with computer experience variables as covariates. As expected, a significant interaction between training condition and transfer type emerged, F (2,49) = 4.20, $p < .05$, $\eta^2 = .15$. In line with predictions, analogical transfer did not differ between groups, F (2,49) = 0.39, $p = .68$, but adaptive transfer did, F (2,49) = 4.34, $p < .05$, $\eta^2 = .15$.

Table 3

Effects of Training Condition on Adaptive Transfer (ANCOVA Contrasts Controlling for Computer Experience)

		Effect size	
	F (*df*)	η^2	Cohen's *d*
Error avoidant vs. error management training groups (group 1 vs. groups 2+3)	6.75* (1,49)	.12	0.75
Error management training vs. error management training plus metacognition (group 2 vs. group 3)	1.28 (1,49)	--	--

Note. *N* = 55. For this analysis, the appropriate effect size estimate is η^2 representing the explained variance. For ease of interpretability, Cohen's *d* was additionally calculated based on residuals after controlling for computer experience.

* $p < .05$, two-tailed.

We found clear support for Hypothesis 1 (Table 3): Adaptive transfer was superior in error management training conditions compared to error avoidant training with a medium to large effect size of $\eta^2 = .12$ (note that the correlation reported in Table 2 between the variable contrasting error avoidant training with error management trainings is not significant whereas the ANCOVA contrast from Table 3 is because the correlation does not take the control variable computer experience into account). The difference between the two error management training conditions (open research question) was not significant ($p = .26$).

2.4.4 Emotion Control and Metacognitive Activity as Mediators of Adaptive Transfer Performance

In Hypotheses 2 and 3 we predicted that emotion control and metacognitive activity during training mediate the effect of training condition on adaptive transfer performance. We first tested these hypotheses separately and then simultaneously for emotion control and metacognitive activity using the procedure recommended by James and Brett (1984). According to this procedure, variable *b* mediates the effect of variable *a* on variable *c* if the following conditions are met: (1) *a* has an effect on *b*, (2) *b* has an effect on *c*, and (3) the effect of *a* on *c* disappears when *b* is held constant. The first and second conditions were met: Table 2 reveals that the training condition (i.e., contrast variable 1) was significantly related to both mediators, and that both mediators were significantly related to adaptive transfer performance. The third condition was tested in hierarchical regression analyses in which training condition was entered as a predictor after controlling for mediating variables. Results are displayed in Table 4. When entered after emotion control or metacognitive activity in separate analyses, the effect of training condition vanished (after emotion control: $\beta = .17$, n.s., after metacognitive activity: $\beta = .01$, n.s.). Further, when entered after both mediators emotion control and metacognitive activity, the effect of training condition disappeared ($\beta = -.08$, n.s.), and the effects of both mediators remained significant ($\beta = .24$ for emotion control, $\beta = .27$ for metacognitive activity, both *p*s $< .05$). Thus, Hypotheses 2 and 3 were supported: Emotion control and metacognitive activity fully and independently mediated the effect of training condition on performance.

To supplement the ordinary least squares regression analyses, structural equation modeling (SEM) was conducted using the maximum likelihood (ML) procedure in LISREL (Linear Structural Relationships; Jöreskog & Sörbom, 1996). These analyses were conducted because SEM offers the advantages (1) that parameters can be estimated simultaneously, (2) that an overall model fit can easily be obtained, and (3) that additional paths can be introduced into the model and tested for statistical significance. Although Lisrel and similar approaches are commonly used as large sample size procedures, recent evidence suggests that SEM-ML can also yield appropriate estimates in mediation models with small samples (Hoyle & Kenny, 1999). In our models, to keep the subject-to-parameter ratio at an acceptable level and to keep the model simple, we did not include the control variables as exogenous variables but used residuals instead. That is, we regressed the four study variables (predictor training condition, the mediators emotion control and metacognitive activity, and criterion adaptive transfer) on the computer experience variables, and used the covariance matrix of the residual variables as input for the Lisrel analyses. The model had an excellent fit, χ^2 (df = 2) = 1.09, p = .58, RMSEA = .00, AGFI = .94, NFI = .98, CFI = 1.00. Standardized parameter estimates of the model are depicted in Figure 4. All hypothesized paths were significant. We further tested the indirect effects of training condition on adaptive transfer for significance using Sobel's first-order solution for standard errors of indirect effects (MacKinnon, Lockwood, Hoffman, West, & Sheets, 2002). Both the paths, via emotion control (t = 2.99, $p < .05$) and via metacognitive activity (t = 5.21, $p < .01$), were significant.

In a second Lisrel model we introduced an additional direct effect of training condition on adaptive transfer (additional to the paths depicted in Figure 4). This path was estimated to be zero (-.09 in standardized solution, t = -0.57). Also, the model fit did not improve, $\Delta\chi^2$ (df=1) = 0.34, $p > .75$. Thus, replicating results of the regression analyses (cf. Table 4), the effect of training condition on adaptive transfer was fully und independently explained by the mediators emotion control and metacognitive activity in Lisrel analyses.

Table 4

Emotion Control and Metacognitive Activity as Mediators of Training Effects on Adaptive Transfer

Predictor /step	*B*	*SE B*	β	R^2	ΔR^2
Direct Effect of Training Condition					
1. Computer experience variables (controls)				.38**	
Years of computer usage	0.60	0.21	.34**		
Number of applications	0.85	0.54	.19		
Number of functions	0.76	0.33	.29*		
2. Training condition				.46**	.08**
Error avoidant vs. Error management	1.69	0.62	.30**		
Mediation by Emotion Control					
2. Mediator				.51**	.12**
Emotion control	3.20	0.91	.37**		
3. Training condition					
Error avoidant vs. Error management	0.98	0.65	.17	.53**	.02
Mediation by Metacognitive Activity					
2. Mediator				.53**	.11**
Metacognitive activity	0.54	0.17	.35**		
3. Training condition					
Error avoidant vs. Error management	0.03	0.86	.01	.53**	.00
Mediation by both Emotion Control and Metacognitive Activity					
2. Mediators				.57**	.16**
Emotion control	2.16	1.01	.24*		
Metacognitive activity	0.42	0.17	.27*		
3. Training condition				.58**	.00
Error avoidant vs. Error management	-0.46	0.85	-.08		

Note. $N = 55$. For all analyses involving metacognitive activity: $n = 49$.

* $p < .05$, two-tailed. ** $p < .01$, two-tailed.

We further explored the relationship between emotion control and metacognition with Lisrel. As can be seen in Table 2, the manifest zero-order correlation between these two variables was significant ($r = .38$, $p < .01$). In a third Lisrel model we introduced a correlation between emotion control and metacognitive activity (in addition to the paths depicted in Figure 4). In this model, the correlation was estimated to be zero (.09 in standardized solution, $t = 0.86$), and model fit did not improve, $\Delta\chi^2$ (df=1) = 0.76, $p > .50$. Thus, the training condition served as an explanatory variable in the mediation model: Emotion control and metacognitive activity covaried only to the extent to which both processes were evoked by the training condition.

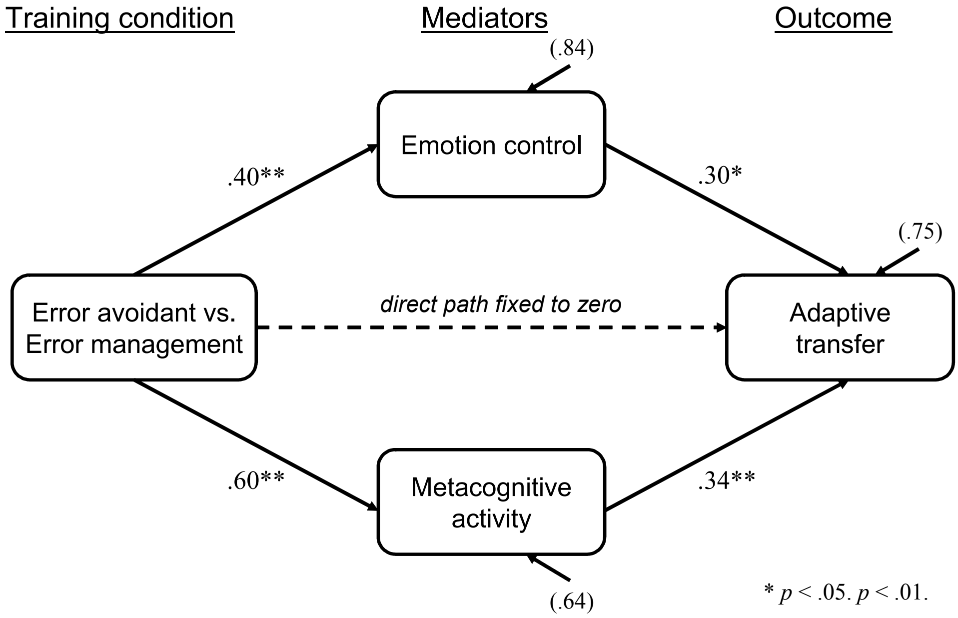

Figure 4. Emotion control and metacognitive activity mediating effects of training condition on adaptive transfer (standardized parameter estimates from Lisrel analyses).

2.5 Discussion

The main goal of our study was to identify processes mediating error management training effectiveness. In line with resource allocation theories assuming a limited amount of attentional resources (e.g., Kanfer & Ackerman, 1989; Kluger & DeNisi, 1996), we argued that error management training helps to exert self-regulative control that in turn leads to better learning and performance. More specifically, we proposed that error management training enhances both emotional self-regulation (i.e., emotion control) and cognitive self-regulation (i.e., metacognitive activity). A second goal of our study was to explore whether there is still room for an add-on effect of additional metacognitive instructions over and above the effect of classical error management training without such instructions.

Our study replicated the main effect on performance that has frequently been found in error management training studies (e.g., Chillarege et al., 2003; Dormann & Frese, 1994; Frese et al., 1991; Heimbeck et al., 2003; Nordstrom et al., 1998; Wood et al., 2000): Error management training participants outperformed those in error avoidant training on an adaptive transfer test. This effect was appreciable (effect size equivalent to a Cohen's *d* of 0.75), given that the error avoidant group was not a nontraining control group. A direct comparison of the two error management training conditions (i.e., error management training vs. error management training supplemented by metacognitive instructions) did not reveal any performance difference. It is possible that the metacognitive instructions were too weak in this study because participants were to engage in metacognitive activities individually whereas other studies had participants work in dyads (King, 1991) or in cooperative groups (McInerney et al., 1997). In a recent study by Schmidt and Ford (2003), the effect of a metacognitive intervention for individual learners depended on their dispositional goal orientation. Also, given that metacognitive activities require effortful and time-consuming processing, the practice phase in the present study might have been too short for the benefits of metacognitive activities to fully develop. Future research should investigate whether metacognitive instructions can improve error management training under conditions involving longer time periods or multiple sessions.

The most intriguing finding of this study is the strong support for our mediation hypotheses: Group differences between error avoidant training and error management training in adaptive transfer performance were fully and independently explained by emotion control and metacognitive activity during training. Supplemental analyses with LISREL further revealed that the empirical zero-order correlation between the two mediators was fully accounted for by training condition in the mediation model. In other words, error management training induced both emotion control and metacognitive activity during training, and these processes enhanced performance in tasks that required finding new solutions. From a self-regulatory perspective, emotional self-regulation (emotion control) and cognitive self-regulation (metacognition) were equally important for adaptive transfer to occur.

Our results concerning emotion control are consistent with theory and research by Kanfer and colleagues (Kanfer & Ackerman, 1989; Kanfer et al., 1996). They argued that emotion control is a skill useful in early phases of skill acquisition because it helps to direct attention away from the self and to the problem at hand in the face of errors and setbacks. From this point of view, error management training may be regarded as a form of emotion control training because participants are confronted with errors early on in training and learn to exert emotion control in order to deal with them. Similarly, within the framework of transactional stress theory (Lazarus & Folkman, 1984), error management training may be thought of as a form of cognitive reappraisal training, because error management instructions reframe errors positively. As a consequence, participants in error management training can conceive errors as less threatening but rather as positive and useful events, which in turn reduces the experience of negative emotions in the face of errors.

Our results concerning metacognitive activity conform to educational theory and research highlighting the benefits of metacognition during learning (e.g., Schunk & Zimmermann, 1994; cf. also Schmidt & Ford, 2003), and with theorizing by Ivancic and Hesketh (2000; Hesketh & Ivancic, 2002). Ivancic and Hesketh (2000) delineated that error management training instigates metacognitive planning, monitoring, and evaluation because errors encourage a systematic analysis of the error's cause as well as an implementation and testing of potential solutions. Error avoidant training that prevents participants from making errors, in contrast, does not provide the opportunity to practice emotion control and metacognition because participants simply follow correct instructions and do not need to work out solutions on their own. This line of argument is also consistent with cognitive theories of action regulation. For example, action theory (Frese & Zapf, 1994; Hacker, 1998) posits that errors disrupt premature automatization of actions because they make learners rethink their strategy. Similarly, control theory (e.g., Lord & Levy, 1994) proposes that discrepancies between standards and feedback (i.e., errors) initiate an increased allocation of attention to the task and that learning occurs when these discrepancies are resolved.

2.5.1 Strengths and Limitations

Although our data shows emotion control to be an effective mediator of adaptive transfer performance, one may doubt whether our measure of emotion control was unbiased because participants filled out the emotion control items soon after they had completed the performance test. More precisely, our results might be distorted due to what is known as self-handicapping in test anxiety research (e.g., Laux & Glanzmann, 1987): Poor performing participants might have indicated their emotion control to be low simply because they were aware of their poor performance. This is an issue that applies not only to the present or other error management training studies using questionnaire data to measure processes (e.g., Debowski et al., 2001; Wood et al., 2000), but to nearly all studies where participants were asked for self-ratings of psychological variables after performance assessment. Although we are confident that not all interindividual variance in emotion control was solely due to participants' self-serving bias, this alternative explanation cannot be ruled out based on the self-ratings we collected after the test phase. A better strategy would be to collect emotion control data during the training session or right before the performance phase or alternatively, to use a method other than self-reports that is less subject to self-serving bias.

Our measurement of metacognitive activity is unaffected by participants' potential self-serving bias. First, we derived this measure not from participants' self-ratings but from verbal protocol ratings that were blind to experimental condition and performance scores. Second, for both methodological and conceptual reasons, we were careful to make a time-lagged prediction: We predicted *later* adaptive transfer performance from the metacognitve activity measure that had been assessed *earlier* in training. From a methodological perspective, this time lag has the advantage that mediator and outcome variable are less likely to be confounded. From a conceptual perspective, we were interested in processes not just concurrent with but predictive for adaptive transfer performance.

Although we feel that our approach to use verbal protocol data for process analyses was successful, one may raise objections concerning the validity of thinking aloud protocols in general. There has been an intensive debate as to whether thinking aloud protocols reflect cognitive processes of participants or whether the processes are critically altered (e.g., Schooler, Ohlsson, & Brooks, 1993). For two reasons we are confident that the conclusions we drew in our study from verbal protocol analysis are valid. First, we carefully followed recommendations to avoid obtrusive instructions for thinking aloud (Ericsson & Simon, 1993; Taylor & Dionne, 2000). Second, our results concerning the superiority of error management training compared to error avoidant training replicated results of other studies with similar effect sizes (Chillarege et al., 2003; Dormann & Frese, 1994; Heimbeck et al., 2003; Frese et al., 1991; Ivancic & Hesketh, 2000; Nordstrom et al., 1998; Wood et al., 2000). If our verbal protocol data were invalid, this would imply that our study produced the *same effects* as other studies, but that these effects were due to *different processes* – an assumption that is of low plausibility.

An obvious drawback to our study is the composition and small size of our sample. It should be noted, however, that other error management training studies (e.g., Debowski et al., 2001; Wood et al. 2000) as well as other studies using verbal protocol analysis (e.g., Ball, Langholtz, Auble, & Sopchak, 1998) have relied on small and sometimes even smaller samples. More importantly, we found group differences in performance as well as process variables *despite* the relatively low statistical power due to the small sample – a finding that corresponds to the considerable effect sizes for these differences (Cohen, 1994; Kramer & Rosenthal, 1999; Sonnentag, 1998). Also, as mentioned above, the superiority of error management training compared to error avoidant training has been found in other studies using larger samples. For reasons of research economy, the use of thinking aloud analysis restricted our sample to a limited number of volunteer students (despite the rather small number of participants, about 18,000 coding units were available from the verbal protocols).

2.5.2 Implications for Future Research

The present study focused on processes in training and did not look at individual differences potentially affecting performance. Some studies, however, suggest that participants may differentially benefit from error management training or error avoidant training depending on person characteristics such as cognitive ability, openness to experience, or goal orientation (Gully et al. 2002; Heimbeck et al., 2003). Future studies should look at differential processes induced by such interactions of training condition and person characteristics. Furthermore, given the strong predictive power of emotion control and metacognitive activity, it would be interesting to identify person characteristics that promote exertion of emotion control and metacognitive activity during training. For example, participants high in learning goal orientation may be more likely to engage in effortful metacognitive activity during training. Likewise, avoidance goal orientation, directed at the avoidance of potential failure in the task and of negative judgment by others, may be negatively related to emotion control in the face of setbacks during training. Apart from the influence of goal orientations as stable person characteristics, goal orientations as temporal states may be affected by error management training as well. Error management instructions, emphasizing the positive role of errors during learning may encourage a learning or mastery orientation. In fact, there are studies that, among other instructions, use positive error statements similar to error management instructions when manipulating learning goal orientation (e.g., Kozlowski et al., 2001).

Starting from the notion that errors instigate metacognitive activity, our study demonstrated the power of *overall* metacognitive activity in error management training. A more microanalytical approach that examines actions and cognitions following errors could further illuminate the processes of how errors instigate metacognitive activity. For example, do errors trigger metacognitive activity immediately? Or does it take several errors to finally engage in effortful metacognitive activity? Another possibility is that there is no simple one-to-one relation between errors and metacognitive activity but that the low level of structure and the frequent errors in error management training together induce a general metacognitive processing mode during training. Future research could use methods such as behavior observation or analyses of concurrent video and verbal protocol data to gain insight into the dynamics of errors and metacognitive activity in error management training.

Such a microanalytical approach could also provide an insight to component processes of metacognitive activity (i.e., planning, monitoring, or evaluation) that are specifically important for the effects of error management training. In post-hoc exploratory analyses, we identified three of the metacognitive subcategories (cf. Table 1) as significant individual predictors of adaptive transfer (partial correlations controlling for computer experience variables > .37, all ps < .05). These subcategories were "Planning – generation of hypotheses" (category 1a in Table 1), "Monitoring – observing changes" (category 1b), and "Evaluation – explicit explanation" (category 1d). Although the results of these exploratory analyses should be interpreted with caution, they might provide some initial directions for future research dealing with metacognitive subprocesses.

Related to this issue, future research could use an error taxonomy to identify what types of errors lead to learning because not all errors can be expected to be equally useful and informative or to automatically lead to metacognitive activity and subsequent enhanced performance. Within an action theory framework, an error taxonomy differentiates errors as to the level of action regulation involved in the error (Zapf et al., 1992; see also Rasmussen, 1982, who distinguishes between knowledge-based, rule-based, and skill-based regulation). The levels of regulation run from conscious regulation to automatic regulation. For example, Zapf et al. (1992) validated a taxonomy that distinguished errors in computer work. First, on the intellectual level, complex problem analyses are regulated which may lead to errors (e.g., planning errors occur when the user selects the wrong course of action for a task). Second, on the level of flexible action patterns, actions are regulated by schemata (e.g., habit errors occur when a well-known action is performed in the wrong situation). Third, on the sensorimotor level, stereotyped and automatic movements are organized (e.g., typing errors or wrong movements of the computer mouse occur here). We would expect, for example, that most learning in error management training occurs from errors on higher levels of regulation rather than from sensorimotor errors such as typos that can be detected and corrected immediately. Future research could use this taxonomy and identify types of errors that lead to learning, both in the present and in other kinds of tasks.

Another related issue deals with the question of how overall errors and errors of different types relate to adaptive transfer. The concept of error management training suggests that the number of errors should positively relate to subsequent transfer performance. Empirically, however, we would not expect a positive but rather a negative relationship because most errors are a result of lack of knowledge which is usually associated with poor performance. Another possibility is a nonlinear relationship of errors and performance that corresponds to the concept of an optimum number of errors for transfer to occur. Ivancic and Hesketh (2000) found a negative relationship between errors in training and performance on a transfer task. At the same time, however, participants tended not to repeat the same errors they made during training. These results possibly indicate that errors and subsequent transfer performance may be negatively related *between* persons but may be unrelated or even positively related *within* persons. Future research could address these questions using a design that involves multiple tasks and trials.

The present study, like other studies dealing with error management training, compared error management training to error avoidant training, the latter hindered participants from making errors by means of step-by-step instructions. Another, probably better known, training approach is behavior modeling which is based on Bandura's (1986) social cognitive theory. Within Bandura's framework, building self-efficacy by mastery experiences is crucial for learning and performance. A training program using behavior modeling usually involves a live or videotaped model demonstrating the correct strategies for task solution followed by the trainees' imitation of the model's behavior in practice (e.g., Gist, Schwoerer, & Rosen, 1989). Thus, behavior modeling is more structured than error management training. In complex tasks with ambiguous feedback and in tasks that require one single best strategy for task solution, behavior modeling probably results in better performance than error management training (Debowski et al., 2001). These two training techniques, however, do not necessarily have to be conceived of as mutually exclusive alternatives. Also, just like behavior modeling, error management aims at building self-efficacy. More specifically, error management is directed at building self-efficacy in the face of problems and errors that occur when working on new tasks. Future research could look at self-efficacy expectations as outcomes of error management training.

Another interesting issue for future research could be to examine the exact relation of emotion control and metacognitive activity. In our study, emotion control and metacognitive activity were conceptualized and shown to be independent mediators of performance effects. The interrelation between the two variables disappeared when training condition was taken into account. In other words, error management training enhanced both emotional and cognitive self-regulation which in turn led to improved performance. This result raises the question of how both processes are intertwined. For example, does metacognitive activity positively affect emotion control because participants engaged in metacognitive activity "forget" to get angry about an error? Or does emotion control serve as a prerequisite for metacognitive activity, because only if participants' negative emotions are controlled, can metacognitive activity be initiated? Theoretically, these kinds of questions go beyond the academic convention to describe emotional and cognitive processes as distinct phenomena using different theoretical models. We believe that the self-regulation perspective adopted in this paper provides a framework for integrating emotions and cognitions into a common model.

2.5.3 Implications for Theory and Practice

Our study corroborates the notion that emotional and cognitive self-regulation mediates effectiveness of error management training. This finding has important implications for both theory and practice. From a theoretical perspective, training research has always been interested in not only the question *if* training works but also *why* it works (e.g., Goldstein & Ford, 2002). Only very few error management training studies have up to now looked explicitly at the processes underlying error management training effectiveness, and none of these have provided conclusive results (Debowski et al., 2001; Wood et al., 2000). Our study contributes to a better theoretical understanding of why error management training leads to better performance than error avoidant training.

From a practical perspective, identifying effective mediators in training is particularly important because this information is useful for modifying error management training or for adapting its principles to another area. Our results suggest that error management training is effective, because it provides the opportunity to practice the metacognitive activities of planning, monitoring, and evaluation – skills that prove useful when it comes to tasks that require a new solution. Practitioners may consider explicitly integrating modules of error management training into the training process by giving participants the opportunity to make errors by working on difficult training tasks on their own and at the same time encouraging them to use their errors as a learning device.

Most importantly, our research highlights the critical role of the kind of information-processing participants engage in during training (cf. Hesketh & Ivancic, 2002). Stated differently, in our study the crucial question for adaptive transfer was not *what* material was learned during the training session (the material was identical in all training conditions) but rather *how* it was learned. When planning a training intervention, practitioners may focus their attention not only on the training material to be covered but also on the kind of information processing that is most promising for transfer to occur.

We are confident that the principles of error management training can be incorporated into areas other than computer training, although research concerning other areas is rare (Gully et al. 2002; Ivancic & Hesketh, 2000). We suggest that error management training is useful whenever the material to be learned cannot be covered completely during the training session and, consequently, for situations where participants need to 'learn to learn' when confronted with new tasks. This is related to the principle of transfer appropriate processing which postulates that those processes required on transfer tasks should be practiced during training (Morris et al., 1977). The present transfer task required discovery type activities involving learning from errors because solutions to problems distinct from those worked on during the training session had to be found. Consequently, error management training, which required the same type of activities during training, resulted in superior performance relative to error avoidant training that taught the correct solutions during training. In trainings covering a relatively small amount of material that is highly structured, however, it is probably more economical to teach the correct strategies directly because exploring and learning from errors may be too time-consuming. Related to this issue, in tasks that require one single best strategy for task solution, behavior modeling probably results in better performance than error management training (Debowski et al., 2001). It should be kept in mind that although error management training may be successful in promoting transfer performance, training performance itself may not be better or may even be worse than in error avoidant training. Not only will participants in error management training make more errors during training – after all, they are told to do so – it will also take them longer to solve the tasks on their own or, if time is limited, they will solve fewer tasks during the same training period than their counterparts in error avoidant training.

Also, when tasks are very complex, error management training should be combined with elements of guided training (Bell & Kozlowski, 2002) because due to the low level of structure and guidance in error management training, participants may run the risk of developing incorrect concepts of the training content (Frese, 1995; Mayer, 2004). For example, a guided approach comprising assistance and external feedback by the trainer could be used to develop basic competencies that subsequent error management training could build on (Debowski et al., 2001). Finally, high fidelity task feedback is probably a prerequisite for error management training because errors can serve as informative feedback only in systems that allow self-regulated error detection and correction. Many of the studies that successfully applied error management training have used computer tasks that usually provide clear task feedback. For example, if a participant takes action to insert a table into a document, he or she will immediately see whether the action leads to the desired goal or not. Other tasks that lack the kind of clarity of task-inherent feedback may not be well suited for error management training. In a social skills training, for example, error management training may not be helpful if a participant is not able to interpret others' reactions to his or her actions or speech correctly, so that augmented feedback by a trainer or by fellow participants may be required. On the other hand, once basic interpretation skills are developed, error management training may be effective in promoting transfer because in real-life interactions augmented feedback is not provided. It is our hope that this work encourages researchers and practitioners to take up error management training principles and apply them to other areas of skill acquisition.

3 Error Management Training as Moderator of the Cognitive Ability/Performance Relationship

One of the best established findings in applied psychology is the relationship between cognitive ability and performance. Numerous studies have investigated predictive validities of cognitive ability measures, and several studies, meta-analyses and reviews conclude that cognitive ability is the best predictor for training success and job proficiency across a wide range of occupations (e.g., Hunter & Hunter, 1984; Ree & Earles, 1991; Ree, Carretta, & Steindl, 2001; Ree, Carretta, & Teachout, 1995; Salgado et al., 2003; Schmidt & Hunter, 1998). Yet, some findings suggest that predictive validities of ability measures may not be as stable as is generally assumed. Predictive validities of diverse ability measures seem to decline over time (Henry & Hulin, 1987; Henry & Hulin, 1989; Hulin, Henry, & Noon, 1990). In other words, ability measures are more predictive of temporally proximal than of distal performance. In a meta-analysis, Hulin et al. (1990) found this effect in a variety of tasks including motor and intellectual tasks, and for a variety of time intervals ranging from a few minutes or hours (e.g., across experimental trials) to years or even decades. Although some researchers have raised objections concerning some of the procedures used in this meta-analysis or the substantive interpretation of the effect offered by the authors of the meta-analysis (e.g., Ackerman & Cianciolo, 2002; Barrett, Alexander, & Doverspike, 1992), there is at least some evidence that the phenomenon of decreasing validities of ability measures exists in some settings.

The present research is concerned with a specific setting in which decreasing validities have been observed, namely, during training. More specifically, we will argue that whether predictive validities decrease depends on the type of training delivered. We will present error management training as a training form that promotes the decrease of validities and that compensates for debilitated performance of lower ability trainees over time. We will further propose that conventional training forms do not show decreasing validities of cognitive ability and that, in other words, the training form moderates the effect of cognitive ability on performance over time. This differential effect of cognitive ability depending on type of training is important from both a theoretical and a practical perspective. From a practical perspective, differential effects of cognitive ability may be considered when deciding what kind of training is suitable depending on the cognitive ability of participants. From a theoretical perspective, the effect of cognitive ability in training can provide insights to the processes effective in the particular training. The present study used the theoretical framework on resource allocation in performance and skill acquisition by Kanfer and Ackerman (1989) as a starting point. Their model allows deriving differential predictions regarding the effects of cognitive ability on training and transfer performance depending on the type of training delivered (i.e., error management training vs. conventional training). These predictions are also implied by action theory (Frese & Zapf, 1994; Hacker, 1998) which distinguishes different regulatory levels that differ in the amount of resources required for action regulation. In the following sections, we will first introduce the basic concepts of error management training and its effects on training and transfer performance. Then, we will turn to the expected effects of cognitive ability in error management training from a resource allocation perspective.

3.1 Error Management Training and Performance

Error management training starts from the assumption that errors represent a valuable source of feedback. Errors are integrated into training because they are expected to help to improve one's knowledge and skills (Ivancic & Hesketh, 1995/1996). A typical error management training provides only minimal task information and then encourages active exploration by participants. In this regard, error management training is similar to exploratory training which also promotes exploration during training (Bruner, 1966). Error management training, however, tends to give more difficult tasks early in training (Heimbeck et al., 2003) – a procedure that inevitably causes participants to make errors. Most error management studies have also included so-called error management instructions (e.g., Dormann & Frese, 1994; Frese et al., 1991). These instructions prepare participants to expect errors while they work on the tasks and inform participants about the positive function of errors (e.g., "The more errors you make, the more you learn!"). For the present line of argument, the error management instructions are not relevant. We will therefore deviate from the description of error management training in other studies and generally refer to error management training as a training form where participants work independently on difficult tasks and where errors are expected to occur, regardless of whether additional error management instructions are given or not.[1]

Performance effects of error management training have been evaluated in several studies. Early studies compared error management training with so-called error avoidant training in teaching a new computer program (e.g., Dormann & Frese, 1994; Frese et al., 1991). In these studies, participants of error management training received only minimal information about the structure and basic functions of the new computer program and then worked independently on difficult training tasks. Thus, participants in error management training had to actively explore and find the correct solutions on their own. Error avoidant training mimicked conventional training forms that adopt a negative view on errors. Participants in this training condition received detailed step-by-step instructions on task solutions to prevent errors from occurring. Thus, these participants' task was to follow the instructions as closely as possible in order to arrive at the correct solutions. If participants made an error despite the instructions, the trainer immediately intervened and corrected the error. After the training, a performance test was conducted in these studies. In most cases, participants of error management training outperformed their counterparts of error avoidant training on moderately to highly difficult transfer tasks (Chillarege et al., 2003; Dormann & Frese, 1994; Frese et al., 1991; Heimbeck et al., 2003; Ivancic & Hesketh, 2000; Keith & Frese, in press; Nordstrom et al., 1998; Wood et al., 2000).

Several cognitive and emotional mechanisms have been proposed to account for the performance effects of error management training. Cognitive approaches argue that error management training fosters exploration, experimentation, and deeper level processing during training (e.g., Dormann & Frese, 1994; Heimbeck et al., 2003; Ivancic & Hesketh, 1995/1996). Emotion-based approaches propose that error

[1] In the empirical study, we also do not differentiate between training conditions with or without error management instructions although we had originally included this as a experimental factor (cf. Method section and Footnote 2).

management training reduces negative emotional reactions such as anxiety and frustration during task completion, because participants are faced with errors and setbacks early in training and learn to regulate their emotions effectively (e.g., Chillarege et al., 2003; Frese et al., 1991; Nordstrom et al., 1998). In an attempt to integrate both views, Keith and Frese (in press; cf. Chapter 2) suggested and found support for the notion that two critical self-regulatory skills are practiced in error management training. Participants learn to exert emotion control aimed at reducing negative emotional reactions to errors and setbacks (Kanfer et al., 1996). Furthermore, participants engage in metacognitive activities which involve planning, monitoring, and evaluation of one's progress toward the goal and revision of strategies where appropriate (Brown et al., 1983). These processes occur in error management training as errors turn participants' attention to the putative causes of the error. Participants then need to come up with solutions to the error, implement the solutions, and monitor their effectiveness (Ivancic & Hesketh, 2000).

Despite the benefits ascribed to error management training and supportive empirical evidence, error management training is not expected to uniformly improve any kind of performance. First, a conceptual and operational distinction between training performance and transfer performance needs to be made. Research has shown that training conditions that positively affect training performance may be detrimental to performance in the long run; conversely, some training conditions may appear to slow down skill acquisition in the first place but promote performance on a transfer task (Ghodsian, Bjork, & Benjamin, 1997; Goodman, Wood, & Hendrickx, 2004; Goodman & Wood, 2004; Schmidt & Bjork, 1992). The latter pattern can be expected when comparing error management training with error avoidant training: During training, error avoidant training should lead to better immediate performance. Participants of error avoidant training merely need to follow the guiding task instructions whereas participants of error management training need to find solutions on their own and, in doing so, sometimes get trapped in error situations. On a transfer performance test, however, where no guidance is provided to participants, the benefits of error management training should unfold, because participants of error management training have acquired emotional control and metacognitive skills that are useful when working on the transfer tasks (Keith & Frese, in press).

Second, a distinction between different types of transfer tasks needs to be made. Transfer implies that knowledge and skills are "transferred from one task or job to another" (Hesketh, 1997, p. 318). Based on the similarity between training and transfer tasks, analogical and adaptive transfer can be distinguished (Ivancic & Hesketh, 2000). Analogical transfer refers to situations where problem solutions are familiar or analogous. Adaptive transfer implies that learned procedures need to be changed or new ones be developed in order to solve the problem at hand. We expect error management training to be particularly effective in promoting adaptive transfer because participants have learned to deal with unexpected problems during training (Keith & Frese, in press). In addition, we suppose that successfully solving adaptive transfer tasks is facilitated by exactly those activities that participants have practiced in error management training: Metacognitive planning, monitoring, and evaluation should be useful when participants try out different ways to solve the new transfer tasks and monitor their effectiveness (Ivancic & Hesketh, 2000). Thus, error management training resembles the transfer situation more than error avoidant training does, and it requires similar activities and processing during training and the transfer test. This issue is captured in the principle of transfer appropriate processing which postulates that those processes required in transfer tasks should be practiced in training (Morris et al., 1977). For analogical transfer tasks, error management training may also be effective. Yet, error avoidant training may be equally effective: To solve transfer tasks that are similar to training tasks (i.e., analogical transfer), participants of error avoidant training merely need to apply the correct strategies they learned during training (Keith & Frese, in press). Based on the foregoing discussion, we expect differential effects of training condition on training performance, analogical transfer, and adaptive transfer performance:

Hypothesis 1a: Error avoidant training will lead to better training performance than error management training.

Hypothesis 1b: Error avoidant training and error management training will be equally beneficial for performance in analogical transfer tasks.

Hypothesis 1c: Error management training will lead to better adaptive transfer performance than error avoidant training.

In other words, we expect participants of error management training to perform worse than participants of error avoidant training in the training tasks, to catch up with them in transfer tasks that are similar to training tasks (i.e., analogical transfer), and finally to outperform them on transfer tasks that require new solutions (i.e., adaptive transfer). In the following sections, we describe how we expect cognitive ability to interact with the training conditions to affect training and transfer performance.

3.2 Cognitive Ability, Error Management Training, and Performance

To our knowledge, only two studies dealing with error management training have investigated interactions of person characteristics (e.g., cognitive ability) and training conditions. Gully et al. (2002) found lower ability participants (i.e., below average) to benefit more from a training that emphasized avoidance of errors; participants at extremely high levels of cognitive ability (i.e., two standard deviations above the mean) performed slightly better in a training encouraging errors. Heimbeck et al. (2003) examined interactions of motivational goal orientations with training condition. They found performance orientations (prove goal orientation and avoidance goal orientation) to positively affect performance in error avoidant training; in error management training, these person characteristics were unrelated to performance. Contrary to what they expected, Heimbeck et al. (2003) did not find highly learning goal oriented participants to benefit more from error management training. These two studies differ from the present one in some important aspects. The study by Gully et al. (2002) did not vary the degree of structure (i.e., active exploration in error management training vs. guiding task instructions in error avoidant training) but focused on different framing of errors in instructions (i.e., encouragement vs. avoidance of errors). Also, Gully et al. (2002) only used training performance as the dependent variable and did not distinguish training from transfer performance. As outlined above, we suggest that error management training studies should explicitly make this distinction, because error management training is expected to affect these outcomes differentially. The study by Heimbeck et al. (2003) varied the degree of structure but did not assess cognitive ability. Finally, these two studies start from a specific view of interactions between person characteristics and training condition that is put forth in research on aptitude-treatment interactions (e.g., Snow, 1986): The basic idea is that some learners benefit more from one treatment than from the other, depending on their particular aptitudes (e.g., cognitive ability or motivational goal orientations). In other words, both studies expected some participants to benefit more from error management training and others to benefit more from error avoidant training.

The theoretical position taken in the present study holds a different view of aptitude-treatment interactions: We start from the (empirically well supported) assumption that cognitive ability generally predicts performance, and we propose that this relation is moderated by the type of training that is delivered. More specifically, we expect that cognitive ability predicts performance in early stages of skill acquisition (regardless of training condition), but that this effect is reduced in error management training (but not in error avoidant training) in later performance phases. Thus, we expect the predictive validity of cognitive ability to decrease in the course of time in error management training, but to be temporally stable in error avoidant training. Empirically, we build this proposition on studies reporting decreasing predictive validities over time (Hulin et al., 1990). Theoretically, we base our argumentation on the resource allocation model by Kanfer and Ackerman (1989) who in turn derive basic assumptions of their model from cognitive information-processing theories (e.g, Kahnemann, 1973; Norman & Bobrow, 1975).

A central assumption in the model by Kanfer and Ackerman (1989) is that cognitive-attentional resources are limited so that individuals can only allocate a limited amount of resources to a particular task. In general, allocation of resources will lead to an increase in task performance. Thus, task performance is a linear function of attentional resources allocated, a relation that is captured by a performance-resource function. Yet, the extent of the increase (i.e., the slope of the performance-resource function) varies depending on certain task characteristics. Tasks where changes in attentional effort are accompanied by corresponding changes in task performance are called resource-dependent; tasks where changes in attentional effort lead to only minimal changes in task performance are called resource-insensitive. For example, very simple or extremely difficult tasks are usually resource-insensitive, because allocating additional attentional effort leads to only minimal improvement in task performance. Another important aspect of the model is that the resource-dependency of a task changes with practice. Over time, tasks that were initially resource-dependent become gradually more resource-insensitive through practice (Norman & Bobrow, 1975). This is consistent with cognitive models of skill acquisition (e.g., Anderson, 1982; cf. Frese & Zapf, 1994; Hacker, 1998) which propose that learners pass through different phases of skill acquisition. Early phases of skill acquisition are characterized by effortful processing as high attentional demands are imposed by the new task. To gain an understanding of the task and to be able to perform the task, learners need to process and integrate various kinds of novel information. In this phase, tasks are resource-dependent. In later phases of skill acquisition, when learners have attained a basic understanding of the task and have developed task-solving strategies, the attentional demands on the learners are reduced, and the same tasks that were resource-dependent in the beginning now become progressively resource-insensitive. Kanfer and Ackerman (1989) translate the performance-resource function into a performance-ability function. They conceptualize individual differences in cognitive ability to reflect individual differences in total cognitive-attentional resource capacity. Thus, from this individual differences perspective, resource-dependent tasks can be described as ability-dependent, and resource-insensitive tasks can be described as ability-insensitive. For skill acquisition, cognitive ability is expected to be related to performance (i.e., tasks are ability-dependent) in early phases where attentional demands are high, but that this relation should decline in later phases when attentional demands are reduced (i.e., tasks become ability-insensitive).

We propose that participants of error management training are sooner to reach later phases of skill acquisition, where tasks become ability-insensitive, as they move from training to transfer tasks than their counterparts of error avoidant training. As a consequence, cognitive ability and *training* performance should be related, but the relation between cognitive ability and *transfer* performance should decline quickly for participants of error management training. The reason for this expected decline lies in the similarity between the training and the transfer situation for participants of error management training. During error management training, participants work on their own, make errors, and need to manage them effectively without further assistance by a trainer. These training activities are challenging and demanding (i.e., ability- or resource-dependent). In this phase, cognitive ability can be expected to relate to performance. Yet, these are the same activities that are also required in the transfer situation; in transfer tasks, just like in error management training, errors occur and no external help is provided. In this respect, participants of error management training have already gained practice of those activities that are needed during transfer – the transfer tasks have become more ability/resource-insensitive for them, and the relation of cognitive ability and transfer performance should be reduced. For participants of the error avoidant training, however, the transfer situation imposes new demands (i.e., the tasks are ability/resource-dependent). Participants of error avoidant training are now left on their own for the first time and may experience errors and setbacks – a situation they have been protected from during training. Because this transfer situation is new to them, cognitive ability can be expected to affect their transfer performance. In other words, we expect training condition to moderate the effects of cognitive ability on transfer performance (i.e., analogical and adaptive transfer), but not the effects of cognitive ability on training performance. In sum, we expect the following relations among training condition, cognitive ability, and performance during training and transfer:

Hypothesis 2a: Cognitive ability will positively affect training performance in error avoidant and in error management training (main effect of cognitive ability).

Hypothesis 2b: Cognitive ability will positively affect analogical transfer performance in error avoidant training; in error management training, this effect will be reduced (interaction of cognitive ability and training condition).

Hypothesis 2c: Cognitive ability will positively affect adaptive transfer performance in error avoidant training; in error management training, this effect will be reduced (interaction of cognitive ability and training condition).

3.3 Method

3.3.1 Participants

Participants were 110 university students, most of them majoring in education (94%). Mean age was 23.95 years (*SD* = 6.08), and the majority of participants were female (86%). Most participants reported having had work experience with 21% having worked regularly before they started attending the university, and 62% working on regular basis while studying for an average of 8.59 hours per week (*SD* = 5.24). Participants' experience with computers differed broadly, but none of them had ever worked with the specific software used in this study (this was a prerequisite for participation).

3.3.2 Experimental Design and Procedure

Participants were trained to create overhead slides with a presentation program (PowerPoint 2000 for Windows) in one of two conditions: error management training (*n* = 54) or error avoidant training (*n* = 56).[2] Sessions were run in groups of 2 to 10 participants. Each group of participants was randomly assigned to one of the training conditions. Sessions lasted approximately three hours (including a 10-minute break). First, demographic data and cognitive ability were assessed. Then, the training part of the session started, comprising three phases: (1) an introductory phase (identical for all participants), (2) the actual training phase where the experimental manipulation took place, and (3) a test phase (identical for all participants; Figure 5). The training material and instructions are provided in Appendix A.

Introductory phase. In the beginning, all participants received a 3-page manual containing general information about the program. The manual briefly explained the

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[2] The original design was a 2 x 2 between-subjects design, where half of the participants of error management training and error avoidant training (Factor 1: Training type) received error management instructions emphasizing the positive function of errors in training (Factor 2: Error management instructions). Yet, because these instructions were not relevant for the present research question and because they did not alter the results, we do not report on this second factor. Also, our study included a measure of error orientations as manipulation check to assess whether participants had understood the error management instructions in the intended way (cf. Study1). There was no difference between groups with and without error management instructions (no main effect of the experimental factor Error management instructions and no interaction between the two experimental factors), indicating that the manipulation had not worked.

menu and toolbars, how specific functions can be activated to create objects (e.g., a rectangle), and how existing objects can be modified (e.g., moving a rectangle). Also, the manual informed about the *undo* function of the program and the *delete* key. To illustrate the position of the elements mentioned in the manual, the manual contained some figures (e.g., screenshots of the toolbars, picture of the delete key). All participants received the same manual so that task information was held constant across training conditions. Reading time was approximately five minutes. Participants were allowed to refer to their manuals during the entire training session (but not during the test phase). After reading the manual and before the actual training started, participants first worked on a simple warm-up slide. This introductory task included creating and modifying a circle, a rectangle, a text box, and an arrow while following written instructions. The experimenter demonstrated the first few steps by reading out loud the instructions and then carrying out the described actions. The computer monitor of the experimenter was projected by a beamer, so that all participants could watch the experimenter's actions on a screen. Participants were asked to complete the introductory task following the written instructions. No time limit was given for this introductory task (the manual and the introductory task were the same as in the study by Keith and Frese, in press; cf. Chapter 2).

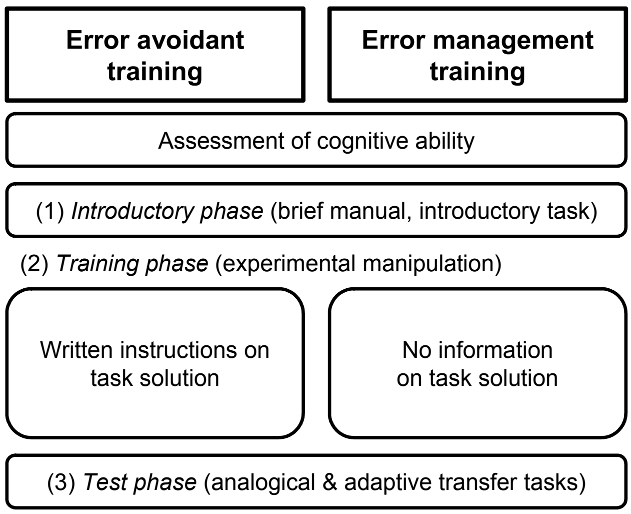


Figure 5. Course of the experiment (Study 2).

Training phase. After the introductory phase, the actual training began in which the training condition was experimentally manipulated. Participants were consecutively given copies of two slides printed on paper. The task was to reproduce these slides as closely as possible. The first slide required creating, moving, and modifying (e.g., coloring) diverse objects such as rectangles, triangles, textboxes, and stars. The second slide involved creating and modifying a table by simple formatting such as coloring cells and centering cell entries. To complete each slide, participants were given 15 minutes, resulting in a training time of 30 minutes (the two slides and the training time were the same as in the study by Keith and Frese, in press; cf. Chapter 2).

Participants completed the training tasks in 1 of 2 training conditions: error avoidant training or error management training. In the *error avoidant training*, participants received detailed written instructions (similar to those in the introductory practice phase) explaining task solution in a step-by-step manner. They were told that these instructions would enable them to learn the most important program functions in the shortest time, and that by following the instructions participants would become familiar with the correct functions from the very beginning. To ensure that participants follow the written instructions, they were asked to tick off each step after finishing it. All but five participants followed this request, that is, the number of tickmarks corresponded to the number of steps taken (to keep up statistical power, we kept these five cases in the analyses, although the results were almost identical when excluding them). In the *error management training*, participants were not provided with any additional information on task solution but were asked to solve the training tasks independently. They were told that working independently would help them to gain an in-depth look into the program and to become familiar with it. Training time was held constant for all participants. In case that participants finished earlier with a slide, the experimenter gave instructions in line with training conditions (cf. Heimbeck et al., 2003). In error avoidant training, participants were told that practice makes perfect, and they were asked to start over with the same slide, following the written instructions. In error management training, participants were asked to use the remaining training time to freely explore and try out any functions they liked. All participants were reminded of the undo function and the delete key before the training commenced.

Test phase. Tasks and instructions in the test phase were identical for all participants. Participants were handed printed copies of four slides. As in the training phase, the task was to reproduce these slides as closely as possible. The first test slide comprised bullet points with test items and a figure consisting of several framed and colored text boxes and arrows. The main task of the second test slide was to produce and to format a table. For the third slide, a vertical bar chart had to be created and edited with the diagram function of the program. The forth slide comprised animated objects. To demonstrate the sequence and type of animations that were to be programmed for the objects, this slide was continuously projected on a screen. Participants were given 10 minutes, respectively, to complete each of the first three slides and 15 minutes for the fourth slide. The first three slides were identical to those used by Keith and Frese (in press; cf. Chapter 2). The fourth slide was newly developed and added to the testing material to include more test tasks that were difficult and dissimilar from the training tasks.

3.3.3 Measures

Performance. Performance ratings were conducted on the basis of the slides that the participants had created during the training and the test phase. Each task was divided into meaningful subtasks. These subtasks served as coding units and were rated as either correctly completed or not (dichotomous rating; cf. Heimbeck et al., 2003; Keith & Frese, in press). One rater coded all training and test slides; a second rater coded a randomly chosen subset of slides from 30 participants (27.3%). Both raters were blind to the experimental condition. Inter-rater agreement (based on the subset) was high for both the training slides (Cohen's kappa = .79) and test slides (Cohen's kappa =.81). To arrive at a measure for overall *training performance*, the number of completed subtasks in the two training slides was computed. To arrive at a measure for *analogical transfer* performance, the number of completed subtasks in testing slides 1 and 2 was computed, because these slides included tasks that were similar to training tasks (e.g., inserting textboxes, formatting a table). To arrive at a measure for *adaptive transfer* performance, the number of completed subtasks in testing slides 3 and 4 was computed, because these slides included tasks that were distinct from training tasks (e.g, formatting a diagram, inserting animated objects). Thus, all three performance measures (i.e., training, analogical, and adaptive transfer performance) were based on two slides, respectively.

Cognitive ability. Cognitive ability was assessed using the number combination test (Zahlen-Verbindungs-Test; Oswald & Roth, 1987). The number combination test is a German paper-and-pencil trail-making test. The task is to draw lines to connect randomly positioned numbers (ranging from 1 to 90) in ascending order as quickly as possible. This test is a general measure of cognitive ability (i.e., speed of information processing). Thus, it corresponds to the concept of cognitive-attentional resource capacity in the model by Kanfer and Ackerman (1989) on which the present research was based. The test authors report a mean correlation of .50 (range .40-.83) with other intelligence measures (e.g., Standard Progressive Matrices and Wechsler Adult Intelligence Scale). Substantial correlations with other intelligence measures in English speaking samples have also been reported (Vernon, 1993; Vernon & Weese, 1993).

Computer experience. Participants were asked how many years they had been using a computer. We subtracted this number from their age to arrive at a measure for *age of first computer usage*, because in pilot studies (and also in the present study), this variable correlated more highly with performance variables than either one (i.e., age or years of usage) alone. We included this computer experience variable as statistical control in all analyses. Note that this variable is expected to correlate negatively with performance variables (the earlier a person starts to use the computer, the greater is his or her computer experience).

3.4 Results

3.4.1 Intercorrelations of Study Variables

Descriptive statistics and intercorrelations of the study variables are displayed in Table 5. As expected, computer experience and cognitive ability correlated substantially with all three performance variables. We included computer experience and cognitive ability as statistical controls in all further analyses.

3.4.2 Performance Effects of Training Condition

Hypotheses 1 predicted differential effects of training condition on performance in training (1a), analogical transfer (1b), and adaptive transfer (1c). We tested this hypothesis using a repeated measures ANCOVA with training condition as between-subjects factor, computer experience and cognitive ability as covariates, and the three performance variables as repeated measures factor. As predicted, there was a significant interaction of the between-subjects factor and the repeated measures factor with a large associated effect size, F (2,105) = 8.91, $p < .01$, $\eta^2 = .15$. Post-hoc univariate analyses revealed that in training, participants of error avoidant training performed better than participants of error management training, F (1,106) = 8.94, $p < .01$, $\eta^2 = .08$, $d = 0.57$; in analogical transfer tasks, there was no difference between the two groups, F (1,106) = 0.58, $p = .45$; and in adaptive transfer tasks, the error management training group performed better than the error avoidant training group, F (1,106) = 4.01, $p < .05$, $\eta^2 = .04$, $d = 0.38$. Thus, Hypothesis 1 was fully supported.

Table 5
Means, Standard Deviations, and Intercorrelations of the Study Variables

			1	2	3	4	5	6
1	Training condition[a]		--					
2	Computer experience[b]		.07	--				
3	Cognitive ability		.01	-.24*	--			
4	Training performance		-.26**	-.30**	.40**	--		
5	Analogical transfer		-.07	-.20*	.37**	.57**	--	
6	Adaptive transfer		.16	-.29**	.39**	.38**	.64**	--
Descriptive statistics								
Total		*M*	-0.02	18.00	47.90	26.83	8.50	11.55
		SD	1.00	5.41	6.31	5.27	4.28	5.30
Error avoidant		*M*	-1.00	17.64	47.85	28.16	8.80	10.71
		SD	0.00	4.75	6.48	5.06	4.53	5.38
Error management		*M*	1.00	18.37	47.96	25.44	8.19	12.41
		SD	0.00	6.04	6.18	5.16	4.02	5.13

Note. N = 110 (error avoidant training: n = 56, error management training: n = 54).

[a] Contrast code: error avoidant training = -1, error management training = 1.

[b] Year of first computer usage; smaller numbers indicate greater computer experience.

* $p < .05$, two-tailed. ** $p < .01$, two-tailed.

3.4.3 Interactions of Training Condition and Cognitive Ability

Hypothesis 2 predicted differential interaction effects of training condition and cognitive ability on performance in training (2a), analogical (2b), and adaptive transfer (2c). We tested this hypothesis in hierarchical moderated regression analyses (Aiken & West, 1991). We entered computer experience and cognitive ability first, followed by the contrast variable representing training condition, followed by the moderator term cognitive ability x training condition. The results are displayed in Table 6. As predicted (Hypothesis 2a), there was no interaction effect on training performance ($\Delta R^2 = .01$, $p = .24$) but a main effect of cognitive ability ($\beta = .36$, $p < .01$). For the two transfer measures (Hypotheses 2b and 2c), there were interactions of cognitive ability and training condition (for analogical transfer $\Delta R^2 = .06$, $p < .01$; for adaptive transfer ($\Delta R^2 = .03$, $p < .05$; cf. Table 6).

Table 6

Interactions of Training Condition and Cognitive Ability on Performance during and after Training

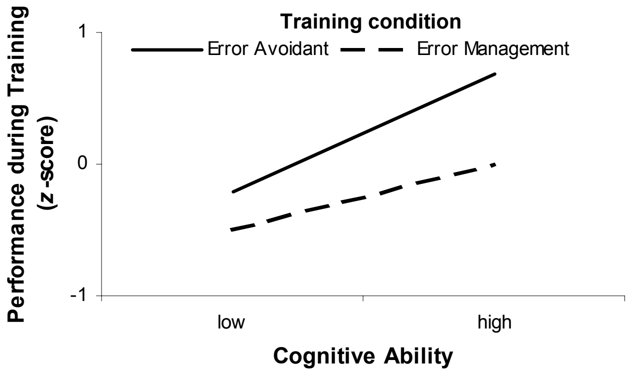
Predictor / step	*B*	*SE B*	β	R^2	ΔR^2
Effects on Performance during Training					
1. Control variables				.21**	
Computer experience (age of first use)	-0.20	0.08	-.20*		
Cognitive ability	0.30	0.07	.36**		
2. Training condition				.27**	.06**
Err. avoid. vs. err. management training	-1.30	0.44	-.25**		
3. Interaction term				.28**	.01
Training condition x Cognitive ability	-0.08	0.07	-.10		
Effects on Analogical Transfer Performance					
1. Control variables				.15**	
Computer experience (age of first use)	-0.09	0.07	-.11		
Cognitive ability	0.23	0.06	.34**		
2. Training condition				.15**	.01
Err. avoid. vs. err. management training	-0.29	0.38	-.07		
3. Interaction term				.22**	.06**
Training condition x Cognitive ability	-0.17	0.06	-.25**		
Effects on Adaptive Transfer Performance					
1. Control variables				.19**	
Computer experience (age of first use)	-0.20	0.09	-.21*		
Cognitive ability	0.29	0.08	.34**		
2. Training condition				.22**	.03*
Err. avoid. vs. err. management training	0.91	0.45	.17*		
3. Interaction term				.25**	.03*
Training condition x Cognitive ability	-0.15	0.07	-.17*		

Note. $N = 110$ (error avoidant training: $n = 56$, error management training: $n = 54$).

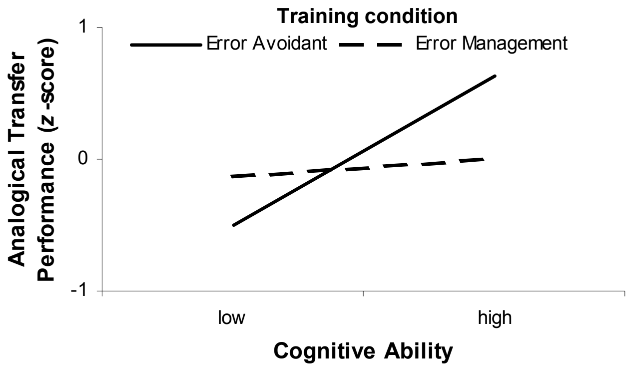
* $p < .05$, two-tailed. ** $p < .01$, two-tailed.

To examine the direction of the interactions, we calculated group-wise simple slopes using the procedure outlined by Aiken and West (1991). As predicted, cognitive ability had an effect on transfer performance in the error avoidant training group (for analogical transfer β = .57, $p < .01$; for adaptive transfer β = .49, $p < .01$). As expected, in the error management training group cognitive ability did not significantly affect transfer performance (for analogical transfer β = .07, $p = .62$; for adaptive transfer β = .14, $p = .27$). Thus, Hypotheses 2b and 2c were also supported: The effect of cognitive ability on transfer performance disappeared in the error management training group.

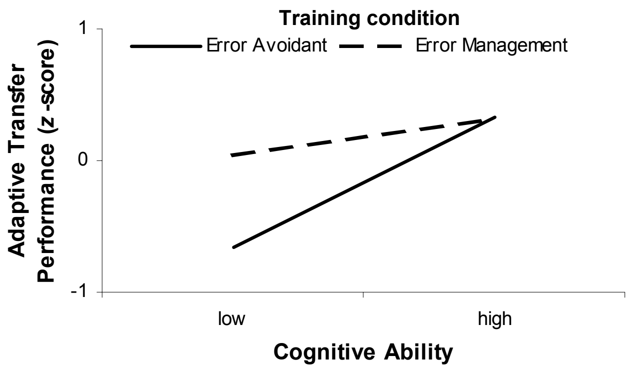
The results for Hypotheses 1 and 2 are graphically summarized in Figure 6 (for clarity and comparability, *z*-scores of performance variables were used). Figure 6a plots the effects of training condition and cognitive ability on training performance: The graphs representing error management and error avoidant training both show a linear increase (i.e., main effect of cognitive ability) and are roughly parallel (i.e., no interaction effect); the overall level of the graph representing error avoidant training is higher (i.e., main effect of training condition in favor of error avoidant training). Figure 6b plots the effects on analogical transfer performance: The graph representing error avoidant training is steeper than the one representing error management training (i.e., interaction effect). As there was no main effect of training condition on analogical transfer performance, the two graphs cross at about the mean value of cognitive ability. This pattern implies that, in terms of analogical transfer performance, lower ability individuals benefited more from error management than from error avoidant training; conversely, higher ability individuals benefited more from error avoidant than from error management training. Figure 6c plots the effects on adaptive transfer: The graph representing error avoidant training is steeper than the one representing error management training (i.e., interaction effect), and the overall level of the graph representing error management training is higher (i.e., main effect of training condition in favor of error management training). This pattern implies that, in terms of adaptive transfer performance, individuals with higher cognitive ability benefited equally well from error management and from error avoidant training; lower ability individuals, however, benefited more from error management than from error avoidant training, and they performed almost as well as individuals with higher ability in either training condition.



(a) Main effect of training condition and cognitive ability on performance during training (no interaction effect).



(b) Interaction of training condition and cognitive ability on analogical transfer performance (no main effect of training condition).



(c) Main effect of training condition and interaction effect of training condition and cognitive ability on adaptive transfer performance.

Figure 6. Main effects and interactions of training condition and cognitive ability on performance during training (a), analogical transfer performance (b), and adaptive transfer performance (c).

3.5 Discussion

The present study contributes to training theory and practice in two ways. First, our study underlines the importance of distinguishing training from transfer performance as well as different types of transfer tasks when evaluating training effectiveness. To our knowledge, no study comparing error management with error avoidant training so far has systematically contrasted effects on training, analogical, and adaptive transfer performance. Our results showed error avoidant training to lead to better immediate performance during training, but this advantage was leveled out for analogical transfer tasks and even reversed for adaptive transfer tasks where error management training lead to better performance. This pattern of results is in line with training research which has shown that those interventions that improve immediate practice performance may be detrimental to performance in the long run and vice versa (Ghodsian et al., 1997; Goodman & Wood, 2004; Goodman et al., 2004; Ivancic & Hesketh, 2000; Schmidt & Bjork, 1992). This distinction is critical because it implies that trainers should not mistakenly conclude from enhanced training performance that their intervention has really produced long term learning. Conversely, seemingly impeded practice performance does not mean that the participant is not learning. Our results suggest that error management training leads to initially impeded observable performance compared with error avoidant training, but that it is better than error avoidant training when participants are confronted with tasks for which they need to develop new solutions (i.e., adaptive transfer).

Training studies that do not explicitly adopt the distinction between different types of performance may lead to completely different conclusions. For example, given the present results, studies investigating training performance rather than transfer performance should come to the conclusion that error avoidant training is better than error management training, and studies investigating analogical transfer performance may conclude that both trainings are equally beneficial. In fact, Gully et al. (2002), who used training performance as criterion variable found a training condition that encouraged errors to lead to worse performance than a training that emphasized avoidance of errors. Thus, it seems worthwhile for error management training studies and probably for training studies in general to be more explicit about the type of performance that is investigated. For practical purposes, adaptive transfer performance seems most important because, in many organizational contexts, not all potential work-related problems and their solutions can be taught within the allotted training time (Hesketh, 1997; Kozlowski et al., 2001; Smith et al., 1997).

Second, our study showed that error management training can reduce the effect of cognitive ability on transfer performance. During training, cognitive ability affected performance in both error management training and error avoidant training. In the later transfer phase, however, this effect remained only in the error avoidant training group but disappeared in the error management training group. An inspection of the pattern of the interaction between training condition and cognitive ability revealed that for analogical transfer performance, higher ability trainees tended to benefit more from error avoidant training and lower ability trainees more from error management training. For adaptive transfer, however, the pattern showed an overall advantage for error management training: Lower ability trainees in error management training performed about as well as their higher ability counterparts from both error avoidant and error management training who did not differ in adaptive transfer performance; adaptive transfer performance was worst for lower ability trainees in error avoidant training (cf. Figure 6). Apparently, for higher ability trainees the type of training does not matter whereas for lower ability trainees error management training is preferable to error avoidant training when the training goal is to promote adaptive transfer performance.

From a theoretical perspective, the interaction effect of training condition and cognitive ability on transfer performance is interesting because it points to potential processes occurring during training and transfer. In explaining the interaction effect, we base our argumentation on the resource allocation model by Kanfer and Ackerman (1989) who distinguish ability-dependent tasks (where individual differences in ability affect task performance) from ability-insensitive tasks (where task performance is relatively insensitive to individual differences in cognitive ability). During skill acquisition, initially ability-dependent tasks are expected to become increasingly ability-insensitive. We propose that, as participants move on from training to transfer tasks, the transfer task becomes less ability-dependent only for participants of error management training because the transfer situation is similar to the training situation and because participants have already developed the skills required for transfer during training. For participants of error avoidant training, however, who were protected from making errors and who received guiding instructions during training, the transfer situation is different from the training situation: The task to find solutions and manage errors independently is new for them and, therefore, ability-dependent. Higher ability participants master this new situation as well as their counterparts from error management training, but lower ability trainees' performance is debilitated. In other words, error management training seems to prepare participants better for requirements of the transfer situation and even compensates for potential performance deficits in lower ability trainees, because the training situation resembles the transfer situation with regard to the processes and task strategies needed by participants. This is in line with the principle of transfer appropriate processing postulating that those processes needed on transfer tasks should be practiced in training (Morris et al., 1977). The interaction effect we found underlines the validity of this principle.

Our study has some limitations which may be addressed in future research. First, we included only few phases of skill acquisition in our training experiment (i.e., training and transfer phase). It may be interesting to include more training and transfer phases to investigate the decrease of the ability/performance relationship in error management training in more detail. Such a design could also answer the question whether the ability/performance relationship we found for error avoidant training remains stable over time or whether it decreases in later transfer phases as participants of error avoidant training, too, gain experience with the transfer situation. Second, we did not directly assess processes in error avoidant and error management training but draw rather indirect conclusions from the pattern of ability/performance relationships across training and transfer phases. Future research could employ more direct measures of processes during training and transfer. Moreover, another test of the resource allocation perspective we adopted for the present study could use the dual-task paradigm from cognitive psychology where participants are asked to work on two similar tasks concurrently. We interpret the decline of the ability/performance relationship for error management training in transfer task as reflecting ability insensitivity of the task. If this interpretation holds, then an error management training group that is asked to concurrently work on a secondary task during transfer should show a lower decline than a group without a secondary task because of the resources demanded by the secondary task. Similarly, for an error management training group receiving a resource-demanding secondary task during training, the decline during transfer may be delayed because it takes longer to develop the strategies needed in transfer due to the secondary task. Finally, we do not know whether the present results generalize to other persons and situations. We are confident that the main effects of training condition generalize to other participant samples because similar results have been found in studies using participants other than university students (e.g, Chillarege et al., 2003; Frese et al., 1991). The same applies for the main effect of cognitive ability on performance which is a well documented finding in applied psychology (e.g., Hunter & Hunter, 1984; Ree et al., 2001; Ree et al., 1995; Ree & Earles, 1991; Salgado et al., 2003; Schmidt & Hunter, 1998). Yet, it is possible that the interaction effect we found for cognitive ability and training condition is weaker or temporally delayed in participant samples with presumably lower levels of cognitive ability than the present university students, because the tasks then may remain more challenging for participants of error management training across time and, consequently, participants' progress in skill acquisition to phases where tasks become ability/resource-insensitive may take longer.

4 PERFORMANCE EFFECTS OF ERROR MANAGEMENT TRAINING: A META-ANALYSIS

Errors at work are a nuisance. Errors interrupt the work flow, error correction can be time-consuming and frustrating, and some workplace errors have severe consequences for individuals and organizations. It is therefore not surprising that people usually prefer to avoid errors in the first place. Consistent with this approach, many scholars in the area of learning and training take a negative view on errors. They conceptualize errors to lead to inefficiencies, wrong habits, and emotional frustration. A famous example is Skinner (1953) who equated errors with punishment that can inhibit behavior but does not contribute to learning. Similarly, Bandura (1986) views errors as detrimental to learning and states that "Without informative guidance, much of one's efforts would be expended on costly errors and needless toil." (p. 47).

Yet, errors are ubiquitous and can not be completely avoided even among experts (Prümper et al., 1992). This is even more true during training, when knowledge and skills are not fully developed (Heimbeck et al., 2003). Thus, strategies of error avoidance may be supplemented by strategies of error management which are directed at quickly reacting to and effectively dealing with errors after they have occurred (Frese, 1995). Furthermore, errors are not entirely negative events but may also lead to positive consequences such as learning or innovation – as long as they can be dealt with adequately (van Dyck et al., in press). Error management training incorporates this somewhat positive view on errors into training. Errors are regarded as informative feedback that helps to improve knowledge and skills (Ivancic & Hesketh, 1995/1996). Consequently, error management training advances active exploration and explicitly encourages participants to make errors and to learn from them.

Since its development in the 1980ies, error management training has repeatedly been shown to lead to better performance than conventional trainings that adopt an error avoidant approach. Many of the early studies on error management training used rather small participant samples in trainings teaching a new computer program (e.g., Frese et al., 1991; Dormann & Frese, 1994). Later studies replicated the performance effects in larger samples (e.g., Chillarege et al., 2003; Heimbeck et al., 2003) or applied error management training in other task areas such as driving simulation training (Ivancic & Hesketh, 2000), decision making (e.g., Gully et al., 2002), electronic search (Debowski et al., 2001; Wood et al., 2000), and teaching firefighting skills (Joung, Hesketh, & Neal, 2004).

Contrary to the results of earlier studies on error management training, some recent studies have found other training forms to be equally effective or even better than error management training (e.g., Debowski et al., 2001; Gully et al., 2002). These findings cast the universal effectiveness of error management training into doubt and seem to support the arguments that are turned against the incorporation of errors in training (Bandura, 1986; Skinner, 1953). The present research takes up these contradictory findings and critical arguments. We propose that error management training can effectively promote performance but suggest that certain conditions have to be met to make this from of training effective. Using meta-analytic techniques, we evaluate the overall effectiveness of error management training. We further examine the conditions that promote or restrict the effectiveness of error management training. A closer investigation of these conditions may be valuable both for researchers and practitioners. Researchers may gain a better understanding of when and how learning form errors can occur. Practitioners may find practical guidelines that specify the situations in which error management training is most promising. In the following, we first provide a brief description of the concept and design of error management training and discuss some processes underlying its effectiveness. In a second step, we turn to the factors which we expect to promote or attenuate the effectiveness of error management training and describe them in more detail.

4.1 Design and Effects of Error Management Training

In error management training, participants are regarded as active learners rather than as passive recipients of instruction (Frese & Zapf, 1994; Greif & Janikowski, 1987). Consequently, instead of detailed information on task solution, participants are given only a minimum of task information and are otherwise encouraged to explore and experiment on their own. In this respect, error management training is similar to exploratory or discovery learning (Bruner, 1966). Error management training, however, places a stronger emphasis on and is more explicit about errors. For example, in a computer training, only minimal information about the structure of the computer program and its main functions is given, and participants work on relatively difficult training tasks on their own and without further help – a procedure that almost inevitably leads to many errors. In order to reduce potential frustration with the errors, Frese et al. (1991) introduced so-called error management instructions that provide a positive framing of errors. In these instructions, participants are prepared to expect errors while they work on the tasks and they are explicitly told about the positive function of errors for learning. The core idea of the error management instructions is summarized verbally and visually in brief positive error statements such as "The more errors you make, the more you learn!", or "You have made an error? That's great, because now you can learn something new!". During the training session, the trainer repeats these statements several times and reminds participants to reflect on errors whenever they happen, but does not provide any further assistance.

Several training experiments found error management training to lead to better transfer performance compared to other forms of training in terms of number of tasks solved successfully (Chillarege et al., 2003; Heimbeck et al., 2001; Nordstrom et al., 1998; Wood et al., 2000), correctness, efficiency, and speed of solutions in difficult tasks (Dormann & Frese, 1994; Frese et al., 1991), or number of errors in transfer tasks (Ivancic & Hesketh, 2000). To account for the performance effects of error management training, diverse mechanisms have been proposed although they have rarely been tested directly. Approaches focusing on cognitive aspects argue that error management training fosters exploration, experimentation, and deeper level processing during training (Dormann & Frese, 1994; Heimbeck et al., 2003; Ivancic & Hesketh, 1995/1996). Approaches focusing on motivational/emotional aspects expect error management training to reduce frustration and anxiety in the face of errors because participants learn to interpret errors as challenges rather than as failures (Chillarge et al., 2003; Frese et al., 1991; Ivancic & Hesketh, 1995/1996; Nordstrom et al., 1998). In an attempt to integrate these two approaches, Keith and Frese (in press; cf. Chapter 2) proposed and found empirical support for the notion that participants of error management training apply two self-regulatory skills that are useful when participants are later confronted with novel tasks. They learn to exert emotion control aimed at reducing negative emotional reactions to errors and setbacks (Kanfer et al., 1996). In addition, they engage in metacognitive activities involving planning, monitoring, and evaluation of one's progress during task completion and revision of strategies when necessary (Brown et al., 1983). Such metacognitive activities are instigated because "errors prompt learners to stop and think about the causes of the error" (Ivancic & Hesketh, 2000, p. 1968) and to experiment with different solutions. In sum, given the empirical evidence on the effectiveness of error management training and the theoretical propositions describing how errors can promote learning, we expect error management training to affect performance positively.

Hypothesis 1: Error management training shows an overall positive effect.

Despite the preceding argumentation emphasizing the benefits of error management training for learning and performance, some qualifications need to be made in the sense of moderating factors that allow these benefits to unfold. These moderating factors, which we will describe next, include the phase of evaluation, the similarity between training and transfer tasks, the clarity of task-generated feedback, and the type of training that error management training is compared with.

4.2 Evaluation Phase

The effectiveness of error management training may depend on the experimental phase that serves as the basis for evaluation. Training research has shown that manipulations that positively affect training performance may negatively affect performance in the long run and vice versa (Ghodsian et al., 1997; Goodman et al., 2004; Goodman & Wood, 2004; Hesketh, 1997; Ivancic & Hesketh, 1995/1996; Schmidt & Bjork, 1992). A conceptual and operational distinction between training phase performance and test phase performance may therefore be reasonable. Accordingly, many (but not all) error management training studies include an explicit test phase at the end of the experiment that takes place after the training phases. During the training phases, error management instructions are given and participants are explicitly encouraged to make errors and to explore the system. During the test phase, however, participants are informed that their performance is now being evaluated (e.g., Keith & Frese, in press; Wood et al., 2000). Other studies have not explicitly made this distinction but rather repeated error management instructions throughout the entire session and then selected one of the practice phases, usually the final phase, to assess criterion performance (e.g., Gully et al., 2002). Such a procedure seems problematic for conceptual and practical reasons: First, the basic idea of error management training is that learning processes are instigated by errors and exploration. During training, these processes may reduce performance in terms of error rate, efficiency, or time for task solution. Participants explore, make errors, and are not concerned with efficiency and may, therefore, sometimes arrive at wrong solutions (Keith & Frese, in press). Second, it seems inconsistent to tell participants to make errors and then use the errors and inefficiencies as indicators of poor performance.

Hypothesis 2: Phase used for evaluation moderates the effectiveness of error management training. Studies assessing performance in a test phase will yield larger effects than studies assessing performance in a training phase.

4.3 Adaptivity of Transfer Task

The effectiveness of error management training may depend on the type of transfer task that is used to evaluate performance. Transfer implies that knowledge and skills are "transferred from one task or job to another" (Hesketh, 1997, p. 318). Depending on the similarity between training and transfer tasks, analogical and adaptive transfer can be distinguished (Ivancic & Hesketh, 2000). Analogical transfer refers to situations where problem solutions are familiar or analogous. Adaptive transfer comprises "using one's existing knowledge base to change a learned procedure, or to generate a solution to a completely new problem" (Ivancic & Hesketh, 2000, p. 1968). Thus, adaptive transfer implies that transfer tasks not only are more difficult than training tasks but that they are structurally distinct in that they require new procedures. From a practical point of view, adaptive transfer seems most important because, in many organizational contexts, not all potential work-related problems and their solutions can be explained and practiced within the allotted training time (cf. Smith et al., 1997). We expect error management training to be particularly effective for adaptive transfer performance because participants learn to deal with unexpected problems during training and thereby gain knowledge that can be useful when confronted with new tasks (Ivancic & Hesketh, 2000; Keith & Frese, in press). For analogical transfer performance, error management training may also be useful (Ivancic & Hesketh, 2000) but it is possible that other training forms may be equally effective as error management training. For example, if training and transfer tasks are very similar (i.e., analogical transfer) and require the same single-best strategy for solution, then an effective and less time-consuming procedure may be to teach the correct task strategies directly rather than to have participants discover this single-best solution on their own by errors and exploration.

Hypothesis 3: Adaptivity of transfer task moderates the effectiveness of error management training. Studies assessing adaptive transfer performance will yield larger effects than studies assessing analogical transfer performance.

4.4 Task-Generated Feedback

The effectiveness of error management training may depend on the type of feedback the task provides. Feedback can serve as a motivator (Ilgen, Fisher, & Taylor, 1979), and it contains information (Ivancic & Hesketh, 1995/1996). Feedback permits an individual to make a judgment about the extent to which he or she has achieved the goal or standard (Carver & Scheier, 1998; Frese & Zapf, 1994; Hacker, 1998; Ilgen et al., 1979; Latham & Locke, 1991; Sonnentag, 1998). Errors are one form of negative feedback that indicates a deviation between the goal or standard and the current state (Frese & Zapf, 1994). Error detection is closely related to task feedback because only in a task that provides sufficient feedback can errors be detected and corrected (Frese & Zapf, 1994). In addition to the judgment about the current state, errors and feedback can be used retrospectively to evaluate the effectiveness of one's previous strategies (Neubert, 1998) and, based on this evaluation, to adjust one's strategies accordingly. In error management training, the tasks or subtasks to be solved serve as the goal or standard the current state is compared with. For example, if the task in a computer training is to format a diagram, participants will constantly monitor and evaluate their progress toward this goal while working on the task. They may try out different solutions if they realize that their current strategy is not working, and they may detect and correct errors (Ivancic & Hesketh, 2000; Keith & Frese, in press). These activities, however, can only be pursued in tasks that provide informative, clearly interpretable, and relatively continuous task feedback. Error management training, therefore, may be less suited for tasks that provide only low-fidelity feedback that can not be readily interpreted (Debowski et al., 2001).

Hypothesis 4: Clarity of task feedback moderates the effectiveness of error management training. Studies using tasks that provide clear feedback will yield larger effects than studies using tasks with unclear feedback

4.5 Type of Comparison Training

Whether error management training yields positive evaluation results may depend on the type of training form that is used as comparison. As mentioned above, many studies compared error management training with traditional trainings that adopt an avoidant approach to errors (Ivancic & Hesketh, 1995/1996) and which have consequently been labeled error-avoidant trainings in some studies (e.g., Frese et al., 1991; Nordstrom et al., 1998). An error avoidant training mimics many conventional tutorials. It provides step-by-step instructions to prevent errors from occurring, and participants are not informed about the positive function of errors (Frese, 1995). Thus, error avoidant training differs from error management training in two aspects, namely the guidance provided and the positive error management instructions. Recent studies have – and justifiably so – criticized that comparisons of error management training with error avoidant training confound these two aspects, so that observed performance differences can not be unequivocally attributed to either one aspect (e.g., Gully et al., 2002). Consequently, some studies isolated the two aspects and compared error management training with trainings that provided as little guidance as error management training but which lacked any positive mentioning of errors as in error management instructions (Bell, 2003; Gully et al., 2002; Heimbeck et al., 2003).

We suppose that error management training is better than both types of comparison trainings (i.e., guided training and unguided training without error management instructions). We consider both aspects of error management training, namely, exploration rather than guidance and error management instructions, to be important for its effectiveness. For learning from active exploration and errors, a positive view on errors, as is conveyed in error management instructions, is essential. Stated differently, "developing an error tolerant attitude ... maximize[s] the informational value of errors" because they are no longer interpreted as failures (Ivancic & Hesketh, 1995/1996, p. 115). Therefore, we expect error management training which includes error management instructions to lead to better performance than other unguided trainings that do not include error management instructions. Yet, we expect the advantage of error management training to be more pronounced when compared with guided trainings, because the latter differ from error management training in two aspects, namely, the guidance provided and the lack of error management instructions.

> *Hypothesis 5*: The type of training that is compared with error management training moderates the effect of error management training on performance. Studies comparing error management training with guided trainings will yield larger effects than studies comparing error management training with unguided trainings without error management instructions.

4.6 Method

4.6.1 Pool of Primary Studies

Effect sizes were drawn from studies that compared one or more error management training conditions with one or more other training conditions (e.g., error avoidant training) with regard to task performance. A training condition was considered to represent error management training if two criteria were met: (1) Participants were asked to find task solutions on their own (i.e., they were not guided to correct task solutions but explored) and, as a consequence, errors could be expected to occur during task completion. (2) Participants received error management or similar instructions that stressed the positive function of errors for learning and explicitly encouraged them to learn from errors. Studies were compiled from database searches of *PsycInfo* (1872-Spring 2004), *SSCI* (1994-Spring 2004), and *Psyndex* (which is the German analogue to *PsycInfo*; 1977-Spring 2004), from manual searches of conference programs of *SIOP* (Society for Industrial and Organizational Psychology), from consulting the reference lists of the identified studies, and from contacting first authors of published papers and other colleagues who worked in the area of errors and error management training. The German data base was included because some early publications by Frese and other researchers were in German. In principle, we did not restrict our search to studies that explicitly referred to error management training in the form developed by Frese and colleagues (Frese, 1995; Frese et al., 1991) but the search did not yield any studies that did not refer to Frese's work and still met the two inclusion criteria listed above. Three studies (Ivancic & Hesketh, 2000; Joung et al., 2004; Lorenzet et al., 2001) explicitly referred to Frese's work but did not include exploration or error management instructions in the operationalization of the training and, therefore, were not included in our study pool.

The final pool comprised 23 independent studies with 1981 participants. Ten of the studies were unpublished. All studies but one were laboratory studies that used experimental designs with participants or small groups of participants randomly assigned to training conditions. The majority of the trainings were software trainings that taught a new computer program (k = 17) or electronic search of databases (k = 3). The remaining three trainings used a computerized decision making task. Six studies included employees who were recruited in the community (e.g., via newspaper advertisements or radio announcements); the remaining studies used samples of university students. In two studies, participant dyads (rather than individuals) worked together and were the unit of analysis.

When studies compared one or more error management training conditions with more than one other training condition, we calculated the mean effect size for use in further analyses. Similarly, when studies assessed multiple task performance outcomes, we included the mean effect size. If the multiple outcomes assessed were not similar but referred to tasks of different levels of difficulty, we only included the most difficult task because this is the most relevant variable from a theoretical point of view. Using only one effect size per study is a generally recommended strategy in order to avoid statistical dependencies which lead to biased estimates (e.g., Hedges & Olkin, 1985; Hunter & Schmidt, 1990; Lipsey & Wilson, 2001; Rosenthal, 1991).

4.6.2 Coding of Study Characteristics and Interrater Agreement

Corresponding to our research hypotheses, we coded four theory-based variables as potential moderators. The complete set of 23 studies was coded independently by two raters (the first author and a graduate student). Interrater agreements (Cohen's kappa) was good to excellent according to Fleiss (1981). Cases with different codings of the two raters were resolved by discussion (the kappa coefficients reported below refer to initial agreements before these discussions). The complete coding scheme is provided in Appendix C.

Evaluation Phase. Evaluation phase was a dichotomous variable that described whether criterion performance referred to a separate performance phase. It was designed to capture whether participants of error management training presumably were aware that their performance was being evaluated or whether they thought that errors and exploration are still encouraged. If participants were informed that their performance was evaluated and errors were no longer encouraged, this was coded as reflecting *test phase performance*. In contrast, if error management instructions were repeated throughout the whole experimental sessions and the study authors based their criterion performance on the final phase, this was coded as reflecting *training phase performance*. Initial interrater agreement (Cohen's kappa) was .83 for this variable.

Adaptivity of transfer task. This dichotomous coding variable was designed to capture whether the criterion tasks were structurally similar to the tasks that participants had worked on during training (*analogical transfer*), or whether the tasks required new solutions (*adaptive transfer*) (Ivancic & Hesketh, 2000). For this coding, the critical characteristic was task distinctiveness rather than task difficulty (Frese & Zapf, 1994; Keith & Frese, in press). For example, if the participants' performance task was to solve the same tasks as in training but under greater time pressure, this task may be more difficult but not structurally distinct, indicating analogical transfer. Initial interrater agreement (Cohen's kappa) was .91 for this variable.

Clarity of task feedback. This dichotomous coding variable was designed to capture the amount of information provided by the system feedback. When the system feedback enabled participants to track the consequences of their action, to judge their progress towards the goal, and to detect errors, this was coded as *clear task feedback*.

When there was ambiguous or no feedback or when further information (e.g., background knowledge) was required to understand whether an action was correct or not, this was coded as *unclear task feedback*. For example, some statistics programs generate rather comprehensive and complex outputs, and without background knowledge or further assistance, the information may not be readily interpretable for novice users. Initial interrater agreement (Cohen's kappa) was .65 for this variable.

Comparison Condition. This categorical coding variable described the type of training that error management training was compared with. The classification was based on the amount of guidance during training. A comparison condition was coded as *guided* if participants received step-by-step instructions or similarly tight personal guidance to correct task solutions while practicing the training tasks. A comparison condition was coded as *unguided* if participants practiced the training tasks basically on their own (regardless of the amount of guiding information received otherwise). For example, if participants first received lengthy information on the task but then worked on practice task without detailed instructions on how to proceed, this was coded as unguided. Some studies used more than one comparison condition out of which some were guided and others were unguided. To account for these studies, we introduced an additional *mixed* category. Initial interrater agreement was perfect for this variable (Cohen's kappa = 1).

Coding of further study characteristics. In addition to the four theory-based study characteristics that referred to the research hypotheses, we coded eight variables for exploratory analyses and for use as controls. These variables included the mean age of participants (available from $k = 20$ studies), the proportion of females in the sample (available from $k = 19$ studies), whether the participants were university students or employees, the task content, whether the training sessions were run individually or in groups, whether the study was published or unpublished, the year of the study, and whether the study was conducted by the research team of the originator of error management training (Frese) or by another research team.

4.6.3 Data Analytic Strategies

The present study used meta-analytic techniques as described by Hedges and Olkin (1985). Mean effect sizes were calculated using the small-sample correction formulas for unbiased effect sizes proposed by Hedges (1981). To test for moderating effects of dichotomous or categorical variables, the procedure analogue to ANOVA by Hedges (1982) was used. To test for moderating effects of continuous variables or of multiple categorical or continuous variables, the modified weighted multiple regression approach by Hedges and Olkin (1985) was used. All analyses were based on random or mixed effects models which take both subject-level and study-level sampling error into account in computations of mean effects sizes and associated test statistics. The ANOVA analog and the weighted regression analysis partition the overall variance into a portion that is explained by the independent variable (i.e., the moderator variable) and an unexplained residual portion. These two portions are represented in a Q statistic (i.e., Q_{between} and Q_{within} in ANOVA analog; $Q_{\text{regression}}$ and Q_{error} in weighted regression analysis). The Q-test is analogous to the F-test in ANOVA or regression analysis and can be interpreted accordingly. Thus, a significant Q_{between} or $Q_{\text{regression}}$ statistic indicates that the independent variable (i.e., the moderator variable) explains significant variability in the effect sizes (Lipsey & Wilson, 2001).

4.7 Results

Effect sizes and confidence intervals of the studies that were included in the meta-analysis are depicted in Figure 7. The majority of effect sizes were positive, and the left side of the confidence interval did not include zero. The large confidence intervals of some of the studies are due to the small participant samples used in these studies. Two studies (Debowski et al., 2001; Gully et al., 2002) had negative effect sizes and confidence intervals comprising only negative values.

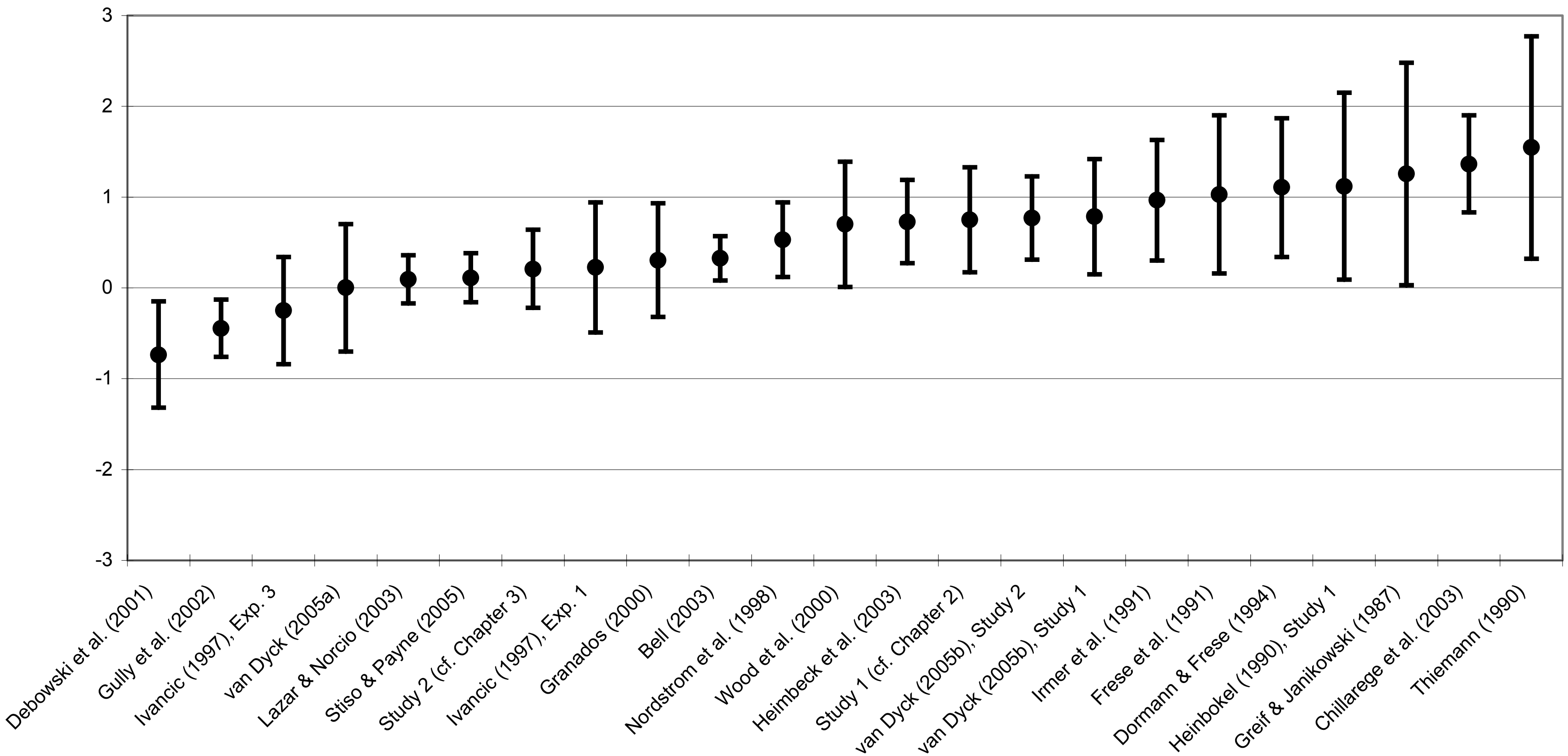


Figure 7. Effect sizes and 95% confidence intervals of the 23 studies included in the meta-analysis.

4.7.1 Overall Effect and Moderator Effects of Theory-Based Variables

Table 7 displays meta-analytic results of hypotheses testing. We found support for Hypothesis 1 which predicted error management training to lead to better performance than other trainings. There was a medium overall effect size across all studies ($d = 0.44$) which significantly differed from zero. The test of homogeneity was not significant indicating that, from a purely statistical perspective, the variablility of effect sizes was not any greater than would be expected from unsystematic sampling error. Yet, since we had a priori and explicit hypotheses about systematic between-study effects, and because the homogeneity test may not have much power when based on relatively small study and participant samples (Hunter & Schmidt, 1990; Lipsey & Wilson, 2001), we still tested our moderator hypotheses.

Hypothesis 2 predicted evaluation phase to moderate the effect of error management training. This hypothesis was supported as evaluation phase significantly affected the magnitude of the effect sizes ($p < .01$; cf. Table 7). In studies using training performance as the criterion variable, the mean effect size was negative and did not differ from zero as indicated by the non-significant *z*-test ($p = .47$). In studies using test performance as the criterion variable, there was a medium effect size that significantly differed from zero ($d = 0.58$, $p < .01$).

Hypothesis 3 predicted adaptivity of the transfer task to moderate the effect of error management training. This hypothesis was supported as adaptivity significantly affected the magnitude of the effect sizes ($p < .01$; cf. Table 7). In studies using an analogical transfer task as criterion variable, the mean effect size was small and did not differ from zero ($p = .16$) whereas in studies using an adaptive transfer task as criterion variable, there was a large mean effect size that significantly differed from zero ($d = 0.80$, $p < .01$).

Table 7

Overall Meta-Analytical Effect of Error Management Training, Moderator Effects, and Statistics in Subsamples

	Moderator Analyses (ANOVA analog)		Statistics in Subsamples							Homogeneity
								95%-CI		
	$Q_{between}$ (*df*)	Q_{within} (*df*)	*k*	*N*	*d*	*SE*	*z*-value	left	right	*Q* (*df*)
Overall effect			23	1981	0.44	0.11	4.09**	0.23	0.66	24.67 (22)
Evaluation phase	9.70** (1)	22.01 (21)								
Training performance			4	505	-0.15	0.21	-0.72	-0.56	0.26	1.24 (3)
Test performance			19	1476	0.58	0.11	5.42**	0.37	0.78	20.78 (18)
Adaptivity	10.94** (1)	21.31 (21)								
Analogical transfer			12	1445	0.17	0.12	1.42	-0.07	0.41	17.29⁺ (11)
Adaptive transfer			11	536	0.80	0.15	5.43**	0.51	1.15	4.01 (10)
Clarity of feedback	2.71⁺ (1)	21.67 (21)								
Low clarity			7	1005	0.19	0.19	1.03	-0.17	0.56	6.61 (6)
High clarity			16	976	0.57	0.13	4.27**	0.31	0.84	15.06 (15)
Comparison condition[a]	6.41* (2)	22.01 (20)								
Guided training			14	850	0.65	0.14	4.52**	0.37	0.92	14.32 (13)
Unguided training			13	1285	0.21	0.11	1.95*	0.00	0.41	12.01 (12)

Note. Cohen's *d* effect sizes. CI = Confidence interval. One-tailed *z*-test for directional hypotheses.

[a] To avoid statistical dependencies, the overall effect of comparison condition was tested in a weighted regression analysis with two dummy variables representing the three comparison conditions guided training (*k* = 10), unguided training (*k* = 9), or mixture of both (*k* = 4). Thus, the $Q_{between}$ and Q_{within} statistic in fact refer to $Q_{regression}$ and $Q_{residual}$, respectively. To calculate statistics in subgroups, two effect sizes from the four studies that included a mixture of guided and unguided comparison trainings were drawn and added to the other guided and unguided training groups, respectively. The total number of studies therefore does not add up to 23, and the total number of participants does not add up to 1981 (because four studies are represented twice).

⁺ $p < .10$. * $p < .05$. ** $p < .01$.

Hypothesis 4 predicted clarity of task feedback to moderate the effect of error management training. This hypothesis received only limited support: The effect of clarity of feedback on the magnitude of the effect sizes did not reach significance at the 5% level (p = .099; cf. Table 7). The statistics in subsamples, however, indicated that only in studies using tasks with clear feedback, there was a significant positive effect (d = 57, p < .01). In studies using tasks with unclear feedback, the mean effect size did not significantly differ from zero (p = .30). Thus, the effect sizes tended to be larger in studies using tasks with clear feedback than in studies using tasks with unclear feedback, but this difference did not reach statistical significance.

Hypothesis 5 predicted type of comparison condition to moderate the effect of error management training. This hypothesis was supported as the comparison condition affected the magnitude of the effect sizes (p < .05, cf. Table 7). When guided training was the comparison training, there was a medium effect size that significantly differed from zero (d = 0.65, p < .01). When unguided training was the comparison training, the effect size was small but significant (d = 0.21, p < .05).

4.7.2 Exploratory Analyses and Effects of Control Variables

In addition to the moderator analyses for the four study characteristics related to our hypotheses, we examined effects of eight further variables Three variables referred to characteristics of the participant samples for which we did not have specific hypotheses (exploratory analyses): mean age of participants, proportion of female participants, and whether the study used a student or employee sample. The other five variables referred to study characteristics which we expected not to affect the magnitude of the effect size (control variables): whether the training content was a computer program or a decision making task, whether training sessions were run individually or in groups, whether the study was published or not, the year of the study, and whether the study was conducted by a team connected to Frese's laboratory or other research teams. To control for alpha inflation due to repeated testing in these supplemental analyses (Lipsey & Wilson, 2001), we conducted bonferroni alpha adjustments for the exploratory and control analyses, respectively.

Exploratory analyses. Mean age of study participants did not influence the magnitude of the effect sizes (p = .13). Also, the magnitude of the effect sizes did not depend on whether participants were employees or university students ($p = .07$). However, the effect sizes increased with the proportion of female participants in the study ($p < .05$).

Control variables. One control variable significantly affected the magnitude of the effect sizes: The effect sizes were larger in studies conducted by Frese's research team ($p < .05$). We suspected, however, that Frese's research team tended to use adaptive transfer tasks and test phases for performance assessment, and that it therefore yielded larger effect sizes. To examine this possibility, we tested the effect of research team after controlling for evaluation phase and adaptivity of transfer task in a common regression model. The overall prediction was significant, $Q_{\text{regression}}(3) = 16.05$, $p < .01$. An inspection of individual regression weights revealed that only evaluation phase (β = 37, $p < .05$) and adaptivity (β = 40, $p < .05$) affected the magnitude of the effect sizes. The effect of research team vanished and did not differ from zero in the common model ($\beta = .05$, $p = .82$). This pattern of results suggests that the initial effect of research team was an artifact due to the effects of evaluation phase and adaptivity of transfer task.

4.8 Discussion

Error management training takes a positive view of errors during training and explicitly encourages participants to make errors and to use them as a learning device. Since its development in the 1980ies by Frese and colleagues, several researchers have taken up the basic ideas of error management training and applied them in diverse areas of skill acquisition. While most of the early studies consistently found error management training to lead to better performance than conventional error avoidant training, more recent studies came to less conclusive results. The present research started out to evaluate the overall effect of error management training and to identify the factors promoting or restricting its effectiveness. For this purpose, we applied meta-analytic techniques to data of 23 independent error management training studies with 1981 participants. The aim was to resolve the conflicting findings reported in the literature and to gain a better understanding of the factors that are crucial for the effectiveness of error management training.

Our results showed that across all studies, error management training leads to better performance than other trainings, with a medium mean effect size of 0.44 (Cohen's *d*). This mean effect size is considerable when compared with the values reported by Lipsey and Wilson (1993). They examined effect sizes from numerous meta-analyses that investigated effects of psychological, educational, and behavioral treatments. Among the 156 meta-analyses that, like the present one, included control group designs from published and unpublished studies, the median effect size was 0.44. Thus, error management seems to be as effective as other psychological, educational, or behavioral treatments that were evaluated with similar research designs. It should be noted, however, that the present meta-analysis only included studies that compared error management training with other training forms; there was no study that tested error management training against no training at all. Taking this into account, the effectiveness of error management training seems even more substantial: Among 80 meta-analyses that evaluated educational interventions against control groups that received alternative treatments rather than no treatment at all, Lipsey and Wilson (1993) found a median effect size of 0.32. Thus, the advantage of error management training in relation to alternative trainings seems to be above average when compared with other educational interventions. All in all, our results demonstrate that incorporating errors into training, as is done in error management training, can boost performance. This result is in contrast to theoretical arguments that deny any positive function of errors during training (e.g., Bandura, 1986; Skinner, 1953).

Our results illuminated the conditions under which error management training seems most promising. The effectiveness of error management training was higher when test performance rather than training performance was the criterion and when the performance tests comprised adaptive transfer rather than analogical transfer tasks. The effectiveness further tended to be higher when the tasks provided clear feedback. Finally, the effect sizes were larger when error management training was compared with guided trainings rather than with unguided trainings that did not include the positive mentioning of errors typical for error management instructions. Additional analyses revealed that the effectiveness of error management training increased with the proportion of female participants, but that it did not depend on the age of participants and on whether participants were employees or university students. Other study characteristics (e.g., publication status, research team) did not affect the magnitude of the effect size, at least when adaptivity of transfer tasks and phase of performance assessment were controlled for.

4.8.1 Implications for Theory and Practice

The present study has several implications for training research and practice. The positive overall effect of error management training demonstrates that giving participants the opportunity and encouraging them to make errors while they are working on their own can be a fruitful way to deliver training. Trainers may generally consider integrating modules of error management training in their programs and should attempt to resist the temptation to offer immediate help when participants face errors and setbacks in the training. With respect to the specific conditions under which error management training seems most promising, our results on adaptivity of the transfer task, evaluation phase, comparison condition, and feedback clarity also provide valuable insights.

The results concerning adaptivity of the transfer task suggest that error management training is preferable when an important training goal is to transfer the skills learned to situations that necessitate the development of new solutions (i.e., adaptive transfer), for example, because the requirements on the job are so diverse and extensive that they can not be completely covered during training. If the training goal is to learn a specific procedure that is required in the same manner on the job (i.e., analogical transfer), it is probably better to directly teach and practice this procedure in order to establish a routine rather than to choose the time-consuming and effortful training that utilizes errors to learn (cf. Ivancic & Heskth, 1995/1996). Ivancic and Hesketh (1995/1996) argued that the goal of training should determine whether an error-free or error management training is appropriate. The present study represents a direct empirical test of this proposition using a broad data base, and provides support for this proposition which previously has been based only on theoretical considerations and on some selected empirical studies.

The crucial role of adaptivity of the transfer task probably also accounts for the result of the study by Debowski et al. (2001) who found a guided training group to perform better than an error management training group. In their study, both the training and test task was to conduct electronic literature searches and to find relevant records concerning a certain research topic (e.g., effects of alcohol use on academic performance). This task was solved best when using a specific search strategy that consisted of eight steps (identify relevant keywords, connect keywords to a search statement etc.). Participants of the guided group (called guided exploration in this study) were interrupted and corrected whenever they departed from the prescribed eight-steps procedure; participants of error management training (called enactive exploration in this study) were informed about the eight steps but otherwise worked independently and without further feedback. In the (analogical) transfer tasks, the guided group probably performed better because the participants then needed exactly the eight-step procedure which they had practiced during training. I addition, we agree with Debowski et al. (2001) that the system feedback (i.e., numerous records pop up after entering a search statement) was probably not readily interpretable for participants to find those records that were *relevant* to the respective research topic.

Some scholars suggested that those interventions that improve immediate practice performance may be detrimental to learning and retention and, conversely, those interventions that slow down or impede immediate performance may be beneficial for learning and performance in the long run (Goodman & Wood, 2004; Goodman et al., 2004; Ivancic & Hesketh, 2000; Schmidt & Bjork, 1992). This proposition seems to agree with our meta-analytical finding that the evaluation phase (training versus test phase performance) moderated the effectiveness of error management training. The distinction between training and test performance is critical because it means that a trainer should not mistakenly be led to the conclusion that his or her intervention produces real learning only because immediate practice performance is enhanced or, conversely, that a participant is not learning just because he or she is not performing well on a practice task (Ghodsian et al., 1997; Goodman & Wood, 2004). Training experiments that compare error management with error avoidant training should find this pattern: During the training phase, participants of error avoidant training perform better because they only need to follow the guiding task instructions; performance in error management training is slowed down because participants have to find solutions on their own and, in doing so, sometimes get trapped in error situations (Keith & Frese, in press). During the test phase, however, the performance difference between the two groups should be reversed. The lack of distinction between training and test performance probably explains the findings by Gully et al. (2002) that error management training was worse than the comparison conditions: Their performance measure was ascertained in a training phase where instructions to make errors were emphasized in the error management training condition.

To our knowledge, only one published study so far has attempted to directly identify the effective elements in error management training (Heimbeck et al., 2003). Is error management training effective because it involves active exploration, or because it encourages to manage errors better due to error management instructions, or because of the combination of both? This can be broken down to the question whether error management training is merely more effective than guided training or also more effective than unguided training. The latter differs from error management training as it does not include the explicit error management instructions. Our results show that error management training is not only more effective than guided training but also more effective than unguided training without error management instructions although the latter effect was small. Yet, from this small effect it should not be falsely concluded that error management instructions were unimportant. Quite to the contrary, it seems very desirable to add error management instructions to other unguided trainings because these seemingly simple and easy-to-administer instructions are powerful enough to produce additional performance increments (Heimbeck et al., 2003). Error management instructions probably need to be presented and verbally reinforced several times during training to be effective. It may well be possible that a single presentation of written error management instructions at the beginning of the training (as may be the procedure in some experiments for standardization purposes) is too weak a manipulation.

Our results concerning clarity of feedback were mixed: We did not find a significant difference between studies using tasks with clear and studies using tasks with unclear feedback. Yet, subgroup analyses revealed that the mean effect size was only significant for the studies that used clear feedback tasks. We suppose that this result points to the importance of task-generated feedback for learning from errors. Learning from errors requires that participants are able to track their progress toward the goal and to detect the errors they make. In environments that lack this kind of feedback, trainers may consider to provide supplemental feedback to participants. If supplemental feedback is given, special attention should be paid to the degree of specificity of the feedback. Recent evidence suggests that highly specific feedback may be of little benefit for later task performance if it tells the actor what to do next and thereby "does the work for recipients" (Goodman & Wood, 2004, p. 809). In this case, participants do not need to engage in effortful information-processing. For error management training to be effective, feedback should inform participants only about the consequences of their action but leave the choice about the next action steps to the participants.

4.8.2 Limitations and Directions for Future Research

Meta-analysis is well suited for our research questions because specificities and weaknesses of individual studies are abstracted from. Greater confidence of generalizability of the research findings can be achieved with a meta-analysis (Hedges & Olkin, 1985; Hunter & Schmidt, 1990; Lipsey & Wilson, 2001; Rosenthal, 1991). There are, however, certain drawbacks inherent to meta-analysis in general. First, meta-analysis is, per definition, a post hoc tool of analysis. This is less of a problem for the estimate of the overall effect size, but the interpretability of meta-analytically identified moderators is limited. For example, we found adaptivity of the transfer task to moderate the effectiveness of error management training. Yet, we do not know whether the differences in effect sizes was actually *caused* by adaptivity of the transfer task, because we did not experimentally manipulate adaptivity but used existing studies and rated this task characteristic post hoc. Second, and related to the foregoing point, we can not rule out the possibility that the moderator effects we found are due to other confounded factors; it is possible that the study characteristics that we included as theory-based moderators are confounded with unknown factors that were the actual causes of the effects.

Finally, the generalizability of any meta-analytical results of course rests upon the characteristics of the primary studies included. The majority of the error management training studies available trained computer-based skills. This popularity of computer tasks in error management training studies is probably due to several reasons: First, computer skills are becoming more and more important both in everyday life and in diverse jobs (Debowski et al., 2001; Quinones & Ehrenstein, 1997). Second, many computer tasks are complex enough so that errors can be expected during training, while also allowing the tracking and correction of errors. Third, feedback can easily be presented via the computer and performance scores can be easily obtained. Thus, computer trainings seem well suitable for error management training research for both conceptual and practical reasons. On the other hand, the exclusive use of computerized tasks in the existing studies seems to limit the generalizability of the present findings. Two studies (which did not meet our study inclusion criteria) have used principles of error management in driving simulation training (Ivancic & Hesketh, 2000) and in teaching firefighting skills (Joung et al., 2004). Future research could continue to use error management training in areas other than computer training to tests its applicability, for example, in intellectual tasks or in motor tasks.

The limitations for the causal interpretation of the results opens up several avenues of future research: Direct tests for differential effects of error management training on analogical and adaptive transfer performance could be conducted. Task characteristics could be systematically varied within an experimental session. Such a procedure could also be used to examine the function of task-generated feedback more closely. Our results concerning clarity of task-generated feedback were not as definite as expected. There was no significant difference but a significant mean effect size only in studies using tasks with clear feedback. Future research could systematically vary the degree of information in task-generated feedback in multiple tasks, for example, by using the paradigm of Goodman and colleagues (Goodman & Wood, 2004; Goodman et al., 2004). Similarly, effects of participant characteristics could be further explored. For example, we found an effect of gender with the proportion of females in studies positively affecting the effect of error management training. A more direct test for gender effects would be to use samples with equal numbers of female and male participants. Females tend to have less favorable attitudes towards computers and tend to use them less frequently than males (e.g., Dickhäuser & Stiensmeier-Pelster, 2002). It is possible that conveying a positive view on errors and encouragement of exploration during computer work is more effective among females when there is anxiety.

Finally, we think it may be useful to expand the present approach to dealing with errors in training. Up to this point, error management training mainly implied active exploration, making errors, and learning from them while adopting a positive attitude towards errors. However, there may be other beneficial ways to integrate errors into the training. For example, typical errors in a task and their consequences may be presented to participants (cf. Ivancic & Hesketh, 2000). Similarly, scenario-based training may include not only successes but also errors in the scenarios (e.g, Joung et al., 2004). It is our hope that such approaches broaden the applicability of errors and error management in training research and practice.

5 Conclusion

Error management training is an active training approach that encourages participants to make errors during training and to learn from them. Participants receive only a minimum of information required for task solution and then explore and experiment with the task on their own. This training form stands in contrast to traditional trainings that often adopt an error avoidant approach. Error avoidant training is tightly structured and tries to prevent errors by providing detailed information on task solution. In comparison with error avoidant training, error management training is expected to be particularly effective in promoting performance on novel and difficult transfer tasks, because participants learn strategies to deal with errors and unexpected problems during training – problems which also often occur in the transfer situation.

This dissertation examined performance effects of error management training, the psychological processes underlying these effects, and the conditions that promote or inhibit the effectiveness of error management training. These and further issues were addressed in three independent studies that used complementary empirical approaches. Studies 1 and 2 (Chapters 2 and 3) were experiments that compared error management training with error avoidant training in which volunteer university students learned a new computer program. Study 1 was mainly concerned with the psychological processes in error management training. It argued that particularly two self-regulatory processes, namely emotion control and metacognitive activity, are instigated in error management training but not in error avoidant training, and that these processes are crucial for performance on novel transfer tasks. To test these assumptions, Study 1 used a micro-analytical approach: In individual training sessions, participants were asked to speak out whatever came into their mind while they worked on the training tasks (think aloud method). The verbal protocols of participants were used to assess processes during training and to derive a measure of metacognitive activity. Emotion control was assessed using a self-report questionnaire. Study 1 found support for the mediational hypotheses: Emotion control and metacognitive activity during training explained performance differences between error management training and error avoidant training on transfer tasks that were dissimilar from the training tasks (i.e., adaptive transfer). On transfer tasks that were similar to the training tasks (i.e., analogical transfer), performance was the same in error management and error avoidant training. Study 1 also explored the effects of a new variant of error management training: Error management training with additional instructions designed to promote metacognitive activity did not lead to performance increments compared with error management training without these additional instructions.

Study 2 was also concerned with the processes during training but used an indirect approach to draw conclusions about these processes. The main line of argument was that processes during error management training resemble those during transfer, and that, therefore, there should be a decline in resource-dependency of performance (i.e., the relation between cognitive ability and performance should decline). This decline was expected for the error management training group but not for the error avoidant training group, because for the latter one the transfer situation imposed new demands (i.e., performance remained resource-dependent). This interaction between cognitive ability and training condition was tested in a training experiment similar to Study 1. Yet, to gain statistical power for the detection of interaction effects, Study 2 used a larger participant sample than Study 1, and it used group sessions rather than individual training sessions. The interaction hypotheses were supported: There was a main effect of cognitive ability on training performance, but this effect vanished on transfer tasks for the error management training group. Like the first experiment, Study 2 distinguished transfer performance on tasks similar to the training tasks (analogical transfer) from transfer performance on tasks distinct from the training tasks (adaptive transfer). In addition, this study explicitly contrasted training and transfer performance: As expected, error management training led to worse performance during training compared with error avoidant training, but on analogical transfer tasks, the difference between the two training forms disappeared, and on adaptive transfer tasks, participants of error management performed better.

Finally, Study 3 used meta-analytical techniques to investigate performance effects of error management training and conditions promoting or inhibiting the effects. Effect sizes were drawn from 23 independent studies that compared error management training with alternative training forms (including Studies 1 and 2 of this dissertation). Most of the studies were training experiments that taught a new computer program; the remaining studies also used computerized tasks (i.e., electronic search tasks, decision making tasks presented on the computer). As expected, the overall effect of error management training was positive and significant with a medium effect size of 0.44 (Cohen's *d*). Further, the effect was larger when transfer performance rather than performance during training was the dependent variable (evaluation phase), when the transfer tasks were dissimilar from training tasks (adaptivity), and when error management training was compared with a guided training rather than with an exploratory training. For clarity of task feedback, the results were mixed: The hypothesis that the effect sizes are larger in studies using tasks with clear feedback received only partial support. The highest effect sizes occurred for studies that used adaptive transfer tasks (Cohen's d = 0.80). In additional analyses, Study 3 found that there were no differences in effect sizes between studies using student samples and studies using employee samples, but that the effect sizes increased with the proportion of females in the samples. Studies conducted by Frese's research team yielded larger effect sizes, but this effect disappeared when two theoretical moderator variables (evaluation phase and adaptivity) were statistically controlled for.

The three studies compiled in this dissertation contribute to the existing research in several ways. Study 1 illuminates the processes underlying the effectiveness of error management training. This issue has been rarely addressed in earlier studies on error management training, and the few studies that dealt with this issue did not arrive at conclusive results (Debowski et al., 2001; Wood et al., 2000). Study 2 expands our knowledge concerning the effect of cognitive ability in error management training. Only one study has examined interactions of cognitive ability and training condition (Gully et al., 2002), but this study had a different focus (it compared similar trainings that only differed in instructions given but not in the guidance provided), and it did not distinguish performance during training from transfer performance. Finally, the meta-analysis presented in this dissertation (Study 3) combines data from a wide range of studies and thereby allows to draw conclusions beyond those implied by individual studies. The findings and implications of the three studies of this dissertation have been extensively treated in the Discussion sections of the respective chapters (Chapters 2, 3, and 4). The remaining part of the present chapter aims to put the findings in a broader perspective and to point out directions for future research. The topics discussed in the following sections include the elements of error management training that are crucial for its effectiveness (section 5.1), potential limits as well as prospects of error management training (sections 5.2 and 5.3), and the transfer of what is learned in error management training to work settings (section 5.4).

5.1 Learning from Errors or Learning by Exploration?

The concept underlying error management training assumes that the processes promoting performance effects are instigated by the errors made during training. The present research found support for the notion that these critical processes are self-regulatory control processes which comprise the regulation of negative emotions in the face of errors (emotion control) and the regulation of cognitions by planning, monitoring, and evaluating one's progress during task completion (metacognitive activity). Both kinds of self-regulatory processes are conceptualized to be the direct result of the errors made during training: Participants may initially experience negative emotions as a reaction to errors but learn to exert emotion control and regulate these negative emotions. Similarly, errors instigate metacognitive activity, because errors turn participants' attention to the causes of the errors (cf. Ivancic & Hesketh, 2000). Yet, the available data do not allow the immediate conclusion that theses self-regulatory processes are in fact the consequence of the errors made. This is because Study 1 did not directly assess processes occurring after errors but merely made an overall comparison of processes during error management and error avoidant training. Thus, other factors that characterize error management training and distinguish it from error avoidant training might be the actual causes of these processes. In other words, the present research provides support for the purported link from error management training to self-regulatory processes and for the link from self-regulatory processes to transfer performance, but it does not necessarily give evidence for the link from the error itself to the self-regulatory processes in error management training.

One characteristic of error management training that distinguishes it from error avoidant training is the activity and exploration that is required from participants. Participants of error management are actively engaged during training: As they explore the system without external guidance, they constantly need to decide what action steps to take next, try out these steps and change them if appropriate. Thus, continuous attentional effort is required in error management training but not (or to a lesser extent) in error avoidant training where guiding information reduces the effort that is needed to solve the tasks. This attentional effort exerted along with exploration might be the actual cause of metacognitive activity (cf. Ivancic & Hesketh, 1995/1996), whereas the errors might in fact be merely a byproduct of exploration that is not crucial for metacognitive activity. Similarly, exploration rather than the error itself may instigate the development of emotion control skills: Negative emotions might be experienced not only after the occurrence of an error (as assumed by proponents of error management training) but during error management training in general, because not really knowing what action step to take next and not receiving any help (although the trainer is present and would be able to provide help) may already be an emotionally adverse situation. This proposition is consistent with the pattern of frustration levels found in the study by Nordstrom et al. (1998): Participants of error management training reported higher frustration during training than participants of error avoidant training, but this pattern was reversed for frustration during the test phase. Thus, hypothetically it should be possible to learn a lot during error management training without making even one error if exploration alone instigates the development of self-regulatory skills. In practice, of course, this seems improbable because exploration usually leads to errors, and dealing with errors is part of exploration, at least within error management training. Yet, whether the error itself or other characteristics of error management training are crucial for its effectiveness remains subject to scrutiny in future studies.

The present research does not give an answer to the question whether errors or mere exploration instigate self-regulatory processes, because it analyzed processes on an aggregate level (i.e., persons as unit of analysis). To gain a better understanding of the moment-to-moment action regulation, particularly with regard to regulatory processes after errors, a more micro-analytical approach would have to be used (cf. van der Linden et al., 2001). Within an observational study, this could be done by identifying those activities where self-regulatory processes are most likely to occur (e.g., after an error vs. when exploring a new part of the system). A drawback of this approach is that it demands high accuracy of the method used to assess the processes, because otherwise the conclusions drawn would be misleading. For example, if the method of thinking aloud were used and if participants tended to verbalize more during exploration of a new part of the system and less after an error has occurred (e.g., because they are surprised or confused after an error), one may falsely conclude that errors do not instigate self-regulatory processes. Another approach, which would also be more appropriate for establishing causality, would be to experimentally manipulate the occurrence of errors. Yet, such a setting is difficult to realize, because the errors need to be the consequence of participants' actions and not, for example, due to system failures that can be easily simulated in an experiment (e.g., a computer hang-up). An approximation to manipulating participants' errors may be to create system environments that differ in the degree to which they provoke errors by participants. In a computer training, for example, this could be implemented by different rearrangements of the menus and toolbars or by disenabling some of the system's options. At the same time, however, the possibilities for exploration need to be kept constant in order not to confound exploration and errors. Such a research setting may be difficult to implement but would be necessary in order to establish causality.

In any case, notwithstanding the theoretical importance of disentangling the effects of errors and exploration, from a practical perspective it seems worthwhile to include error management instructions in exploratory trainings. The present research suggests that there is a small but significant effect in favor of error management training including these instructions when compared with exploratory training without these instructions (cf. Study 3). Given that error management instructions are inexpensive and easy to administer, they should be routinely included in exploratory trainings even if the expected additional benefit may be small.

5.2 Limits of Error Management Training

The present research shows that integrating errors explicitly into the training rather than avoiding them can be a fruitful approach to promote performance. Yet, even the numerous training studies included in the meta-analysis (Study 3) shared certain features with regard to the training content: All studies comprised trainings that were delivered on the computer, many of them taught a computer program. This restriction raises the question about the generalizability of the present results to settings other than computer trainings. There are at least three characteristics of computer trainings which facilitate the applicability of error management training in this area and which, therefore, may be considered when designing training in another area. First, errors made while working with a computer program are relatively easy to detect without external guidance. Participants can work and detect errors on their own, because most contemporary computer programs provide sufficient feedback for this purpose. Thus, for training in settings or with tools that produce less clear feedback, additional aids may be given to participants to make feedback interpretable for them. Second, contemporary computer programs provide ready-to-use error recovery options (e.g., the undo button) that enable users, in principle, to quickly correct errors. In systems that do not provide this possibility (for example, because a single wrong action can start a long-term process that cannot be easily stopped), error management training may not be a viable option. Finally, and related to the previous point, errors in computer work are relatively inexpensive (partially because they can be corrected quickly). In areas where errors lead to costly consequences, error management training may be difficult to implement. Yet, it should not be falsely concluded that error management training is useless in these areas. Quite the contrary, it seems advisable to integrate errors particularly in those areas where errors can have fatal consequences, because if participants have learned to deal with errors quickly during training, these consequences are later less likely to occur. Of course, error management training for operating a nuclear power plant, for flying aircrafts, for performing medical surgery and the like cannot be conducted on-the-job. Rather, a safe environment needs to be created where learners can make errors and deal with their virtual consequences without being faced with the real consequences (e.g., in simulator training).

5.3 Integrating Elements of Error Management Training Into Other Training Forms

Error management training is a relatively new training form that is just beginning to become popular. The present dissertation compiles studies that demonstrate the effectiveness of error management training in promoting transfer to novel tasks. We suggest that error management training is a promising training form to be applied in the future in diverse areas of skill acquisition. In addition, the effectiveness of existing training forms may be improved by integrating elements of error management training. For example, an area where elements of error management training probably can be implemented without additional costs are business games, a training form that has become popular in educational programs of business schools. Business games may be supplemented, for example, by including phases within the game where making errors and learning from them are explicitly encouraged. Such instructions possibly lead to more experimentation by participants who thereby gain a better understanding of the subject, because they try out more alternative actions and learn about their consequences.

One of the most influential training approaches in applied psychology is behavior modeling (Bandura, 1986). Behavior modeling implies that a model (e.g., the trainer) demonstrates the correct the behavior. The learner then imitates this behavior and receives corrective feedback (from the trainer or from other training participants) which is supposed to be expressed positively. Negative feedback is generally avoided in behavior modeling or it is reformulated in a positive fashion (e.g., Latham & Saari, 1979). Thus, behavior modeling differs from error management training in the emphasis on guidance, correctness of actions, and positive reinforcement. Learning from models can occur both formally (e.g., in a behavior modeling training or within a mentoring system) or informally (e.g., by watching and imitating behavior of a colleague or supervisor). In comparison with error management training, the advantage of behavior modeling is that relatively complex behaviors or, more precisely, behavior *sequences* can be taught in a short period of time. For example, it may be tedious to learn a particular motion sequence (e.g., how to do the serve in tennis) by continuous exploration and without watching a model, because if one's trial is ineffective, it is difficult to determine what part of the sequence needs to be improved (e.g., is it the way I move the racket or the way I throw the ball?). Similarly, complex social interactions can be modeled and practiced in a role play (e.g., Latham & Saari, 1979) – an area where error management training may not be implemented as easily. Thus, the applicability of error management training seems to be limited to training contents where discrete actions (rather than longer sequences of behavior) of the learner lead to observable changes in the system that can be identified by the learner.

Despite the advantages of behavior modeling for some training contents, it may be beneficial to supplement it with elements of error management training. Behavior modeling has been shown to be an effective training form (Wexley & Latham, 2002), but it is possible that this training form is best suited in situations where one particular behavior or procedure is to be learned (e.g., Debowski et al., 2001). When transfer to novel tasks not practiced during training is to be achieved (i.e., adaptive transfer), however, errors may be explicitly integrated into the training. Such an approach is in contrast to the view held by Bandura (1986) who equates errors with "needless toil" (p. 47). Practically, behavior modeling could be supplemented by altering the principles of correctness and positive reinforcement. In a role play, for example, participants could not only practice correct behaviors but also try out incorrect behaviors to explore their consequences, and the trainer and fellow participants could provide both positive and negative task feedback (cf. Frese, Beimel, & Schoenborn, 2003). It is possible that this results in a better understanding of the training content, because the participants do not mechanically imitate what the trainer does but comprehend the reason why certain behaviors or movements are more appropriate than others. In addition, such an approach could teach additional behavioral strategies that may be useful when, for example, a social interaction does not work out as favorable as in the safe training environment. Thus, error management training may add important features to the dominant tradition of behavior modeling: A behavior modeling training augmented by elements of error management training may lead to wider and more flexible behavioral repertoires of participants than traditional behavior modeling. This proposition may be tested in future research.

Another area where principles of error management training may be effectively incorporated is team training. Error management training in the existent form is focused on individual learning. There are, however, many work tasks that are too complex or too diverse to be accomplished by individuals, or where the coordination of individual work tasks is essential. Consequently, training of these tasks is usually conducted in teams (e.g., Salas, Fowlkes, Stout, Milanovich, & Prince, 1999). Research on team effectiveness suggests that effective teamwork is a function of shared knowledge representations or shared mental models about the task and the team structure (e.g., Cannon-Bowers, Salas, Converse, 1993; Marks, Sabella, Burke, & Zaccaro, 2002). For individual training, error management training is assumed to support the development of adequate mental models, because errors pinpoint to misconceptions and instigate continuous accommodations of the mental models (Frese, 1995; Heimbeck et al., 2003). Analogically, errors experienced in team training may foster the development of both more adequate and similar mental models among team members. Also, the positive view of errors conveyed in error management training may induce a more tolerant attitude not only toward one's own errors but also toward errors made by teammates.

5.4 Error Management, Performance, and Adaptability

The present research shows that error management training affects performance on difficult transfer tasks given to participants immediately after the training. Future research should investigate whether error management training also promotes transfer of learned skills to the workplace (Baldwin & Ford, 1988). We agree with Ivancic and Hesketh (1995/1996) that error management training is well suited to prepare participants for work tasks, because participants learn to work independently and to deal with errors from the very beginning in training. Moreover, as this research has shown, error management training instigates the development of self-regulatory skills (i.e., emotion control and metacognition), and these self-regulatory skills should also be useful when participants are confronted with new tasks at work. To go even one step further, it may be argued that these self-regulatory skills are useful in any challenging tasks that cannot be solved by applying readily available plans. Thus, error management training may even promote transfer to tasks that are seemingly unrelated to the training content. For example, a participant who underwent error management training to learn a particular computer program may learn to exert emotion control and metacognitive activity when working on computer tasks in general (i.e., not only when working with the particular computer program that was taught in the training) or even, say, on managerial tasks unrelated to computer work. Future research could test whether this kind of generalizability occurs as a result of error management training.

The idea of generalizability is consistent with the finding that a positive error management culture predicts organizational performance (van Dyck et al., in press). A positive error management culture implies that people in an organization communicate openly about errors and assist each other in preventing, detecting, and quickly responding to errors. Also, learning from errors rather than punishment is emphasized in organizations with a positive error management culture. It is possible that a positive error management culture implicitly encourages emotion control and metacognitive activity which in turn lead to faster error detection and responding to errors, because the members of the organization need to be less concerned about negative consequences of potential errors they make.

Another area where conveying principles of error management may be beneficial is the development of adaptability. As outlined in the Introduction, continuous changes in the workplace due to globalization, mergers/acquisitions, and organizational restructuring call for workers who are capable to flexibly adapt to these changes (Ilgen & Pulakos, 1999). Error management may be a key factor determining the adaptability of workers, because changes and adjustment to changes always include the risk of making errors as well as the chance of learning from them. Indeed, it is somewhat surprising that despite the widespread interest in concepts like flexibility and adaptability, there seems to be no discussion of errors and error management in this context (e.g., Pulakos et al., 2000). We propose that a positive attitude toward errors, as is suggested by the error management approach, may be an avenue for the development of openness and adaptability to rapid and continuous changes in the workplace.

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APPENDICES

APPENDIX A: TRAINING MATERIAL

APPENDIX B: SCALES USED IN STUDIES

APPENDIX C: CODING SCHEME FOR META-ANALYSIS

APPENDIX D: GERMAN SUMMARY

APPENDIX A: TRAINING MATERIAL

A.1 TRAINING MANUAL USED IN STUDIES 1 AND 2 (ORIGINAL GERMAN VERSION)

Willkommen zum PowerPoint-Training

Zunächst erhalten Sie einige grundlegende Informationen über das Programm PowerPoint, die Ihnen teilweise bekannt sein werden, wenn Sie schon einmal mit einem ähnlich aufgebauten Programm gearbeitet haben (z.B. mit Word oder Excel).

Allgemeine Informationen über PowerPoint

PowerPoint ist ein Präsentationsprogramm, mit dem man Folien für den Overhead-Projektor sowie für Bildschirmpräsentationen erstellen kann. Durch seine Oberfläche ist das Programm sehr benutzerfreundlich; die Befehle können aus den verschiedenen Bearbeitungsleisten ausgewählt werden.

Die Bearbeitungsleisten in PowerPoint

Sie starten das Training auf einer leeren Präsentationsseite. Schauen Sie sich bitte zunächst den Bildschirm (bzw. die Abbildung) genau an. Ganz oben finden Sie die **Menüleiste (1)**:

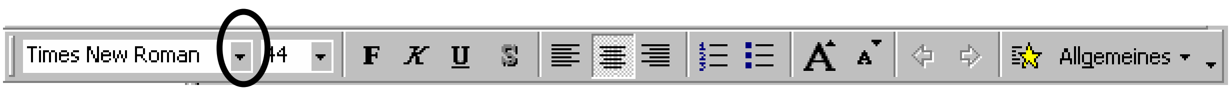
Durch Klicken mit der linken Maustaste auf eines dieser Felder öffnet sich das entsprechende Menü **(2)**, das **weitere Funktionen** oder Befehle enthält. Unter "Bearbeiten" erscheint beispielsweise "Kopieren", "Suchen" etc. Grundsätzlich beziehen sich diese Befehle immer auf die **markierten** Objekte oder Seiten.

Die zweite Leiste von oben **(3)** ist die **Standard-Symbolleiste**.

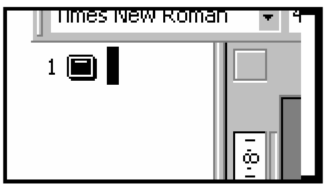
Sie enthält einige Bilder oder Symbole, sogenannte **Icons**. Wenn man den Pfeil, den man mit der Maus bewegen kann, auf diese Icons führt, ohne zu klicken, erscheint ein Feld, das die **Funktion des Icons** angibt. Beim ersten Icon von links ist dies beispielsweise "Neu". "Neu" bedeutet, daß eine neue Präsentation geöffnet werden soll.

Wenn Sie im Laufe des Trainings das Icon "Neue Folie" benötigen, wählen Sie bitte von den Folienarten, die zur Verfügung stehen, zunächst einmal die ganz leere Folie aus.

Die dritte Leiste von oben **(4)** ist die **Format-Symbolleiste**.



In dieser Leiste wird angezeigt, welche Schriftart und Schriftgröße gerade verwendet wird. Hier kann durch Klicken auf den **kleinen Pfeil** rechts eine Veränderung vorgenommen werden. Außerdem enthält die Leiste weitere Icons zur Formatierung.



Unter dieser Leiste finden Sie die **Foliensortierung (5)**, die anzeigt, auf welcher Seite Sie sich gerade befinden. Diese enthält jetzt nur eine Folie, da Sie noch keine weiteren erstellt haben.

In der Mitte des Bildschirms sehen Sie die Folie, auf der Sie aktuell arbeiten können **(6)**.

Am unteren Bildrand finden Sie weitere Bearbeitungsleisten. Die obere lässt verschiedene Ansichten des Materials zu **(7)**. 

Anfangs ist für Sie nur die "Folienansicht" relevant, die schon voreingestellt ist.

Die nächste Leiste ist die Leiste zum **Zeichnen (8)**.

Neben verschiedenen Objekten (z.B. Linie, Pfeil, Quadrat / Rechteck und Kreis / Ellipse) kann auch ein **Textfeld** ausgewählt werden.

Aktivieren von Funktionen

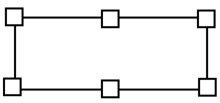
Grundsätzlich werden die verschiedenen **Funktionen** durch Klicken auf die entsprechenden Felder **aktiviert**. Möchte man beispielsweise ein Quadrat zeichnen, so klickt man mit der linken Maustaste auf das Symbol "Rechteck" unten in der Zeichnen-Leiste. Wenn man danach die Maus auf die Folie führt und noch einmal klickt, erscheint an dieser Stelle ein Quadrat. Hält man beim zweiten Klick die Maustaste gedrückt, kann man durch Ziehen der Maus ein beliebig geartetes Rechteck erstellen, welches auf der Folie erscheint, wenn man die Maustaste wieder loslässt. Analog gilt dies für die anderen Funktionen.

Markieren von Objekten

Dient eine Funktion dazu, ein schon vorhandenes Objekt oder einen Text zu verändern, z.B. "Fett", muss das Objekt zunächst **markiert** werden. Dies erreicht man bei Objekten durch Anklicken und bei zu verändernden Texten durch Halten der linken Maustaste, die dann über den Text gezogen wird, bis er schwarz hinterlegt ist. Man kann auch mehrere Objekte gemeinsam markieren, indem man die Maus bei gehaltener Maustaste quer über den Bereich zieht, der markiert werden soll.

Ist ein Objekt (oder mehrere Objekte) markiert, wird dies von PowerPoint mit Hilfe von kleinen weißen Kästchen angezeigt, die um das Objekt herum angeordnet sind. Zum Beispiel wird ein markiertes Rechteck **(9)** von acht solcher Kästchen "umrahmt" (ein Kästchen in jeder der vier Ecken und jeweils ein Kästchen in der Mitte der vier Seiten des Rechtecks).

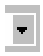
markiertes Rechteck	nicht markiertes Rechteck



Führt man die Maus auf eines dieser Kästchen, kann die **Form** oder die **Größe** des Objekts verändert werden. Führt man die Maus in die Mitte eines markiertes Objekts (also nicht auf eines der Kästchen), kann das Objekt **verschoben** werden.

Wenn ein Objekt oder ein Textfeld markiert ist, kann man durch Klicken auf die rechte Maustaste weitere Funktionen aktivieren. Es erscheint dann ein weiteres Menü.

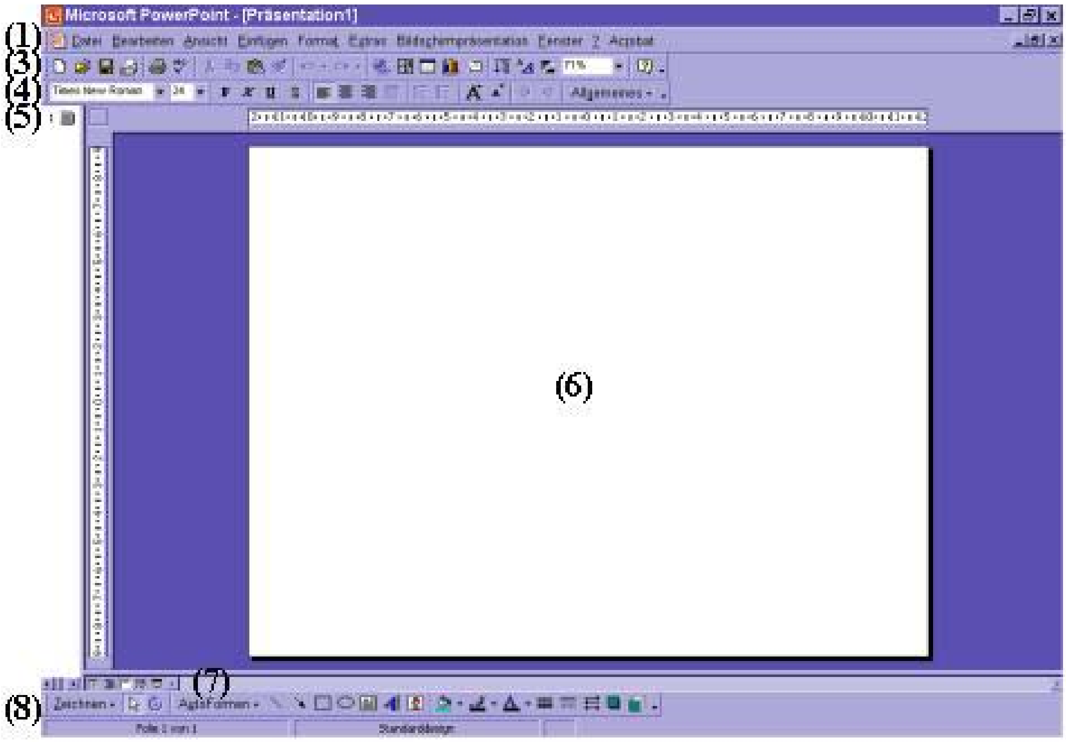
Grundsätzlich ist also wichtig:

- PowerPoint bietet in seinen Bearbeitungsleisten (dies sind die Menüleiste ganz oben und mehrere Symbolleisten) verschiedene Befehle oder Funktionen an.
- Diese Funktionen werden durch Klicken ausgeführt.
- Bezieht sich die Funktion auf ein vorhandenes Objekt, muss dieses zunächst markiert werden.
- Markieren kann man durch Klicken auf das Objekt bzw. Ziehen der Maus über den Text.
- Die Funktionen der verschiedenen Icons in den Symbolleisten kann man durch Zeigen mit der Maus auf das Icon (ohne zu klicken) erfahren.
- Tasten mit kleinen schwarzen Pfeilen  (jeweils rechts neben einem Icon) zeigen immer die Möglichkeit an, zwischen verschiedenen (Unter-)Funktionen zu wählen.
- In der Standard-Symbolleiste (zweite Leiste von oben) finden Sie ein **Icon "Rückgängig"** (Pfeil, der nach links zeigt) , mit dem Sie versehentlich ausgeführte Schritte einfach rückgängig machen können.
- Wenn Sie ein erstelltes Objekt löschen wollen, können Sie es per Mausklick markieren und dann die Entfernen-Taste drücken (Taste "Entf" oder "Del", rechts auf der Tastatur).

Zu diesen Basisinformationen können Sie während des Trainings jederzeit zurückkehren.

Die Funktionen von PowerPoint können Sie in den nun folgenden Übungen ausprobieren. Beachten Sie dabei, was sich auf dem Bildschirm verändert, während Sie arbeiten.

Viel Spaß beim Arbeiten mit PowerPoint!


Microsoft PowerPoint - [Präsentation1]
Datei Bearbeiten Ansicht Einfügen Format Extras Bildschirmpräsentation Fenster ? Acrobat
(1)
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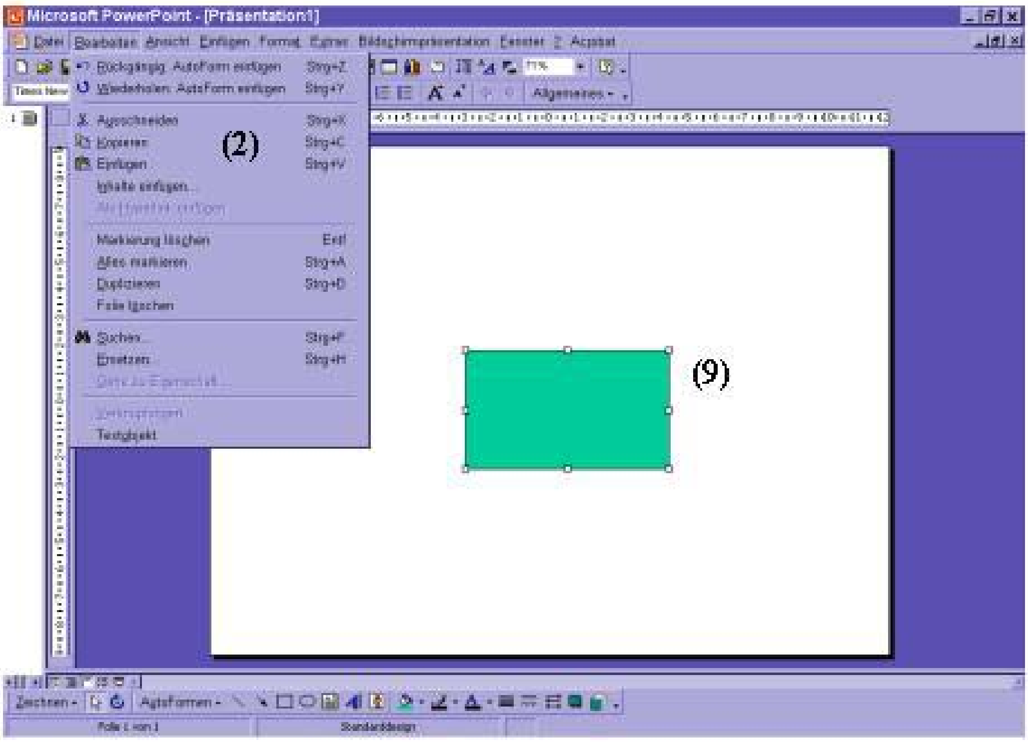
(6)
(7)
(8)
Zeichnen
AutoFormen
Allgemeines
Standarddesign


Microsoft PowerPoint - [Präsentation1]
Datei Bearbeiten Ansicht Einfügen Format Extras Bildschirmpräsentation Fenster ? Acrobat
Rückgängig: AutoForm einfügen Strg+Z
Wiederholen: AutoForm einfügen Strg+Y
Ausschneiden Strg+X
Kopieren Strg+C
Einfügen Strg+V
Inhalte einfügen...
Markierung löschen Entf
Alles markieren Strg+A
Duplizieren Strg+D
Folie löschen
Suchen... Strg+F
Ersetzen... Strg+H
Textobjekt
(2)
(9)
Zeichnen
AutoFormen
Allgemeines
Standarddesign

A.2 Training manual used in Studies 1 and 2 (English translation)

Welcome to the PowerPoint training

At first you are given some basic information about the computer program PowerPoint, some of which will be familiar to you if you have already worked with a similarly structured program (e.g., Word or Excel).

General information about PowerPoint

PowerPoint is a program used to design slides for overhead or computer presentations. Owing to its user interface PowerPoint offers a high usability. The relevant commands can be selected from different toolbars.

The PowerPoint toolbars

The training session starts on a new and empty presentation page. Please take a close look at the screen (or the figure). At the very top of the screen you can see the **menu bar (1)**:

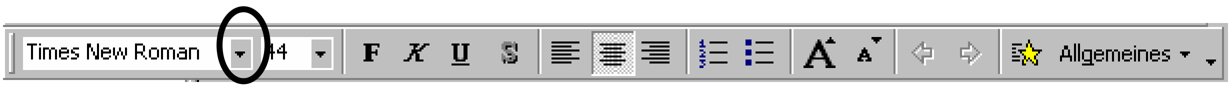
By clicking with the left mouse button on one of the different buttons in the menu bar you can open the respective submenu **(2)**, which offers **additional functions** and commands. Within the submenu “edit” for example you can find functions like “copy” or “search” etc. Generally these commands are executed for the parts of the slide(s) that were highlighted in advance.

The second bar from the top (underneath the menu bar) **(3)** is the **standard toolbar**

It contains several symbols or pictures called icons. When you move the little arrow that can be moved by the mouse across this icon without actually clicking, a little field showing **the icons function** appears. For the first icon on the left side the function displayed is “new”. This “new slide” means that a new and blank presentation slide will be opened.

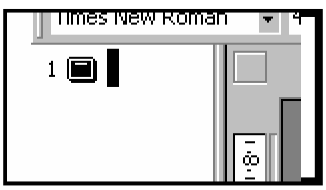
In case you need to use the icon “new slide” throughout the course of the training, please select the slide layout showing a slide that is completely empty from the different layouts available for new slides.

The third bar from the top **(4)** is the **formatting toolbar**.



This toolbar contains information about the font that is being used and the font size. Any changes in the font or the size can be made by clicking on the **small black arrow**. Additional Icons concerning the formatting are included in this toolbar.

Underneath the formatting toolbar the **outline window (5)** is positioned. Right now there is only one slide displayed in this outline window because you have not started designing further slides.



The slide you can work on right now is displayed in the center of the screen **(6)**.

As you can see there are additional toolbars located at the bottom of the screen. The upper one allows the user to select one of the different views on the working material **(7)**. 

The „normal view“, which is the screen layout relevant to you at the beginning, is preset when starting the program.

The next toolbar is the **drawing** toolbar **(8)**.

Both objects (like lines, arrows, squares/rectangles and circles/ellipses) and **text** boxes can be selected from this toolbar.

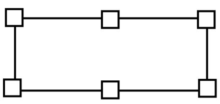
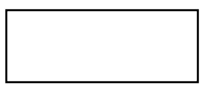
How to activate PowerPoint functions

Generally the different **functions** can be **activated** by clicking on the respective buttons or icons. If, e. g. you wanted to draw a square, you would have to click (using the left mouse button) on the symbol showing a rectangle in the drawing toolbar below. Afterwards you have to move the mouse to the slide and click again. Then a square appears on the slide. By keeping the mouse button pressed and moving the mouse you can create a rectangle of any shape. This rectangle appears on the slide when you stop pressing down the mouse button. Other functions work according to this mechanism the same way.

How to highlight objects

In case a function or command is used to change or format an already existing object or text part (e.g. formatting text in order to have bold lettering), you have to **highlight** the object or text in advance. In order to highlight an object you click on it with the mouse, highlighting text is done by keeping the left mouse button pressed and moving the mouse across the text you want to highlight. Highlighted text parts are marked by appearing on a black background. The simultaneous highlighting of different objects is done by moving the mouse, with the left mouse button pressed across the area you want to highlight.

PowerPoint shows whether an object or several objects are highlighted by framing the highlighted object(s) with little white squares located around the object. A highlighted rectangle **(9)**, e. g. is framed by eight of those little squares (one marking each of the corners and one on each of the four sides).

Highlighted rectangle	Not highlighted rectangle
	

Moving the mouse on one of these little squares allows you to change its **size** and **shape**. Moving the mouse to the centre (and <u>not</u> on one of the little white squares framing it) of the object on the other hand enables you to **move** the whole object and change its position on the slide.

Clicking with the <u>right</u> mouse button on a highlighted object or text box reveals a submenu of additional functions to be activated or applied to it.

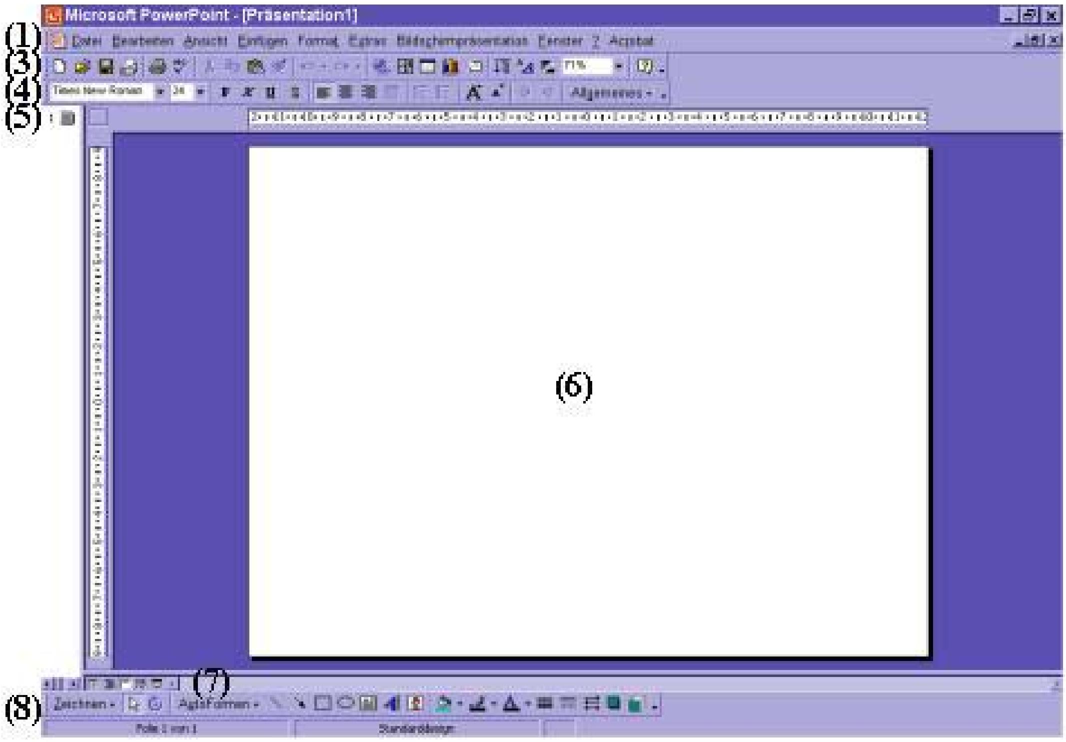
Important points:

- The different PowerPoint toolbars (including the menu bar on top of the screen) offer different functions and commands.
- The different functions are executed by a mouse click.
- In case the function is supposed to be used on an already existing object, this object has to be highlighted before executing the function.
- An object is marked by clicking on it, text is marked by clicking and then movinig the mouse across it (keeping the mouse button pressed down).
- The functions of the different icons contained in the toolbars are shown when the mouse is pointed on the icon (without actually clicking it).
- The keys containing a small black arrow  (placed on the right side of the respective icon) indicate the possibility to chose between different (Sub-)functions
- You can use the **„undo“ icon** (arrow  pointing to the left) in order to reverse commands or actions you did unintentionally. This icon is to be found in the standard toolbar (second toolbar from the top of the screen).
- In order to delete an object from the slide, you mark it with a mouse-click and push the „delete“ key (key marked “Del”, on the right side of the keyboard).

You can use this booklet containing the basic information throughout the whole training session.

During the following training tasks you will be able to explore and try the different functions PowerPoint offers. Please observe the consequences of the commands you execute while working on the slides.

Enjoy working with PowerPoint!


Microsoft PowerPoint - [Präsentation1]
Datei Bearbeiten Ansicht Einfügen Format Extras Bildschirmpräsentation Fenster ? Acrobat
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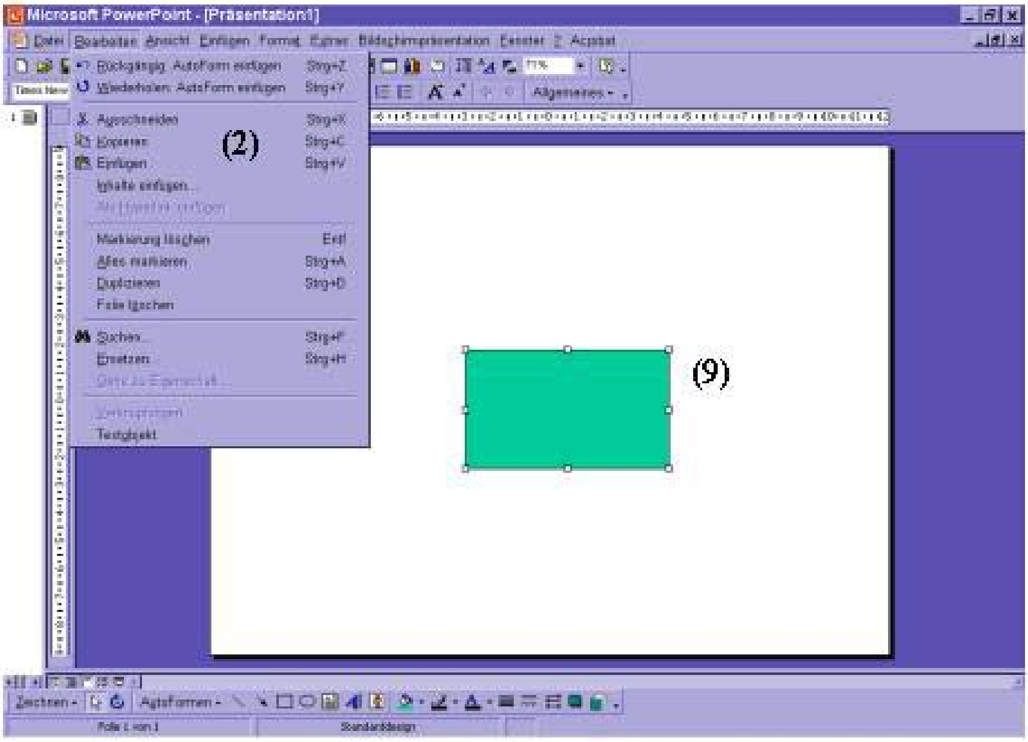
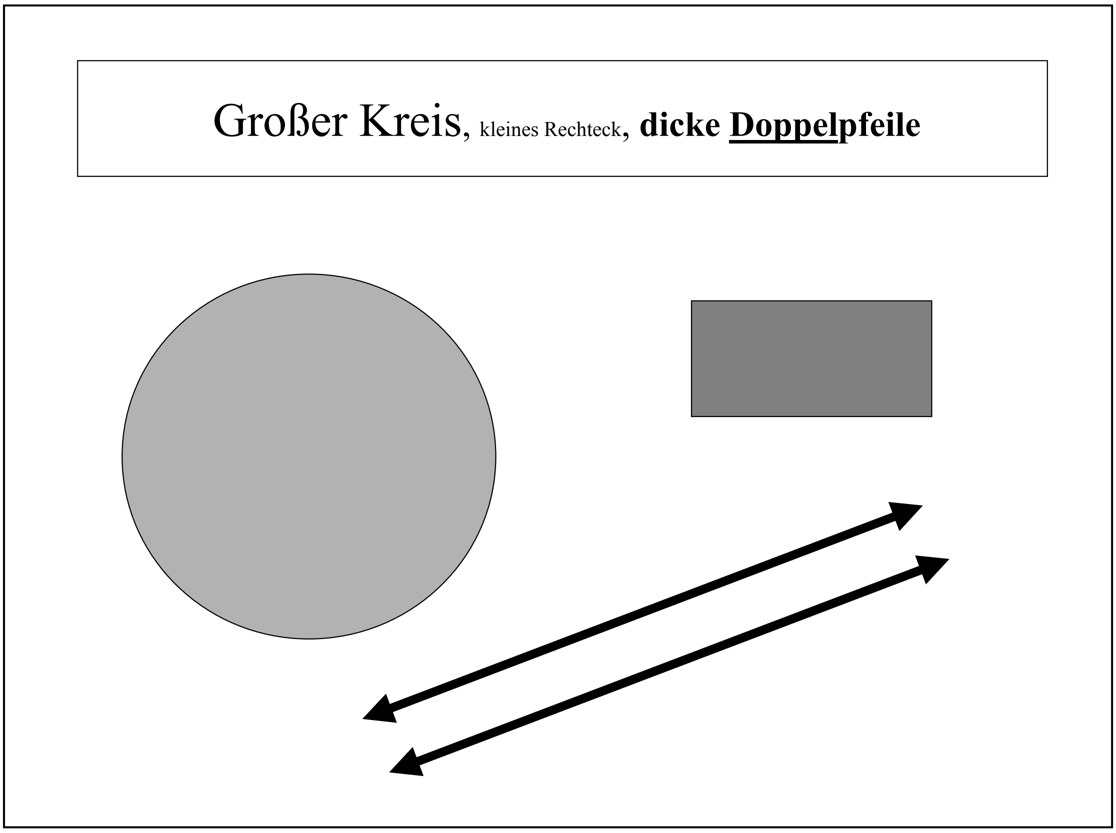
Zeichnen
AutoFormen

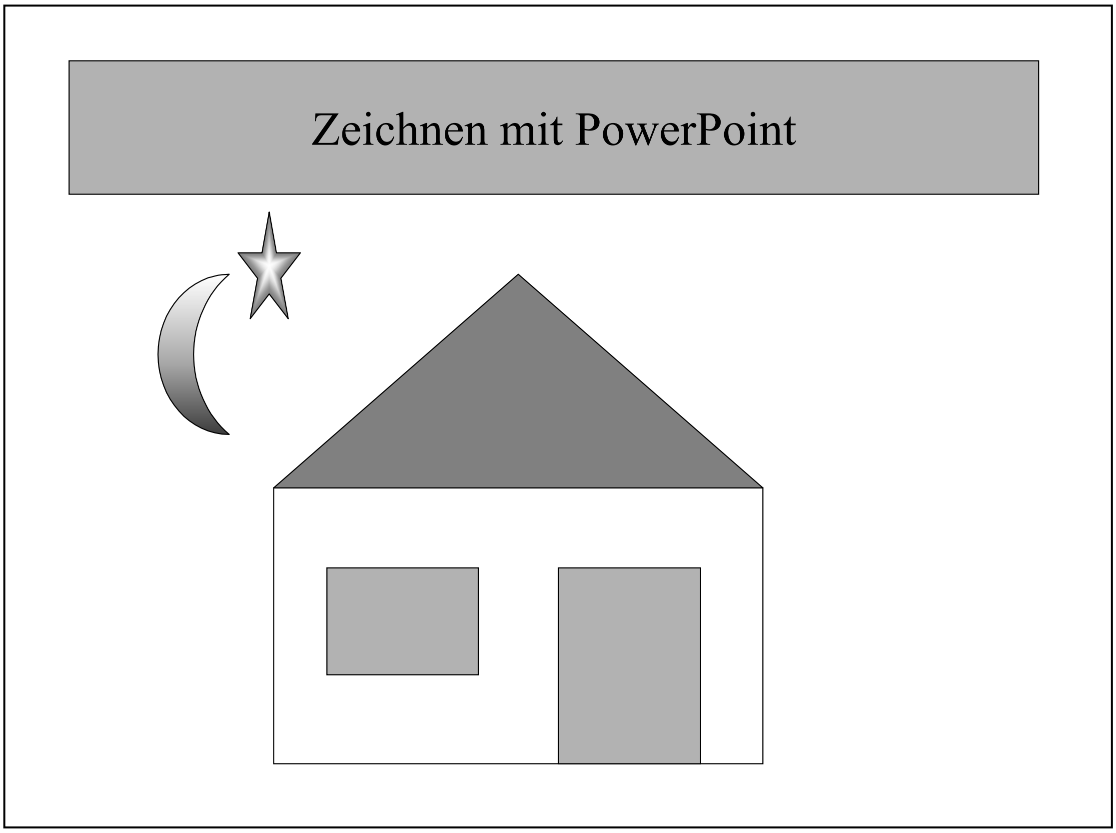

Microsoft PowerPoint - [Präsentation1]
Datei Bearbeiten Ansicht Einfügen Format Extras Bildschirmpräsentation Fenster ? Acrobat
Ausschneiden
Kopieren
Einfügen
(2)
(9)
Zeichnen
AutoFormen

A.3 TRAINING AND TEST TASKS (STUDIES 1 AND 2)

Introductory slide:



Training slide 1:



Training slide 2:

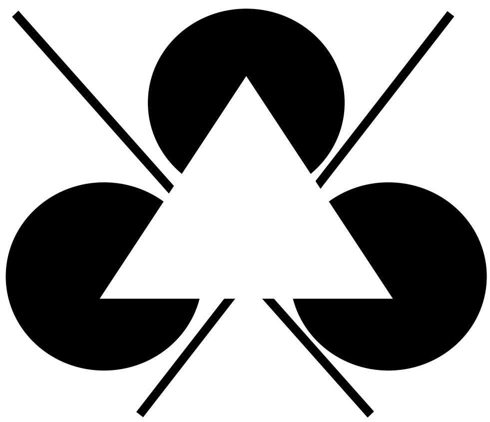
Die Universitäten Frankfurt und Gießen im Vergleich

	Anzahl Studierende (Gesamt)	Davon Neueinschreibungen
Uni Frankfurt	31.588	6.539
Uni Gießen	20.212	3.481

Stand: Wintersemester 2001/2002

Training slide 3 (used in Study 1 only):

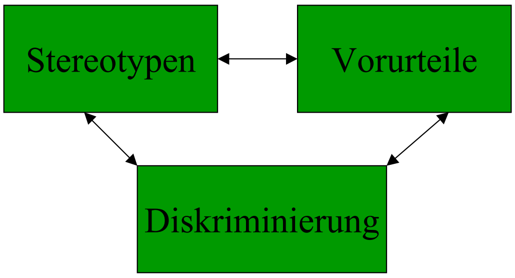
Ein erdachtes Dreieck



Test slide 1 (original test slides were in color):

Definitionen

- **Stereotypen**: Überzeugungen über eine Personengruppe.
- **Vorurteile**: negative Gefühle gegenüber einer Personengruppe.
- **Diskriminierung**: Verhalten gegenüber einer Personengruppe.



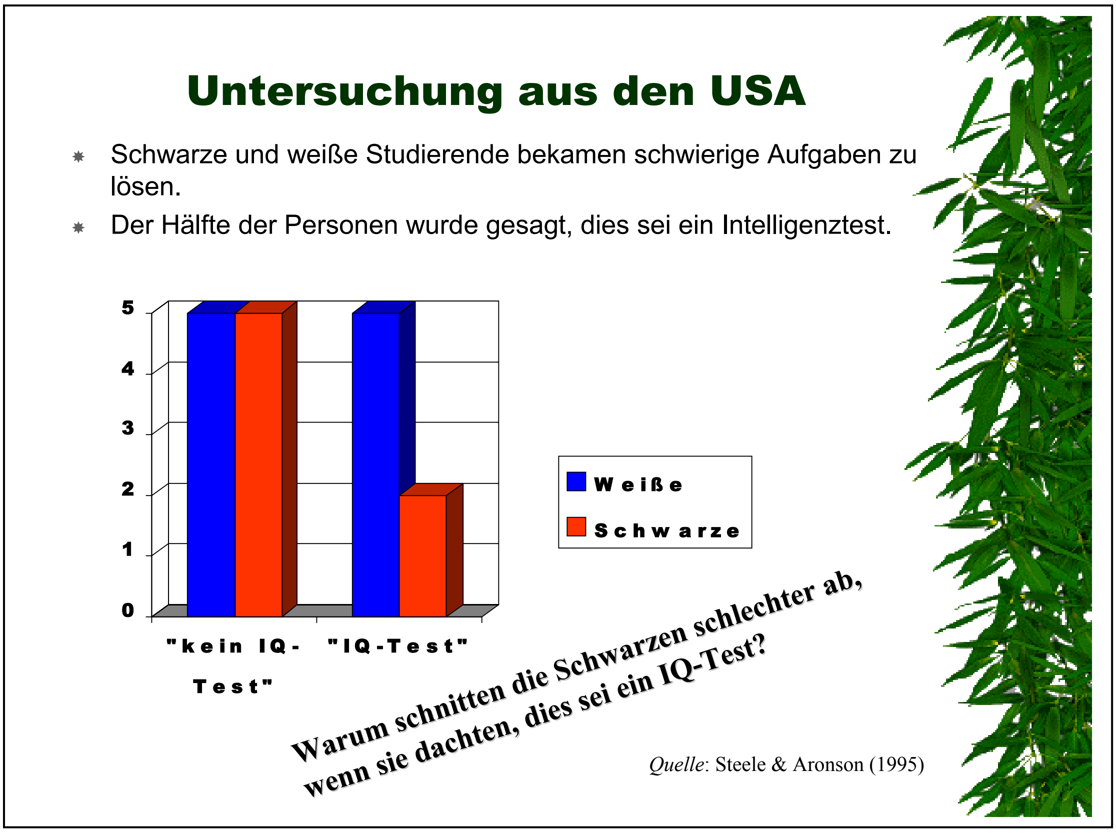
Test slide 2:

Umfrage unter weißen US-Amerikanern

Schwarze sind ... (Ja-Antw. in %)	1933	1967	1993
... faul	75	26	5
... dumm	22	4	0

Quelle: Brehm et al., 1999

Test slide 3:



Test slide 4 (all objects were animated; used in Study 2 only):

A.4 Task instructions for Introductory slide (Studies 1 & 2; original German version)

Erste Übung mit PowerPoint

Aufgabe: Bitte erstellen Sie eine Folie mit PowerPoint, die genauso aussieht wie die Papiervorlage *(muß nicht "auf den Millimeter" genau sein. Es sollten nur die Objekte, ihre Form, Farbe und ungefähre Position stimmen)*!

Schritte zur Lösung der Aufgabe:

1. Oberer Teil der Folie: Balken & Überschrift

a) Um den Balken zu erstellen, klicken Sie mit der linken Maustaste auf das Icon "Rechteck" in der Zeichnen-Leiste (dies ist die unterste Leiste). Lassen Sie die Maustaste wieder los.

b) Führen Sie die Maus nun auf die Folie, und zwar an die Stelle, wo die linke obere Ecke des Balken erscheinen soll. Klicken Sie dort auf die linke Maustaste und halten Sie die Maustaste gedrückt.

c) Ziehen Sie nun (bei gedrückter Maustaste) die Maus nach rechts unten, und zwar dorthin, wo die rechte untere Ecke des Balkens erscheinen soll.

d) Lassen Sie die Maustaste los. Es erscheint ein Rechteck, das mit einer grünen Farbe unterlegt ist. Das Rechteck ist von kleinen Kästchen eingerahmt.

e) Ggf. können Sie nun die Form oder Größe des Rechtecks ändern, indem Sie die Maus auf eines der Kästchen führen und sie entsprechend bewegen. Zum Beispiel können Sie den Balken nach rechts hin vergrößern, indem Sie die Maus auf das Kästchen rechts führen, klicken, die Maus nach rechts bewegen und dann loslassen.

f) Zum Verschieben des Balkens klicken Sie auf die Mitte des Balkens (nicht auf ein Kästchen), halten die Maustaste gedrückt und bewegen die Maus in die gewünschte Richtung.

g) Um die Farbe des Rechtecks zu ändern, klicken Sie in der Zeichnen-Leiste (die Leiste ganz unten) auf den kleinen Pfeil neben dem Icon "Füllfarbe" (Eimer, aus dem Farbe läuft).

h) Es öffnet sich ein Menü. Wählen Sie dort "Keine Farbe", indem Sie mit der Maus auf das Feld "Keine Farbe" klicken. Lassen Sie dann los. Der Balken ist nun fertig.

i) Schreiben der Überschrift: Klicken Sie mit der Maus auf das Icon "Textfeld" in der Zeichnen-Leiste (weißes Quadrat, in dem ein Buchstabe A und einige Querstriche abgebildet sind).

j) Klicken Sie mit der Maus in das linke Ende des Balkens auf der Folie. Es erscheint ein leeres Textfeld, in welchem der Cursor blinkt

k) Schreiben Sie den Text "Großer Kreis, kleines Rechteck, dicke Doppelpfeile" in das Textfeld.

l) Ggf. können Sie das Textfeld nun verschieben. Dazu markieren Sie zunächst das Textfeld, indem Sie auf den quergesteiften Rahmen des Textfelds klicken. Der Rahmen ist nun gepunktet.

m) Jetzt können Sie das Textfeld verschieben, indem Sie mit der Maus auf den Rahmen klicken und sie (bei gehaltener Maustaste) in die gewünschte Richtung bewegen.

n) Formatieren einzelner Wörter im Textfeld: Vergrößern Sie zunächst die Schriftgröße von "Großer Kreis". Dazu markieren Sie zunächst diese beiden Wörter, indem Sie die Maus bei gehaltener Maustaste über diese Wörter ziehen. Die beiden Wörter sind nun schwarz unterlegt.

o) Klicken Sie nun mit der Maus auf den kleinen schwarzen Pfeil neben dem Feld in der Format-Leiste (2. Leiste von oben), in der die Schriftgröße angezeigt ist (vermutlich ist "24" voreingestellt).

p) Es öffnet sich ein Menü. Wählen Sie dort "32", indem Sie mit der Maus auf die "32" klicken. Die "32" erreichen Sie, indem Sie mit der Maus zweimal auf den kleinen schwarzen Pfeil neben der "24" unten in dem geöffneten Menü klicken (erst erscheint "28", dann "32"). Wenn Sie jetzt auf die "32" klicken, ändert sich die Schriftgröße von "Großer Kreis" in Ihrem Textfeld auf "32".

q) Verkleinern Sie nun die Wörter "kleines Rechteck" auf dieselbe Weise: Markieren wieder Sie die Wörter, indem Sie die Maus bei gehaltener Maustaste über die Wörter ziehen, und ändern Sie die Schriftgröße über die Format-Leiste auf 14.

r) Fettdrucken von "dicke Doppelpfeile": Markieren Sie wieder Sie die Wörter, indem Sie die Maus bei gehaltener Maustaste über die Wörter ziehen Klicken Sie oben in der Format-Leiste auf das Icon "Fett" (fettgedrucktes F).

s) Untersteichen des Wortteils "Doppel": Markieren Sie den Wortteil "Doppel", indem Sie die Maus wieder (bei gehaltener Maustaste) darüber ziehen. Klicken Sie oben in der Format-Leiste auf das Icon "Unterstrichen" (unterstrichenes U).

t) Mit dem Text sind Sie nun fertig. Ggf. können Sie die Position des Textfelds noch einmal korrigieren, indem Sie es verschieben [wie unter den Punkten l) & m) beschrieben].

2. Unterer Teil der Folie: Kreis, Rechteck & Pfeile

a) Kreis: Klicken Sie in der Zeichnen-Leiste auf das Icon "Ellipse" und lassen wieder los.

b) Führen Sie die Maus auf die linke Hälfte der Folie (ungefähr dort, wo der Kreis erscheinen soll).

c) Klicken Sie dort hin, und lassen die Maustaste wieder los. Es erscheint ein grüner Kreis, der von mehreren weißen Kästchen umrahmt ist.

d) Vergrößern Sie nun den Kreis, z.B. indem Sie das rechte obere Kästchen anklicken und bei gehaltener Maustaste die Maus in Richtung rechts oben ziehen. Lassen Sie wieder los, wenn der Kreis die Richtige Größe und Form hat.

e) Ggf. sollten Sie den Kreis verschieben. Klicken Sie dazu auf den Kreis (nicht auf eines der Kästchen), verschieben Sie den Kreis dann bei gehaltener Maustaste in die richtige Position.

f) Um die Farbe des Kreises zu verändern, klicken Sie wieder auf den Pfeil neben dem Icon "Füllfarbe".

g) Wählen Sie dort das Hellgrau aus, indem Sie mit der Maus auf das hellgraue Feld klicken.

h) Rechteck: Klicken Sie mit der Maus auf das Icon "Rechteck" in der Zeichnen-Leiste und lassen wieder los.

i) Führen Sie die Maus an die Stelle in der Folie, wo die linke obere Ecke des Rechtecks erscheinen soll.

j) Drücken Sie die Maustaste, halten Sie sie gedrückt und führen Sie die Maus nach rechts unten, wo die rechte untere Ecke des Rechtecks erscheinen soll. Lassen Sie die Maustaste los.

k) Ggf. können Sie wieder die Form, Größe oder Position des Rechtecks ändern (Größe & Form mit Hilfe der Kästchen; verschieben durch Klicken auf das Rechteck, nicht auf eines der Kästchen).

l) Verändern Sie die Farbe des Rechtecks, indem Sie (wie gehabt) unter "Füllfarbe" auf das dunkelgraue Feld klicken.

m) Pfeile: Klicken Sie mit der Maus auf das Icon "Pfeil" in der Zeichnen-Leiste (Pfeil, der nach rechts unten zeigt) und lassen wieder los.

n) Führen Sie die Maus an die Stelle in der Folie, wo das linke Ende des oberen Pfeils erscheinen soll.

o) Drücken Sie die Maustaste, halten Sie sie gedrückt und führen Sie die Maus nach rechts oben, wo das rechte Ende des Pfeils erscheinen soll. Lassen Sie dort die Maustaste los.

p) Um aus dem einfachen Pfeil einen Doppelpfeil zu machen, klicken Sie mit der Maus auf das Icon "Pfeilart" (3. Icon rechts in der Zeichnen-Leiste). Es öffnet sich ein Menü, das verschiedene Pfeilarten anbietet.

q) Wählen Sie dort den Doppelpfeil, der dem der Papiervorlage entspricht (7. von oben), indem Sie mit der Maus auf den Doppelpfeil klicken.

r) Um die Stärke des Doppelpfeils auf Ihrer Folie zu verändern, klicken Sie mit der Maus auf das Icon "Linienart" in der Zeichnen-Leiste (5. Icon von rechts).

s) Wählen Sie dort die Linie mit der Stärke "6 Pt", indem Sie auf mit der Maus auf diese Linie im Menü klicken.

t) Ggf. können Sie noch die Position sowie die Länge des Pfeils korrigieren. Für die Länge des Pfeils benutzen Sie wieder eines der Kästchen an den Enden des Pfeils. Für die Position klicken Sie auf den Pfeil selbst (nicht auf eines der Kästchen) und bewegen die Maus.

u) 2. Pfeil: Stellen Sie sicher, daß der Pfeil, den Sie schon erstellt haben, markiert ist (angezeigt durch die Kästchen an den Enden des Pfeils). Klicken Sie nun mit der Maus auf das Icon "Kopieren" in der Standard-Leiste (zwei übereinanderliegende Blätter, Icon rechts neben der Schere), dann auf das Icon "Einfügen" (Icon rechts daneben).

v) Unter Ihrem ersten Pfeil erscheint nun ein zweiter Pfeil auf der Folie, der in Farbe, Form und Größe identisch ist. Verschieben Sie nun diesen neuen Pfeil etwas nach unten in die richtige Position, indem Sie mit der Maus auf den markierten Pfeil klicken (nicht auf eines der Kästchen an den Enden des Pfeils) und ihn bei gehaltener Maustaste in die richtige Richtung bewegen.

Mit Ihrer ersten Folie sind Sie nun fertig!

Bitte geben Sie der Untersuchungsleiterin Bescheid!

A.5 Task instructions for Introductory slide (Studies 1 & 2; English translation)

First Exercise With PowerPoint

Task: Please design a slide using PowerPoint that looks like the printed original *(it does not have to be identical to a millimetre but the presented objects in their original shape, color and position should be included)*!

Steps or actions to get to the solution:

1. Upper part of the slide: Bars & Heading

a) In order to create the bar, activate the icon „rectangle“ in the drawing toolbar at the bottom of the screen by clicking on it using the left mouse button. After clicking release the mouse button, do not keep it pressed down.

b) Now move the mouse to the slide to the position where the upper left corner of the bar is supposed to appear. When you have reached this position click on it with the left mouse button and keep the button pressed down.

c) Move the mouse (still keeping the left mouse button pressed down) towards the position where the lower right corner of the bar is supposed to be located.

d) Release the mouse button. On doing so a rectangle filled with a green color will appear. It is framed by small squares.

e) If necessary you can now correct the size or shape of the rectangle by moving the mouse to one of these little squares and moving it. If you wanted to expand the rectangle towards the right side for instance you would move the mouse toward the little square on the right side of the rectangle, click on it and then move the mouse towards the right. Then release the mouse button.

f) In order to change the bar’s position click on the centre of the bar (not on one of the little squares) and move the mouse in the desired direction.

g) To change the color of the rectangle click on the little arrow next to the icon „fill color“ (showing a bucket with paint flowing out of it) in the drawing toolbar (toolbar at the bottom of the screen.

h) After clicking on the arrow a menu will open. Select the option “no color” from this menu and release the mouse button. The designing of the bar is now finished.

i) Writing the Headline: Use the mouse to click on the icon “text box” (displaying a white square with a letter A and some horizontal lines) which is located in the drawing toolbar.

j) Now move the mouse to the left side of the bar on the slide and click. An empty text box will appear with the cursor blinking inside the text.

k) Write the text inside the text box ("Big circle, small rectangle, big double-headed arrow“).

l) If needed you can move the text box to its right position by highlighting the text box with a click on its striped frame, which will turn to a frame of dots in order to mark it as highlighted.

m) Now you can move the text box by clicking on the text boxes’ frame (keeping the mouse button down) and moving the mouse in the desired direction.

n) How to format single words inside a text box: Start with increasing the font size of the words „Big Circle“. Highlight the words by moving the mouse with the left mouse button pressed down across the two words. These words are now displayed in front of a black background.

o) Now click on the small black arrow next to the field showing the font size (which is presumably preset on “24”). It is located in the formatting toolbar (second toolbar from the top).

p) After clicking on the little black arrow a menu opens up. Select “32” out of this menu by clicking on the “32” with the mouse. You get to the “32” by clicking twice on the little arrow next to the “24” at the bottom of the opened menu (upon clicking once the “28” will appear, upon clicking twice the “32”). The click on the “32” changes the font size of the words “Big circle” in your text box to “32”.

q) Now scale down the font size of the words “little rectangle” the same way: Highlight the words by moving the mouse with the mouse button pressed down across the words and change the font size using the formatting toolbar to “14”.

r) Change the lettering of the words „big double-headed arrows“ to bold: Highlight the words by moving the mouse across them with the left mouse button pressed down and then click on the icon “bold” (B in bold lettering) in the formatting toolbar.

s) Underline the word "double-headed": Highlight the word „double-headed“ by moving the mouse across it with the mouse button pressed down. Then click on the icon “underline” (displaying an underlined U) which is located in the formatting toolbar.

t) You have now finished designing the text. In case it is necessary you may correct the position of the text box again [as described in steps l) and m)].

2. Lower part of the slide: Circle, Rectangle & Arrows

a) Circle: Click on the icon “ellipsis” displayed in the drawing toolbar and release the mouse button.

b) Now move the mouse to the left side of the slide (approximately to the postion the circle is supposed to appear).

c) Click on that point and release the mouse button. A green circle framed by several white squares will appear.

d) Enlarge this circle, e. g. by clicking on the upper right square and (keeping the mouse button pressed down) moving the mouse in the upper right direction. Release the mouse button when the circle has the right shape and size.

e) You might need to move the circle to its right position. In order to do that you click on the circle (not on one of the little squares) and move the circle by moving the mouse (keeping the mouse button pressed down).

f) To change the circle’s color, you click on the little black arrow next to the icon “fill color”.

g) There you select the light grey by clicking on the light grey square.

h) Rectangle: Click on the Icon rectangle in the drawing toolbar and then release the mouse button.

i) Move the mouse to the position on the slide where the upper-left corner of the rectangle is supposed to be.

j) Now press the mouse button, keep it pressed down and move the mouse towards the position where the lower-right corner of the rectangle is supposed to appear. Release the mouse button.

k) Here again you can – if necessary – change shape, size or position of the rectangle (size and shape are changed using the little white squares; changes of the rectangle’s position by clicking on it and not on one of the squares).

l) Change the rectangle’s color by clicking (like you did with the other objects) on the icon “fill color” and select the dark grey field.

m) Arrows: Click on the icon “arrow” that is located in the drawing toolbar (shows an arrow pointing to the lower right corner) and release the mouse button.

n) Move the mouse to the position on the slide where the upper end of the arrow is supposed to be positioned.

o) Press down the mouse button and keep it pressed while moving the mouse to the right where the right end of the arrow is supposed to be located. Release the mouse button when you have reached that position.

p) In order to change a one-headed arrow into a double-headed arrow click on the icon “type of arrow” (third Icon from the right in the drawing toolbar). A menu offering different types of arrows will open.

q) Select the double-headed arrow resembling the one in the printed original (seventh arrow from the top) by clicking on it with the mouse.

r) Change the thickness of the double-headed arrow by clicking on the icon “line style” in the drawing toolbar (fifth icon from the right).

s) Select the line with the thickness of “6 Pt” by mouse-clicking on that line in the menu.

t) You might want to correct the position or length of the arrow. In order to alter the length use one of the little white squares on either end of the arrow. The position is changed by clicking on the arrow itself (and not on one of the little squares) and moving the mouse.

u) Second Arrow: Make sure that the arrow you already designed is highlighted (in case it is, it will be framed by little squares). Now use the mouse to click on the icon “copy”(showing two overlapping pieces of paper, right next to the scissors) which is located in the standard toolbar. Then click on the icon “paste” (located right of the icon “copy”).

v) Underneath your first arrow a second arrow now appears on your slide which is identical in terms of color, shape, and size. Move this second arrow to its designated position by clicking on the highlighted arrow (not on one of the little squares on either end of the arrow) and moving it using the mouse and keeping the mouse button pressed all the while.

You have now finished designing your first slide!

Please inform the experimenter that you have finished!

A.6 Training instructions (Study 1): Error avoidant training (original German version)

Willkommen zum zweiten Teil des PowerPoint-Trainings

In den vergangenen Minuten haben Sie unter Anleitung eine erste Folie nach einer Papiervorlage erstellt.

Der zweite Teil des Trainings ist ganz ähnlich aufgebaut: Ihre Aufgabe ist es, eine weitere Folie nach einer Papiervorlage zu erstellen. Sie bekommen dazu wieder die Lösungsschritte erläutert, so wie bei der Bearbeitung der letzten Folie. Zusätzlich können Sie auch auf das Informationsmaterial zurückgreifen, das Sie ganz zu Beginn des Trainings bekommen haben. Eine Anleitung durch die Untersuchungsleiterin bekommen Sie in diesem Teil des Trainings allerdings nicht mehr. Bitte erstellen Sie die Folie, die Sie gleich in Papierform erhalten werden, selbständig mit Hilfe des schriftlichen Materials.

Während Sie die zweite Folie erstellen, folgen Sie bitte den schriftlichen Anweisungen möglichst genau. Die Folie sowie die zugehörigen Lösungsschritte sind so aufgebaut, daß Sie innerhalb kurzer Zeit zu den wichtigsten Stellen des Programms "geführt" werden. Dadurch wird gewährleistet, daß Sie von Anfang an die richtigen Schritte beim Arbeiten mit PowerPoint einüben.

Falls Ihnen trotz Befolgens der Lösungsschritte einmal ein Fehler unterlaufen sollte, haben Sie die Möglichkeit, durch Klicken auf das **Icon "Rückgängig"** oben in der Standard-Symbolleiste (Pfeil, der nach links zeigt) die Schritte rückgängig zu machen, die nicht zum gewünschten Ergebnis geführt haben. Kehren Sie dann einfach zu der Stelle zurück, bei der der Fehler auftrat, und beginnen Sie erneut. Wenn Sie ein erstelltes Objekt löschen wollen, können Sie es per Mausklick markieren und dann die Entfernen-Taste drücken (Taste "Entf", rechts auf der Tastatur). Danach können Sie das Objekt noch einmal neu erstellen.

Falls diese Maßnahmen nicht helfen sollten, geben Sie bitte der Untersuchungsleiterin Bescheid.

A.7 Training instructions (Study 1): Error avoidant training (English translation)

Welcome to the second part of the PowerPoint training

Within the last couple of minutes you designed a first slide according to the printed original by following the instructions.

The second part of the training is structured in a similar way: Your task is to design another slide on the basis of a printed original. Again you will get explanations concerning the steps leading to the solution of the task. In addition to these explanations you may feel free to consult the manual containing basic information on PowerPoint you were given at the start of the training session. In contrast to the first training slide you will not get any instructions by the experimenter on this task. Please design the slide for which the printed original will be given to you in a moment independently, using the written material.

Please follow the written instructions carefully while working on the slide. Both the slide and the written instructions are designed in a way that ensures that you will be “led” to the most important parts of the slide within a short space of time. This allows you to train the right steps in working with PowerPoint right from the start.

In case an error occurs even though you followed the instructions you can reverse the undesired action(s) by clicking on the “**undo” icon** in the standard toolbar at the top of the screen (the icon shows a little arrow pointing to the left). After reversing your error just go back to the step where the error occurred and start over again. If needed, you can delete an object by highlighting it with a mouse click and pushing the “delete” key (key “del” on the right hand side of your keyboard). Afterwards you can create that object again.

In case these measures do not lead to the desired effect, please contact the experimenter.

A.8 TRAINING INSTRUCTIONS (STUDY 1): ERROR MANAGEMENT TRAINING (ORIGINAL GERMAN VERSION)

Willkommen zum zweiten Teil des PowerPoint-Trainings

In den vergangenen Minuten haben Sie unter Anleitung eine erste Folie nach einer Papiervorlage erstellt und dabei grundlegende Kenntnisse über die Funktionsweise von PowerPoint erworben. Diese Grundkenntnisse sollen Sie jetzt im zweiten Trainingsteil festigen und erweitern. Dazu ist es wichtig, daß Sie sich möglichst intensiv mit PowerPoint auseinandersetzen. Daher sollen Sie in der restlichen Trainingszeit selbständig arbeiten. Denn nur selbständiges Arbeiten mit PowerPoint ermöglicht eine wirklich intensive Auseinandersetzung mit dem Programm.

Auch in dieser Trainingsphase ist es Ihre Aufgabe, eine Folie nach einer Papiervorlage zu erstellen. Allerdings bekommen Sie in diesem Trainingsteil keine Lösungsschritte mehr erläutert und auch keine Anleitung durch die Untersuchungsleiterin. Sie können aber auf das Informationsmaterial zurückgreifen, das Sie ganz zu Beginn des Trainings bekommen haben.

Während Sie ganz selbständig Ihre zweite Folie erstellen, werden Ihnen sicherlich einige **Fehler** unterlaufen. Das ist **gut so und ganz im Sinne des Trainings!** Denn durch Fehler lernen Sie, besonders gut mit PowerPoint umzugehen. Fehler sind ein natürlicher Bestandteil des Lernens!

Es lohnt sich also, einfach mal ein paar Funktionen des Programms auszuprobieren, auch wenn Sie sich nicht ganz sicher sind, ob Sie "auf dem richtigen Weg" sind. Außerdem gibt es immer einen Weg, aus einer Fehlersituation herauszukommen.

Falls Ihnen ein Fehler unterlaufen sollte, haben Sie beispielsweise die Möglichkeit, durch Klicken auf das **Icon "Rückgängig"** oben in der Standard-Symbolleiste (Pfeil, der nach links zeigt) die Schritte rückgängig zu machen, die nicht zum gewünschten Ergebnis geführt haben. Wenn Sie ein erstelltes Objekt löschen wollen, können Sie es per Mausklick markieren und dann die Entfernen-Taste drücken (Taste "Entf", rechts auf der Tastatur).

Wenn Ihnen ein Fehler unterläuft, bedenken Sie immer:

- ✓ Fehler sind nichts Schlimmes, sondern ein natürlicher Bestandteil des Lernens!
- ✓ Es gibt immer einen Weg, aus einer Fehlersituation herauszukommen!
- ✓ Fehler zeigen, was man noch lernen kann!
- ✓ Aus Fehlern wird man also wirklich klug!

A.9 Training instructions (Study 1): Error management training (English translation)

Welcome to the second part of the PowerPoint-Training

Within the last couple of minutes you designed a first slide according to a printed original supported by careful instructions. This gave you the chance to get a first insight into the functions of and working with PowerPoint. The second part of the training session is designed to consolidate and expand your knowledge about PowerPoint. Therefore, it is important that you work intensively with the program. Accordingly you are required to work independently throughout the rest of the training session. This is due to the fact that only independent working with PowerPoint results in an intensive dealing with the program.

Similar to the first training part it is now your task to design a slide according to a printed original. In contrast to the first part of the training you will neither receive written information about the steps leading to the solution, nor get any instructions by the experimenter. You may however refer to the manual containing the basic information about the program PowerPoint that was handed to you at the beginning of the first part of the training.

While working independently on your second slide you will certainly make some **errors**. This is a **good thing and in line with the idea of this training!** By making errors you will learn to deal with the program PowerPoint more effectively. Errors are a natural part of the learning process!

It is worth it trying some of the functions of the program even when you are not sure whether you are on the right track. In any case there is always a way to leave the error situation.

In case an error occurs you can for example fix it by clicking on the "**undo" icon** in the upper standard toolbar (the icon shows a little arrow pointing to the right). By clicking it you can reverse the actions that did not lead to the desired outcome. In case you want to delete an object from the slide, highlight it with a mouse click and push the "delete" key (key "del" on the right hand side of your keyboard).

In case you make an error think about the following:

- ✓ Errors are a natural part of the learning process!
- ✓ There is always a way to get out of the error situation!
- ✓ Errors inform you about what you can still learn!
- ✓ The more errors you make, the more you learn!

A.10 Training instructions (Study 1): Additional instructions for Error management training plus metacognition condition (original German version)

Die letzte Folie haben Sie ganz selbständig und ohne Anleitung erstellt. Dabei haben Sie bedacht, daß Fehler nichts Schlimmes, sondern ein natürlicher Bestandteil des Lernens sind, daß es immer einen Weg gibt, um aus einer Fehlersituation herauszukommen und daß man aus Fehlern klug wird.

Es ist richtig und wichtig, daß Fehler eine positive Funktion beim Lernen haben. Bitte denken Sie auch in der nächsten Trainingsphase daran!

An dieser Stelle möchten wir Ihnen einen weiteren Baustein dieses Trainings vorstellen, der Ihnen beim Umgang mit PowerPoint helfen wird: die **Selbstbefragungs-Strategie**.

Was ist die Selbstbefragungs-Strategie?

Wie der Name schon sagt, sollen Sie sich während Ihrer Arbeit mit PowerPoint ab und zu selbst befragen und diese Fragen selbst beantworten.

Wenn man mit einem neuen Computerprogramm arbeitet, ist man meistens erst einmal "überwältigt" von den vielen Möglichkeiten, die vom Programm angeboten werden. Sie müssen sich in dem "Wirr-Warr" zurechtfinden und z.B. überlegen, welche Teile des Programms für Sie im Moment wichtig sind und welche unwichtig. Außerdem müssen Sie, wann immer Sie nicht weiterwissen, eine Möglichkeit finden, sinnvoll weiterzuarbeiten (z.B. nicht *irgendwo*, sondern an genau den Stellen im Programm nach einem geeigneten Befehl suchen, wo die Wahrscheinlichkeit hoch ist, daß Sie ihn auch finden werden).

Die Fragen, die Sie sich stellen und selber beantworten, sollen Ihnen dabei helfen, sich besser im Programm zu orientieren, Ihre Gedanken zu ordnen, geeignete Strategien zu entwickeln und Ihre eigenen Arbeitsschritte kritisch daraufhin zu bewerten, ob und warum sie zielführend oder nicht zielführend waren.

Ihre Fragen sollen vier Bereiche abdecken, nämlich:

1. Problemanalyse: Zunächst sollen Sie sich bewußt machen, was genau Ihr Problem und Ihr Ziel ist, was genau Sie erreichen wollen.

2. Entwicklung einer Strategie: Dann sollen Sie sich systematisch Informationen ins Gedächtnis rufen, die Ihnen für die Entwicklung einer geeigneten Strategie nützlich sein könnten.

3. Beobachten: Anschließend sollen Sie Ihre Strategie durchführen und genau darauf achten, was Sie tun und was dabei passiert. Manchmal "klickt" man zu schnell weiter und übersieht dabei etwas, was einem – jetzt oder später – nützlich sein könnte.

4. Analyse des Ergebnisses: Abschließend sollen Sie analysieren, welche Folgen Ihre Aktionen hatten. Sie sollen beurteilen, ob und warum Ihre Aktion (nicht) erfolgreich war und ob Sie vielleicht Ihre Strategie ändern müssen.

Wann brauche ich die Selbstbefragungs-Strategie nicht?

Immer dann, wenn Sie genau wissen, was zu tun ist (z.B. weil Sie die Aktion, die Sie jetzt ausführen wollen, schon bei der letzten Folie erfolgreich angewendet haben), brauchen Sie die Strategie nicht.

Und wann brauche ich die Selbstbefragungs-Strategie?

In folgenden Situationen brauchen Sie die Selbstbefragungs-Strategie:

- Wenn Sie nicht weiterwissen (und z.B. nach einem neuen Befehl suchen müssen), analysieren Sie Ihr Problem und entwickeln eine Strategie! Fragen Sie sich:
    - Was ist mein Problem? Was genau will ich eigentlich erreichen?
    - Was für einen Befehl brauche ich jetzt und wo könnte ich sinnvollerweise danach suchen?
    - Was weiß ich schon über PowerPoint (aus den Trainingsunterlagen oder aus der Bearbeitung der letzten Folien), was mir jetzt weiterhelfen könnte?

- Wenn sich ein Fenster oder ein Menü geöffnet hat und Sie herausfinden wollen, was dieses Fenster / das Menü bietet, beobachten Sie genau! Fragen Sie sich:
    - Was genau sehe ich in diesem Fenster / diesem Menü? Fahren Sie langsam mit der Maus von links nach rechts, von oben nach unten! Schauen Sie genau hin!
    - Was passiert, wenn ich _____________ anklicke? (Schauen Sie auch hier genau hin!)
- Wenn etwas Neues passiert, analysieren Sie Ihr (Zwischen-)Ergebnis! Fragen Sie sich:
    - Was ist passiert? Warum ist das passiert?
    - Habe ich mein Ziel erreicht? Warum / warum nicht?
    - Was könnte ich anders machen?
- Ganz allgemein sollten Sie, während Sie mit PowerPoint arbeiten, ab und zu innehalten und sich fragen:
    - Was tue ich gerade überhaupt? Und warum tue ich das?
    - Was ist mein aktuelles Ziel? Was will ich erreichen?

Ihre Aufgabe während der Bearbeitung der nächsten Folie ist es, diese Fragen möglichst häufig zu stellen und zu beantworten, und zwar immer dann, wenn eine der gerade geschilderten Situationen vorliegt (vergessen Sie auch nicht, ab und zu innezuhalten!). Sprechen Sie Ihre Fragen und Antworten laut aus! **Nutzen Sie Ihre Fragen und Antworten gezielt dazu "weiterzudenken"!**

Ich weiß nicht weiter → Problem analysieren & Strategie entwickeln!

- Was ist mein Problem? Was will ich erreichen?
- Welchen Befehl / welche Funktion von PowerPoint brauche ich jetzt? Wo sollte ich danach suchen?
- Was weiß ich schon über PowerPoint (aus den Unterlagen oder dem Training), was mir jetzt weiterhilft?

Ein Fenster / Menü hat sich geöffnet → Genau beobachten!

- Was genau sehe ich? (von links nach rechts, von oben nach unten)
- Was passiert, wenn ich ___________ anklicke? (genau hinschauen!)

Etwas Neues ist passiert → (Zwischen)ergebnis analysieren!

- Was ist passiert? Warum ist das passiert?
- Habe ich mein Ziel erreicht? Warum / warum nicht?
- Was war gut? Was war nicht so gut? Was könnte ich anders machen?

Allgemein - Ab und zu innehalten!

- Was tue ich gerade überhaupt und warum?
- Was ist mein aktuelles Ziel? Was will ich erreichen?

A.11 Training instructions (Study 1): Additional instructions for Error management training plus metacognition condition (English translation)

You designed the last slide independently and without any instruction. While working on the slide you thought about the fact that errors are not bad but a natural part of the learning process. Furthermore there is always a way to leave the error situation and that the more errors you make, the more you learn.

It is both right and important that errors do have a positive function throughout the learning process. Please consider this throughout the following part of the training as well!

At this point in the training session we would like to introduce to you another module of the training which will help you working with PowerPoint: the **self-questioning technique.**

What is the self-questioning technique?

As implied by the name you are supposed to ask yourself questions while you work with PowerPoint and answer them yourself.

When working with a new and unfamiliar computer program it is normal to be overwhelmed by the many different options and functions this program offers. You have to find your way around in that "jumble" and find out which parts of the program are relevant and important to you at the moment and which parts are not. In addition to that you have to find a way to continue working towards your goal whenever you get stuck and do not know how to go on (this includes e. g. searching for an appopriate function or command not *anywhere* within the program but somewhere with a high possibility to actually find it).

The questions you are asking and answering to yourself are supposed to help you in terms of orientation, getting your thoughts in order and develop a strategy as well as evaluate the steps you took regarding the reasons why they did or did not work the way you intended them to work.

Your questions should cover four different topics:

1. Problem analysis: You should ask yourself what exactly your problem is and what you want to achieve.

2. Development of a Strategy: Subsequently you should systematically gather information that is useful while developing an appropriate strategy.

3. Observation: Then you should try to implement your strategy and keep track of what happens while you execute the commands that form your strategy. Sometimes one moves on from one click to the next to rashly which might lead to a loss of information that would be useful in the further working process.

4. Analysis of results: Finally you should analyze the consequences of your actions. You are supposed to evaluate if and why you did (not) achieve the desired result with a certain action. This evaluation might lead to the conclusion that your strategy has to be modified.

When do I not need to use the self-questioning technique?

Whenever you know exactly what to do next (for instance because the action you are about to perform was successful while working on another slide) there is no need to use this technique.

And when do I need the self-questioning technique?

The self-questioning technique should be used in each of the following situations:

- Whenever you do not know what to do next (e. g. because you have to find a new command) analyze your problem and develop a strategy! Ask yourself:
    - What is my problem? What exactly do I want to achieve next?
    - What type of command do I need and where is a plausible area to look fort hat sort of command?
    - What do I already know about PowerPoint (from the training manual ort he slides I designed beforehand) and which of the information is likely to help me move on now?

- Whenever a new window or menu has been opened and you want to find out what this window / menu offers. Observe closely and ask yourself:
  - What exactly do I see in this window / menu? Move the mouse cursor slowly across it from all directions and observe what happens. Take a close look !
  - What happens when I click on _____________? (Here again, take a close look!)
- When something new happens, analyze your (intermediate) results! Ask yourself:
  - What happened? Why did it happen?
  - Did I reach my goal? Why / why not?
  - What can I change or do differently?
- In general you should every now and then while working with PowerPoint pause for a moment and ask yourself:
  - What am I doing right now? And why am I doing it?
  - What is my goal right now? What do I want to achieve?

Your task while working on the next slide is to ask and answer these questions to yourself as frequently as possible. Use this technique in situations like those described above and do not forget to stop and think from time to time. Please ask and answer these questions aloud!

Use your questions and answers to „think ahead“!

I don't know how to proceed → Analyze the problem & develop a strategy!

- What is my problem? What am I trying to achieve?
- What PowerPoint function do I need? Where shall I look for it?
- What do I know about PowerPoint so far that might help me now?

A window / menu has opened up → Watch closely!

- What exactly do I see? (from left to right, from top to bottom)
- What happens if I click on ___________ ?

Something new has happened → Evaluate the result!

- What happened? Why did that happen?
- Did I reach my goal? Why / why not?
- What was good / not so good? What would I do differently next time?

Generally - Stop & think from time to time!

- What am I doing right now and why?
- What is my current goal?

A.12 Training instructions (Study 2): Error avoidant training (original German version)

Willkommen zum zweiten Teil des PowerPoint-Trainings

In den vergangenen Minuten haben Sie unter Anleitung eine erste Folie nach einer Papiervorlage erstellt.

Der zweite Teil des Trainings ist ganz ähnlich aufgebaut: Ihre Aufgabe ist es, eine weitere Folie nach einer Papiervorlage zu erstellen. Sie bekommen dazu wieder die Lösungsschritte erläutert, so wie bei der Bearbeitung der letzten Folie. Zusätzlich können Sie auch auf das Informationsmaterial zurückgreifen, das Sie ganz zu Beginn des Trainings bekommen haben. Eine Anleitung durch den Untersuchungsleiter bekommen Sie in diesem Teil des Trainings allerdings nicht mehr. Bitte erstellen Sie die Folie, die Sie gleich in Papierform erhalten werden, selbständig mit Hilfe des schriftlichen Materials.

Während Sie die zweite Folie erstellen, folgen Sie bitte den schriftlichen Anweisungen möglichst genau. Es ist sehr wichtig für die Untersuchung, daß Sie die Anweisungen Schritt für Schritt nacheinander durchgehen. Um dies zu gewährleisten und um Ihnen eine Orientierungshilfe zu geben, streichen Sie bitte die Kästchen am Anfang jeder Anweisung dann durch, wenn Sie die Anweisung ausgeführt haben.

Die Folie sowie die zugehörigen Lösungsschritte sind so aufgebaut, dass Sie innerhalb kurzer Zeit zu den wichtigsten Stellen des Programms "geführt" werden. Dadurch wird gewährleistet, dass Sie von Anfang an die richtigen Schritte beim Arbeiten mit PowerPoint einüben.

Falls Ihnen trotz Befolgens der Lösungsschritte einmal ein Fehler unterlaufen sollte, haben Sie die Möglichkeit, durch Klicken auf das **Icon "Rückgängig"** oben in der Standard-Symbolleiste (Pfeil, der nach links zeigt) die Schritte rückgängig zu machen, die nicht zum gewünschten Ergebnis geführt haben. Kehren Sie dann einfach zu der Stelle zurück, bei der der Fehler auftrat, und beginnen Sie erneut. Wenn Sie ein erstelltes Objekt löschen wollen, können Sie es per Mausklick markieren und dann die Entfernen-Taste drücken (Taste "Entf", rechts auf der Tastatur). Danach können Sie das Objekt noch einmal neu erstellen.

Sollten diese Maßnahmen nicht helfen, wenden Sie sich bitte umgehend an den Versuchsleiter, er wird Ihnen die richtigen Schritte zeigen. Versuchen Sie bitte nicht, durch Ausprobieren die Lösung zu finden, da Sie sonst Gefahr laufen, sich falsche Schritte anzueignen. Außerdem kämen Sie dann mit den schriftlichen Lösungsschritten durcheinander.

A.13 Training instructions (Study 2): Error avoidant training (English translation)

Welcome to the second part of the PowerPoint training

Within the last couple of minutes you designed a first slide according to the printed original by following the instructions.

The second part of the training is structured in a similar way: Your task is to design another slide on the basis of a printed original. Again you will get explanations concerning the steps leading to the solution of the task. In addition to these explanations you may feel free to consult the manual containing basic information on PowerPoint you were given at the start of the training session. In contrast to the first training slide you will not get any instructions by the experimenter on this task. Please design the slide for which the printed original will be given to you in a moment independently, using the written material.

Please follow the written instructions carefully while working on the slide. It is very important for this study that you follow the instructions closely and implement them step by step. In order to ensure this and to give you an additional support for your orientation please check off the little boxes in front of every instructional part after realizing it.

Both the slide and the written instructions are designed in a way that ensures that you will be "led" to the most important parts of the slide within a short space of time. This allows you to train the right steps in working with PowerPoint right from the start.

In case an error occurs even though you followed the instructions you can reverse the undesired action(s) by clicking on the "**undo" icon** in the standard toolbar at the top of the screen (the icon shows a little arrow pointing to the left). After reversing your error just go back to the step where the error occurred and start over again. If needed, you can delete an object by highlighting it with a mouse click and pushing the "delete" key (key "del" on the right hand side of your keyboard). Afterwards you can create that object again.

In case these measures do not lead to the desired effect, please contact the experimenter, he will show you the right steps to move on. Please do not try to solve the problem yourself by trying out different functions, as you would be in danger of learning wrong steps and actions. Furthermore you would get into disorder with the steps toward the solution in your instructions.

A.14 Training instructions (Study 2): Error management training (original German version)

Willkommen zum zweiten Teil des PowerPoint-Trainings

In den vergangenen Minuten haben Sie unter Anleitung eine erste Folie nach einer Papiervorlage erstellt und dabei grundlegende Kenntnisse über die Funktionsweise von PowerPoint erworben. Diese Grundkenntnisse sollen Sie jetzt im zweiten Trainingsteil festigen und erweitern. Dazu ist es wichtig, dass Sie sich möglichst intensiv mit PowerPoint auseinandersetzen. Daher sollen Sie in der restlichen Trainingszeit selbständig arbeiten. Denn nur selbständiges Arbeiten mit PowerPoint ermöglicht eine wirklich intensive Auseinandersetzung mit dem Programm.

Auch in dieser Trainingsphase ist es Ihre Aufgabe, eine Folie nach einer Papiervorlage zu erstellen. Allerdings bekommen Sie in diesem Trainingsteil keine Lösungsschritte mehr erläutert und auch keine Anleitung durch den Untersuchungsleiter. Sie können aber auf das Informationsmaterial zurückgreifen, das Sie ganz zu Beginn des Trainings bekommen haben.

Falls Ihnen ein Fehler unterlaufen sollte, haben Sie die Möglichkeit, durch Klicken auf das **Icon "Rückgängig"** oben in der Standard-Symbolleiste (Pfeil, der nach links zeigt) die Schritte rückgängig zu machen, die nicht zum gewünschten Ergebnis geführt haben. Wenn Sie ein erstelltes Objekt löschen wollen, können Sie es per Mausklick markieren und dann die Entfernen-Taste drücken (Taste "Entf", rechts auf der Tastatur). Danach können Sie das Objekt neu erstellen.

A.15 TRAINING INSTRUCTIONS (STUDY 2): ERROR MANAGEMENT TRAINING (ENGLISH TRANSLATION)

Welcome to the second part of the PowerPoint training

Within the last couple of minutes you designed a first slide according to a printed original supported by careful instructions. This gave you the chance to get a first insight into the functions of and working with PowerPoint. The second part of the training session is designed to consolidate and expand your knowledge about PowerPoint. Therefore, it is important that you work intensively with the program. Accordingly you are required to work independently throughout the rest of the training session. This is due to the fact that only independent working with PowerPoint results in an intensive dealing with the program.

Similar to the first training part it is now your task to design a slide according to a printed original. In contrast to the first part of the training you will neither receive written information about the steps leading to the solution, nor get any instructions by the experimenter. You may however refer to the manual containing the basic information about the program PowerPoint that was handed to you at the beginning of the first part of the training.

In case an error occurs you can for example fix it by clicking on the "**undo" icon** in the upper standard toolbar (the icon shows a little arrow pointing to the right). By clicking it you can reverse the actions that did not lead to the desired outcome. In case you want to delete an object from the slide, highlight it with a mouse click and push the "delete" key (key "del" on the right hand side of your keyboard). After deleting you can create the object again.

APPENDIX B: SCALES USED IN STUDIES

B.1 EMOTION CONTROL SCALE (GERMAN VERSION & ENGLISH TRANSLATION)

German version:

Bei der Aufgabenbearbeitung sind vielleicht einige Schwierigkeiten aufgetreten. Bitte wählen Sie diejenige Antwortmöglichkeit, die am besten Ihre Reaktion auf auftretende Schwierigkeiten wiedergibt.

	Bei auftretenden Schwierigkeiten ...	trifft nicht zu	trifft eher nicht zu	weder noch	trifft eher zu	trifft zu
1	... habe ich mich nicht aus der Ruhe bringen lassen.	⓪	①	②	③	④
2	... habe ich mich gezielt weiter auf die Aufgabe konzentriert.	⓪	①	②	③	④
3	... habe ich in Ruhe überlegt, wie ich weiter vorgehen kann.	⓪	①	②	③	④
4	... habe ich mich von sorgenvollen Gedanken ablenken lassen.	⓪	①	②	③	④
5	... habe ich mich aus dem Konzept bringen lassen.	⓪	①	②	③	④
6	... habe ich mich von der Aufgabenbearbeitung ablenken lassen.	⓪	①	②	③	④
7	... konnte ich meine gesamte Konzentration auf die Aufgabe richten.	⓪	①	②	③	④
8	... konnte ich mich dazu anspornen, einfach weiterzumachen.	⓪	①	②	③	④

English translation:

Some difficulties may have arisen while working on the task(s). Please choose the response that best describes your reaction to these difficulties.

	When difficulties arose ..	False	Is somewhat false	Is neither true or false	Is somewhat true	True
1	... I did not allow myself to lose my composure.	⓪	①	②	③	④
2	... I purposely continued to focus myself on the task.	⓪	①	②	③	④
3	... I calmly considered how I could continue the task.	⓪	①	②	③	④
4	... I allowed myself be distracted by worrisome thoughts.	⓪	①	②	③	④
5	... I let myself become distracted.	⓪	①	②	③	④
6	... I let myself be sidetracked from the task	⓪	①	②	③	④
7	... I was able to focus all my attention on the task.	⓪	①	②	③	④
8	... I was able to motivate myself to continue.	⓪	①	②	③	④

B.2 ERROR ORIENTATION SCALE (GERMAN VERSION & ENGLISH TRANSLATION)

German version:

Beim Erstellen der Folien haben Sie vielleicht einige Fehler gemacht. Wie sind Sie mit Ihren Fehlern umgegangen? [learn = Subskala 'Learning from errors'; strain = Subskala 'error strain']

		trifft nicht zu	trifft eher nicht zu	weder noch	trifft eher zu	trifft zu
1	Wenn ich einen Fehler gemacht habe, habe ich den kühlen Kopf verloren und mich darüber geärgert. [strain]	⓪	①	②	③	④
2	Fehler waren für mich sehr hilfreich, um meine Arbeit zu verbessern. [learn]	⓪	①	②	③	④
3	Wenn mir ein Fehler passiert ist, war dies eine wichtige Information für die Durchführung der PowerPoint-Aufgabe. [learn]	⓪	①	②	③	④
4	Meine Fehler haben mir gezeigt, was ich besser machen kann. [learn]	⓪	①	②	③	④
5	Ich habe Angst davor gehabt, Fehler zu machen. [strain]	⓪	①	②	③	④
6	Aus meinen Fehlern habe ich viel für die Arbeit mit PowerPoint gelernt. [learn]	⓪	①	②	③	④
7	Während des Arbeitens habe ich mir Sorgen gemacht, etwas falsch zu machen. [strain]	⓪	①	②	③	④
8	Wenn mir ein Fehler passiert ist, habe ich mich dafür geschämt. [strain]	⓪	①	②	③	④
9	Ich habe es als belastend empfunden, einen Fehler zu machen. [strain]	⓪	①	②	③	④

English translation:

You may have made some errors while working on the task(s). How did you deal with your errors? [learn = Subscale 'Learning from errors'; strain = Subscale 'error strain']

		False	Is somewhat false	Is neither true or false	Is somewhat true	True
1	When I made a mistake, I 'lost my cool' and became angry. [strain]	⓪	①	②	③	④
2	Mistakes assisted me to improve my work. [learn]	⓪	①	②	③	④
3	Mistakes provided useful information for me to carry out the PowerPoint task. [learn]	⓪	①	②	③	④
4	My mistakes helped me to improve my work. [learn]	⓪	①	②	③	④
5	I was afraid of making mistakes. [strain]	⓪	①	②	③	④
6	I have learned a lot from my errors for my work with PowerPoint. [learn]	⓪	①	②	③	④
7	While working I was concerned that I could do something wrong. [strain]	⓪	①	②	③	④
8	I felt embarrassed when I made an error. [strain]	⓪	①	②	③	④
9	I found it stressful when I erred. [strain]	⓪	①	②	③	④

APPENDIX C:
CODING SCHEME FOR META-ANALYSIS

1. Evaluation phase

(Code 0) Criterion performance was assessed during training (training phase performance)

(Code 1) Criterion performance was assessed after training (test phase performance)

This variable's purpose is to reflect whether participants presumably were aware that their performance was being evaluated (Code 1) or whether, in the case of error management training, they presumably thought they were (still) in a training phase where errors and experimentation is encouraged (Code 0).

Look for informational cues in the report that describe at what point in time or in the course of the experimental session (i.e., in what practice phase) the dependent variable performance was assessed. Straightforward cues include the statement that training performance (e.g., of the last training phase) was the dependent variable (Code 0), that participants were told that a test phase was going to start where performance would be evaluated (Code 1), or that there was only one practice task (which served as training and transfer task at the same time) where performance was assessed and used as dependent variable (Code 0). In many cases, where study authors provide less straightforward information, inferences have to be drawn from informational cues that were less clear cut than the ones just listed. These cues include: Error management instructions were given in a first phase but removed or not repeated before a second phase, and performance in the second phase was the dependent variable (Code 1). Error management instructions were given in a first phase and repeated before a second phase, and performance in the second phase was the dependent variable (Code 0). Error management instructions were given (exclusively) before the phase where the performance was the dependent variable (Code 0). Information on the task (e.g., manuals) was provided in a first phase but removed in a second phase, and performance in the second phase was the dependent variable (Code 1). Assistance by trainer or experimenter was provided in a first phase but independent work was required in a second phase, and performance in the second phase was the dependent variable (Code 1). Practical tasks were presented to participants within a testing block (e.g., after or along with a knowledge test) (Code 1).

2. Adaptivity of transfer task

(Code 0) Analogical transfer

(Code 1) Adaptive transfer

This variable's purpose is to reflect whether the criterion performance tasks required new solutions that had to be developed by participants while working on the task in the test phase (i.e., testing tasks were distinct from training tasks; Code 1) or whether the tasks could be solved directly by applying the skills and strategies learned during training (i.e., testing tasks were similar to training tasks; Code 0). Note that *distinctiveness* of transfer task from training task is the critical factor for this coding. If training and transfer task were merely *different* or slightly more *difficult*, this may be a necessary but not a sufficient condition for distinctiveness.

Look for explicit mention of tasks characteristics such as "difficult" / "complex" / "adaptive transfer" task in report (Code 1). Additionally, consult further task descriptions and examples (from method section of report) or original tasks (e.g., from appendix of report) to verify coding. For example, if the study author claims to have assessed performance in a difficult / complex / adaptive transfer task but after inspection of further task information this task appears structurally similar to or only slightly more difficult than training tasks, code as analogical transfer (Code 0). As another example, if the study author claims to have assessed performance in difficult / complex / adaptive transfer task but the testing task was identical to the training task except that it required solving the same tasks within a shorter time or more tasks in the same time as in training, code as analogical transfer (Code 0). In cases where no or too little information for a clear judgement is provided in the report (e.g., vague wordings such as "various tasks were to be solved by participants"), code as analogical transfer (Code 0) because it can be assumed that if there is no explicit mention of difficulty / complexity / adaptivity of tasks, the researchers have not deliberately attempted to construct distinctive transfer tasks for the testing phase but rather have used tasks that cover the material learned in training.

3a. / 3b. Clarity of task-inherent feedback

(Code 0) Less clear task-inherent feedback

(Code 1) Clear task-inherent feedback

Code separately for training and transfer task. In a second step, assign an overall code according to the following rules: If either training tasks or transfer tasks or both were coded 0, assign Code 0 as overall code. Assign overall Code 1 (clear task-inherent feedback) if both training and transfer tasks were rated Code 1.

This variable's purpose is to reflect whether the training and transfer task's feedback was informative to participants in the sense that the participants had the possibility to track the consequences of their actions during task engagement (e.g., an error or a successful action) and that the participants had the possibility to judge whether they have approached or achieved the (sub)goal to solve the (sub)task at hand. Note that there is hardly any task or system that provides no feedback at all (i.e., there is probably always some way to track one's action or to evaluate one's progress towards the goal). Thus, this coding is not designed to distinguish 'no feedback at all' from 'some kind of feedback'. Rather, it aims at differentiating clear and unequivocal feedback (Code 1) from feedback that is present but ambiguous or less informative than it could be (Code 0).

Look for information describing the training and the transfer task. Based on this information, try to imagine what kind of system responses participants (in most cases) received while they worked on the task. The following cues can be considered: Participants' actions were followed by visible (or in some other way perceptible) changes in the system (Code 1). For example, many computer programs are based on the WYSIWYG ("What You See Is What You Get") principle and therefore provide immediate visible system feedback that allows users to track the consequences of one's actions and to judge whether one's action promoted or hindered task completion. In other tasks, however, there may be immediate and visible feedback from a system that can not readily be interpreted (with regard to task completion) because for an adequate interpretation of the system feedback (e.g., to judge whether one's task solution was correct or not; to judge what information needs to be selected from all information provided in the system answer), further information or knowledge about the topic would be required from participants (Code 0). Also, participants may receive a summary feedback on success after they have finished a task but may not receive such feedback while working on the task (Code 0), or they may receive immediate feedback during training (Code 1 for training), but this feedback is removed during the test phase (Code 0 for test phase).

4. Comparison condition

(Code 0) Proceduralized / guided training

[(Code 1) Several conditions, both Code 0 and Code 2-trainings included in one study]

(Code 2) Explorative / unguided training

This variable's purpose is to describe the alternative training method that error management training was compared with in the respective study. Error management training may be defined as (1) a discovery or exploratory type of training (where participants – at least in major parts of the training – work on their own without guidance) that (2) also includes the presentation of error management instructions (introducing errors as positive events and encouraging participants to make errors and learn from them). Training conditions that have been compared to error management training (as defined here) shall be grouped into either proceduralized / guided trainings (Code 0) or explorative / unguided trainings (Code 2).

Proceduralized / guided trainings (Code 0) refer to training methods where participants are asked to follow a prescribed way while working on the training tasks. This prescription can be realized by means of (a) written instructions that participants of error management training in the same study do not receive (e.g., by detailed information on how to proceed or even by step-by-step instructions), by means of (b) tutorial devices (e.g., by tutorial disks that present tasks and solutions in a fixed order), and / or by (c) a trainer who watches the participant (who is initially working on his or her own) and immediately interrupts (and maybe even corrects) the participant's work if he or she deviates from the prescribed way of doing the task.

Some studies compare error management training with a training condition that the authors call error management training "without instructions / heuristics / error management strategies", where participants work on their own but where errors are not mentioned in any instructions. These training conditions should be coded as explorative / unguided trainings (Code 2) because despite the authors' naming as error management training, this type of training does not meet the second part of the definition of error management training outlined above (namely, the inclusion of error management instructions).

Explorative / unguided training (Code 2) does not necessarily imply that participants are explicitly encouraged to explore and discover solutions on their own. Rather, explorative / unguided training implies that there are practice phases in the course of the training where there is no trainer or where there are no written instructions that guide the participants but where they have to work on their own without further help, regardless of the instructions they receive (for example, to do their best, or simply no explicit instructions on how to work).

For training studies that include more than one alternative to error management training out of which some can be grouped to Code 0 and others to Code 2, Code 1 shall be given. In other words, Code 1 is not a mixture category for trainings that do not perfectly match the criteria for Code 2 (explorative / unguided) or Code 0 (proceduralized / guided). Rather, all studies must be categorized in either Code 0 or Code 2; only those studies comprising both Code 0 and Code 2 conditions in one study, shall be coded Code 1.

APPENDIX D: GERMAN SUMMARY [DEUTSCHE ZUSAMMENFASSUNG]

Überblick

1 EINLEITUNG UND THEORETISCHER HINTERGRUND

Fehler bei der Arbeit sind ein Ärgernis. Sie stören den Arbeitsablauf, sind frustrierend und können unter Umständen sogar fatale Konsequenzen nach sich ziehen, wie an prominenten Beispielen wie der Tschernobyl-Katastrophe deutlich wird. Dementsprechend verwundert es wenig, wenn die meisten Menschen versuchen, Fehler zu vermeiden. Eine ähnlich negative Sichtweise auf Fehler wird häufig auch bei der wissenschaftlichen Auseinandersetzung mit der Rolle von Fehlern beim Lernen eingenommen. Ein berühmter Vertreter dieser negativen Sichtweise ist Skinner (1953), für den ein Fehler nichts anderes als ein aversiver Stimulus darstellt, welcher zwar ein Verhalten zu hemmen vermag, aber keinesfalls dem Lernen dienlich sein kann. Eine ähnliche Sicht vertritt Bandura (1986), der sich für angeleitetes und fehlerfreies Training ausspricht und Fehler als nutzlos ansieht.

Allerdings sind Fehler ein ubiquitäres Phänomen; sie lassen sich niemals vollständig vermeiden, auch nicht durch jahrelange Erfahrung und Expertise (Prümper, Zapf, Brodbeck & Frese, 1992). Insbesondere beim Training sind Fehler kaum vermeidbar, sind doch Wissen und Fertigkeiten der Teilnehmer/innen noch nicht fertig ausgebildet (vgl. Heimbeck, Frese, Sonnentag & Keith, 2003). Die vorliegende Arbeit beschäftigt sich mit dem Fehlermanagement-Training, einer Trainingsform, die Fehler als etwas Positives im Lernprozeß ansieht und Fehler dementsprechend explizit ins Training einbezieht. In drei empirischen Untersuchungen werden Fragen zur Wirksamkeit des Fehlermanagement-Trainings, zu den psychologischen Prozessen, die dieser Wirksamkeit zugrunde liegen, sowie den Bedingungen, die die Effektivität des Trainings begünstigen bzw. vermindern, behandelt. Bei diesen Untersuchungen handelt es sich um zwei Trainingsexperimente (Untersuchungen I und II) und eine Meta-Analyse (Untersuchung III). Bevor diese vorgestellt werden, sollen zunächst das theoretische Konzept des Fehlermanagement-Trainings (Abschnitt 1.1) sowie die empirischen Befunde vorgestellt werden, die bisher aus diesem Bereich vorliegen (Abschnitt 1.2).

1.1 Das Konzept des Fehlermanagement-Trainings

Das Fehlermanagement-Training ist eine aktive Trainingsform. Dies beinhaltet, daß die Teilnehmer/innen nicht als passive Rezipienten von Unterricht, sondern als aktive Mitgestalter des Lernprozesses angesehen werden (Greif & Janikowski, 1987). Daher wird das Ausmaß an direkter Unterweisung auf ein Minimum reduziert, und die Teilnehmer/innen werden aufgefordert, sich die Aufgaben explorativ zu erarbeiten. In dieser Hinsicht ähnelt das Fehlermanagement-Training dem entdeckendem Lernen (Bruner, 1966), das ebenfalls die selbständige Exploration durch die Lerner/innen fördert. Das Fehlermanagement-Training rückt jedoch die Bedeutung des Fehlers im Lernprozeß deutlicher in den Vordergrund: Fehler werden als informative Rückmeldung angesehen, die der Aneignung von Wissen und Fertigkeiten nützlich sind (Frese & Zapf, 1994). Dementsprechend erhalten die Teilnehmer/innen eines Fehlermanagement-Trainings Instruktionen, in denen sie zum einen darauf hingewiesen werden, daß Fehler bei der Aufgabenbearbeitung zu erwarten sind, und in denen sie zum anderen dazu aufgefordert werden, die Fehler aktiv zu nutzen, um gezielt aus ihnen zu lernen und dadurch ihr Wissen über die Trainingsinhalte zu erweitern. Um möglichen Frustrationen durch Fehler während des Trainings vorzubeugen, werden diese Fehlermanagement-Instruktionen außerdem noch in Form von kurzen Aussagen zusammengefaßt und präsentiert, zum Beispiel "Fehler sind nichts Schlimmes, sondern ein natürlicher Bestandteil des Lernens!" oder "Hurra, ich habe einen Fehler gemacht! Jetzt kann ich etwas Neues lernen!" (Dormann & Frese, 1994; Frese et al., 1991; Wood, Kakebeeke, Debowski & Frese, 2000).

1.2 Bisherige Befunde zum Fehlermanagement-Training

In bisherigen Untersuchungen zum Fehlermanagement-Training wurde dieses insbesondere beim Erlernen von Computerprogrammen eingesetzt und dabei hinsichtlich der Wirksamkeit mit einem angeleiteten Fehlervermeidungstraining verglichen. Das Fehlervermeidungstraining ähnelt herkömmlichen Trainingsformen insofern, als daß den Teilnehmern/innen detaillierte Aufgabeninformationen an die Hand gegeben werden, die sie während der Bearbeitung Schritt für Schritt befolgen sollen. Damit wird angestrebt, daß die Aufgaben effizient und fehlerfrei gelöst (und damit gelernt) werden.

In zahlreichen Trainingsexperimenten hat sich das Fehlermanagement-Training dem Fehlervermeidungstraining gegenüber als überlegen gezeigt, und zwar bei mittleren bis schwierigen Aufgaben, die den Teilnehmern/innen beider Trainings im Anschluß an das Training vorgelegt wurden. Dieser Leistungseffekt zugunsten des Fehlermanagement-Trainings ließ sich vor allem bei Trainings zum Erlernen von Computerprogrammen replizieren (Chillarege, Nordstrom & Williams, 2003; Dormann & Frese, 1994; Frese, 1995, Frese et al., 1991; Heimbeck et al., 2003; Nordstrom, Wendland & Williams, 1998), zeigte sich aber auch bei elektronischen Rechercheaufgaben (Wood et al., 2000) sowie bei einem Training am Fahrsimulator (Ivancic & Hesketh, 2000).

Trotz der zahlreichen Befunde zur Wirksamkeit des Fehlermanagement-Trainings blieben in bisherigen Arbeiten einige zentrale Forschungsfragen weitgehend ungeklärt, darunter die Frage nach den psychologischen Prozessen, die der Wirksamkeit des Fehlermanagement-Trainings zugrundeliegen, sowie den Bedingungen, die die Wirksamkeit des Fehlermanagement-Trainings begünstigen bzw. einschränken. In den folgenden Kapiteln werden drei Untersuchungen vorgestellt, die diese (und weitere) offenen Forschungsfragen zum Thema hatten.

2 Emotionskontrolle und metakognitive Aktivität als Mediatoren von Leistungseffekten des Fehlermanagement-Trainings (Untersuchung I)

2.1 Fragestellung

Die vorliegende Untersuchung beschäftigte sich mit der Frage nach den der Wirksamkeit des Fehlermanagement-Trainings und den dieser Wirksamkeit zugrundeliegenden psychologischen Prozessen.

Zunächst einmal wurde angenommen, daß das Fehlermanagement-Training im Vergleich zum Fehlervermeidungstraining nicht alle Formen des Transfers gleichförmig begünstigt. Allgemein beinhaltet Transfer die Anwendung von Wissen und Fertigkeiten auf andere Aufgabeninhalte (Hesketh, 1997). Dabei lassen sich zumindest zwei Typen des Transfers unterscheiden: (1) *Analoger Transfer* bezieht sich auf Problemlösungen, die denen der Trainingsaufgaben ähnlich oder analog sind. *Adaptiver Transfer* hingegen beinhaltet die Anwendung des eigenen Wissens zur Veränderung einer gelernten Prozedur bzw. die Entwicklung einer neuen Lösung zu einer vollkommen neuartigen Aufgabe (Ivancic & Hesketh, 2000). Vom Fehlermanagement-Training wird nun erwartet, daß es insbesondere den adaptiven Transfer fördert, da die Teilnehmer/innen schon während des Trainings lernen, mit unerwarteten Problemen und Fehlern umzugehen, die in ähnlicher Weise auch während des adaptiven Transfers auftauchen werden. Bezüglich des analogen Transfer ist die Vorhersage weniger eindeutig zu treffen: Zwar fördert das Fehlermanagement-Training vermutlich ebenfalls den analogen Transfer, da durch Fehler der Abruf schon einmal verwendeter Lösungswege erleichtert wird (vgl. Ivancic & Hesketh, 2000). Jedoch kann auch ein Fehlervermeidungstraining den analogen Transfer begünstigen, da die Teilnehmer/innen nur die im Training eingeübten Schritte durchführen müssen. Demnach wäre ein Leistungsunterschied des Fehlermanagement-Trainings im Vergleich zum Fehlervermeidungstraining nur bei adaptiven, nicht jedoch bei analogen Transferaufgaben zu erwarten.

Weiterhin wurde angenommen, daß selbstregulatorische Prozesse die Wirksamkeit des Fehlermanagement-Trainings auf den adaptiven Transfer vermitteln. Selbstregulation beinhaltet solche Prozesse, die es Personen ermöglichen, das eigene zielgerichtete Verhalten über die Zeit hinweg zu steuern. Dies kann die Modulation des Denkens, des Affekts, des Verhaltens oder der Aufmerksamkeit einschließen (Karoly, 1993). Die vorliegende Arbeit betrachtet erstens die Regulation von negativen Emotionen, die als Folge von Fehlern auftreten können (Emotionskontrolle; Kanfer, Ackerman & Heggestad, 1996), als möglichen Mediator. Es wird angenommen, daß die Teilnehmer/innen des Fehlermanagement-Trainings (nicht jedoch die des Fehlervermeidungstrainings) während des Trainings lernen, mit möglichen negativen Emotionen umzugehen, und daß dies ihnen in der späteren Transferphase zugute kommt. Zweitens wird angenommen, daß das Fehlermanagement-Training (nicht jedoch das Fehlervermeidungstraining) die Entwicklung von metakognitiven Fertigkeiten zur Planung, Überwachung und Bewertung der eigenen kognitiven Aktivitäten (Brown, Bransford, Ferrara & Campione, 1983) während der Aufgabenbearbeitung fördert, weil Fehler die Aufmerksamkeit auf das eigenen Tun und Denken richten (Ivancic & Hesketh, 2000). Auch diese Form der Selbstregulation sollte den Teilnehmern/innen bei der späteren Bearbeitung von Transferaufgaben zugute kommen.

Schließlich hatte die vorliegende Untersuchung im Sinne einer offenen Forschungsfrage zum Ziel zu überprüfen, ob sich die Effektivität des Fehlermanagement-Trainings noch weiter steigern läßt, wenn es durch ein Modul zur gezielten Förderung der metakognitiven Aktivitäten erweitert wird.

Zusammenfassend wurden die folgenden Hypothesen bzw. offenen Forschungsfragen überprüft:

Hypothese 1: Fehlermanagement-Training führt zu besserem adaptiven Transfer als Fehlervermeidungstraining.

Hypothese 2: Emotionskontrolle mediiert den Effekt der Trainingsbedingung auf adaptiven Transfer insofern, als daß Fehlermanagement-Training zu höherer Emotionskontrolle führt und Emotionskontrolle den adaptiven Transfer positiv beeinflußt.

Hypothese 3: Metakognitive Aktivität mediiert den Effekt der Trainingsbedingung auf adaptiven Transfer insofern, als daß Fehlermanagement-Training zu höherer metakognitiver Aktivität führt und metakognitive Aktivität den adaptiven Transfer positiv beeinflußt.

Offene Forschungsfrage: Führt ein Fehlermanagement-Training mit zusätzlichen Metakognitionsinstruktionen zu verbessertem adaptiven Transfer?

2.2 Methode

Fünfundfünfzig Lehramtsstudenten/innen erlernten das Computerprogramm PowerPoint (in der Version 2000 für Windows) unter einer von drei Bedingungen, denen sie per Zufall zugeordnet wurden. (1) Im Fehlervermeidungstraining erhielten die Teilnehmer/innen genaue Anweisungen, wie die Trainingsaufgaben zu lösen sind. (2) Im Fehlermanagement-Training erhielten die Teilnehmer/innen keinerlei solche Anweisungen. Statt dessen wurden sie in kurzen schriftlichen Instruktionen dazu aufgefordert, die Aufgaben selbständig zu bearbeiten und die dabei auftretenden Fehler zum Lernen zu nutzen (Fehlermanagement-Instruktionen). (3) Die Teilnehmer/innen der dritten Gruppe (Fehlermanagement plus Metakognition) arbeiteten im ersten Teil des Trainings auf dieselbe Weise wie die zweite Gruppe, erhielten aber im zweiten Teil des Trainings zusätzliche Instruktionen (Metakognitionsinstruktionen), in denen sie dazu ermuntert wurden, durch Fragen, die sie sich gezielt selbst stellen und beantworten sollten, die metakognitive Aktivität zu erhöhen (vgl. King, 1991).

Zu Beginn des Trainings erhielten alle Teilnehmer/innen dasselbe zweiseitige Manual mit Informationen über das PowerPoint-Programm, in welchem der Aufbau (z.B. Menüleisten, Symbolleisten) sowie die Funktionsweise (z.B. Aktivieren von Funktionen, Markieren von Objekten) erläutert wurde. Außerdem wurde eine Übungsfolie unter Anleitung bearbeitet, bevor die experimentelle Manipulation stattfand. An das Training schloß sich eine Testphase an, in der sowohl ähnliche Aufgaben wie im Training (analoger Transfer) als auch schwierige und andersartige Aufgaben als im Training (adaptiver Transfer) selbständig zu bearbeiten waren.

Das Training fand in individuellen Sitzungen von jeweils etwa zweieinhalb Stunden statt (inklusive einer zehnminütigen Pause). Während des Trainings (nicht jedoch während der Testphase) waren die Teilnehmer/innen dazu aufgefordert, alles, was ihnen in den Sinn kam, laut auszusprechen (Methode des lauten Denkens). Die Aussagen der Teilnehmer/innen wurden aufgezeichnet und später zur Bildung eines Maßes zur metakognitiven Aktivität verwendet. Die Emotionskontrolle wurde anhand eines vorgetesteten selbstentwickelten Fragebogens (8 Items) erfaßt.

2.3 Ergebnisse

Hypothese 1 wurde gestützt: Bei adaptiven Transferaufgaben schnitt die Fehlermanagement-Gruppe besser ab als die Fehlervermeidungsgruppe, $F(2,49) = 4.34$, $p < .05$, $\eta^2 = .15$. Auch die Mediationsannahmen (Hypothesen 2 und 3) konnten gestützt werden: Emotionskontrolle und metakognitive Aktivität hingen sowohl mit der Trainingsbedingung als auch mit dem adaptiven Transfer zusammen, und der Effekt der Trainingsbedingung auf den adaptiven Transfer verschwand, wenn Emotionskontrolle und metakognitive Aktivität statistisch kontrolliert wurden. Die Ergebnisse des pfadanalytischen Mediationsmodells (Lisrel-Modell) sind in Abbildung 1 aufgeführt.

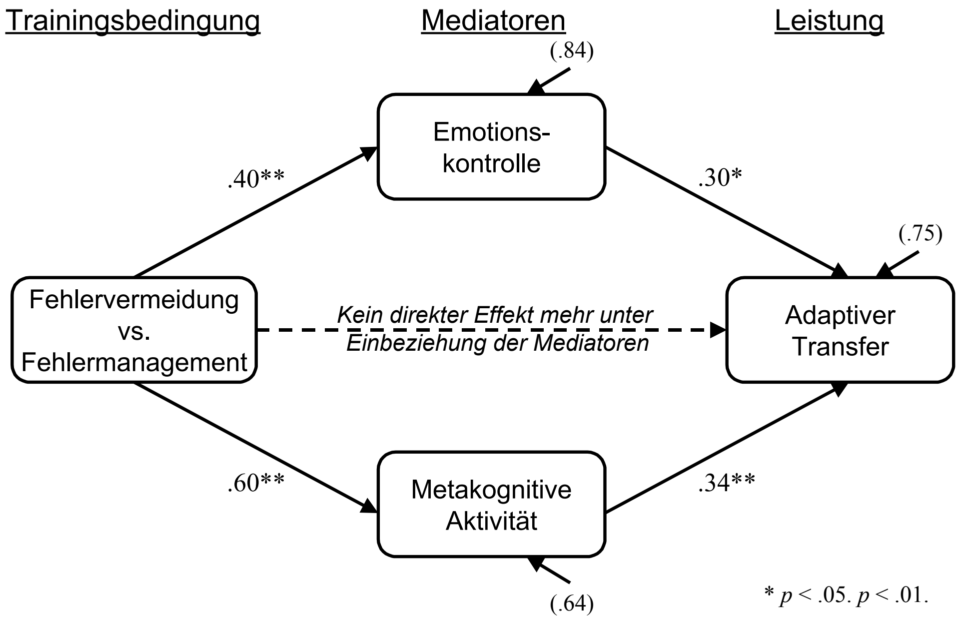


Abbildung 1. Emotionskontrolle und metakognitive Aktivität als Mediatoren des Effekts der Trainingsbedingung auf adaptiven Transfer (standardisierte Lösung in Pfadanalyse mit Lisrel).

Hinsichtlich der offenen Forschungsfrage zeigte sich keine Leistungsverbesserung des durch Metakognitionsinstruktionen erweiterten Fehlermanagement-Trainings gegenüber dem Fehlermanagement-Training ohne diesen zusätzlichen Instruktionen, $F(1,49) = 1.28$, $p = .26$.

2.4 Diskussion

Die Ergebnisse zeigen, daß das Fehlermanagement-Training gegenüber dem Fehlervermeidungstraining die Emotionskontrolle und die metakognitive Aktivität zu steigern vermag und daß diese selbstregulatorischen Prozesse für die Wirksamkeit des Fehlermanagement-Trainings ausschlaggebend sind. Damit konnte diese Untersuchung einen wesentlichen Wirkmechanismus aufdecken, was in vorherigen Untersuchungen zum Fehlermanagement-Training (sofern sie sich überhaupt damit befaßt haben) nicht in zufriedenstellender Weise gelungen ist (z.B. Wood et al., 2000). Diese Arbeit trägt zum besseren theoretischen Verständnis der Wirksamkeit des Fehlermanagement-

Trainings bei. Auch in praktischer Hinsicht ist dies wichtig, da eine Trainingsmaßnahme nur dann effektiv verbessert werden kann, wenn die zugrundeliegenden Prozesse bekannt sind.

Kritisch läßt sich anmerken, daß die Teilnehmer/innen des Trainings durch das laute Denken möglicherweise in ihrer normalen Informationsverarbeitung gestört worden sind und insofern die Methode des lauten Denkens keine validen Messungen der relevanten Prozesse geliefert haben könnte. Dies erscheint jedoch unwahrscheinlich, da die in dieser Untersuchung ermittelte Leistungsüberlegenheit des Fehlermanagement-Trainings gegenüber dem Fehlervermeidungstraining (im Sinne der Effektgröße) derjenigen vorheriger Untersuchung entspricht. Sollten die Prozesse nicht valide erhoben worden sein, würde dies bedeuteten, daß die vorliegende Untersuchung zwar ähnliche Effekte erbracht hat, diese aber auf andere Prozesse als in anderen Untersuchungen zurückzuführen sind – eine Annahme, die wenig plausibel erscheint.

Offen bleibt in dieser Untersuchung, wie die beiden vermittelnden Prozesse (Emotionskontrolle und metakognitive Aktivität) miteinander interagieren bzw. ob der eine Prozeß dem anderen vorgeschaltet sein muß, um seine Wirksamkeit entfalten zu können. Außerdem könnte in zukünftigen Untersuchungen überprüft werden, welche Arten von Fehlern für das Lernen besonders förderlich sind, da davon auszugehen ist, daß nicht alle Fehler gleich informativ und damit potentiell nützlich für das Lernen sind.

3 Fehlermanagement-Training als Moderator der Beziehung zwischen kognitiven Fähigkeiten und Leistung (Untersuchung II)

3.1 Fragestellung

Wie die erste Untersuchung dieser Dissertation (vgl. Kap. 2) beschäftigte sich auch die zweite mit den psychologischen Prozessen während des Fehlermanagement-Trainings, jedoch in einer weniger direkten Weise. Das Hauptargument in dieser

Untersuchung war, daß die psychologischen Prozesse, die im Fehlermanagement-Training ablaufen, denjenigen während der Transferphase ähneln und daß daher im Fehlermanagement-Training die Ressourcenabhängigkeit gemindert sein sollte. Unter Ressourcen werden hier kognitive Fähigkeiten verstanden, deren prädiktive Kraft für die Vorhersage von Trainingsleistung sowie der Arbeitsleistung über verschiedene Berufsgruppen hinweg als gesichert gilt (z.B. Hunter & Hunter, 1984; Ree & Earles, 1991; Ree, Carretta & Steindl, 2001; Salgado et al., 2003; Schmidt & Hunter, 1998). Gleichzeitig gibt es empirische Hinweise darauf, daß die prädiktive Validität von Fähigkeitsmaßen über die Zeit, sei es innerhalb weniger Minuten während einer experimentellen Untersuchung oder über mehrere Jahre hinweg, abnimmt (Henry & Hulin, 1987; Henry & Hulin, 1989). Demnach sind Fähigkeitsmaße besser zur Vorhersage zeitlich nahe liegender als zeitlich weiter entfernt liegender Leistung geeignet. Dieses Phänomen läßt sich im Rahmen der Ressourcen-Theorie von Kanfer und Ackerman (1989) erklären: Zu Beginn des Fertigkeitserwerbs werden die kognitiven Ressourcen stärker in Anspruch genommen als in späteren Phasen, in denen einige Aufgabenstrategien bereits routinisiert werden können (vgl. auch Hacker, 1998). Dementsprechend sind kognitive Fähigkeiten besonders für die Leistung in frühen Phasen prädiktiv, während die Prädiktionskraft mit Fortschreiten der Zeit bzw. des Fertigkeitserwerbs nachläßt. Die vorliegende Arbeit nimmt nun an, daß diese Minderung der Prädiktionskraft durch das Fehlermanagement-Training beschleunigt wird. Zwar nimmt das eigentliche Training kognitive Ressourcen in Anspruch, weil zugleich die Aufgabe sowie der Umgang mit Fehlern gelernt werden müssen. In der Transferphase aber, die dem Fehlermanagement-Training insofern ähnelt, als daß auch hier Fehler passieren und keine externe Hilfe zu erwarten ist, sinkt dann die Anforderung an die Ressourcen. Im Fehlervermeidungstraining jedoch beinhaltet die Transferphase neue Anforderungen, weil die Teilnehmer/innen während des Trainings nicht die Gelegenheit hatten, den Umgang mit Fehlern einzuüben. Im statistischen Sinne impliziert diese Vorhersage eine Interaktion von Trainingsbedingung und kognitiven Fähigkeiten: Das Fehlermanagement-Training moderiert gleichsam die Beziehung zwischen kognitiven Fähigkeiten und der Leistung.

Weiterhin wurde auch in Untersuchung II (wie in Untersuchung I) zwischen der Leistung bei Transferaufgaben mit Inhalten, die denen des Trainings ähnlich sind (analoger Transfer), und mit neuartigen Inhalten (adaptiver Transfer) unterschieden. Des weiteren wurde hier auch zwischen der Leistung während des Trainings und der Transferphase unterschieden. Es wurde erwartet, daß die Teilnehmer/innen des Fehlervermeidungstrainings während des Trainings eine höhere Leistung zeigen (da sie genaue Aufgabeninformationen zur Lösung der Trainingsaufgaben bekommen), daß sich dieser Effekt (wie in Untersuchung I) bei analogen Transferaufgaben aber ausgleicht und bei adaptiven Transferaufgaben sogar zugunsten des Fehlermanagement-Trainings umkehrt.

Zusammenfassend wurden folgende Annahmen überprüft:

Hypothese 1a: Fehlervermeidungstraining führt zu besserer Leistung im Training als Fehlermanagement-Training.

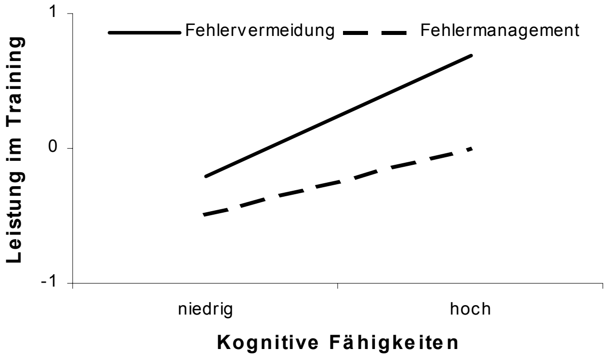
Hypothese 1b: Fehlervermeidungstraining und Fehlermanagement-Training führen zu gleicher Leistung bei analogen Transferaufgaben.

Hypothese 1c: Fehlermanagement-Training führt zu besserer Leistung als Fehlervermeidungstraining bei adaptiven Transferaufgaben.

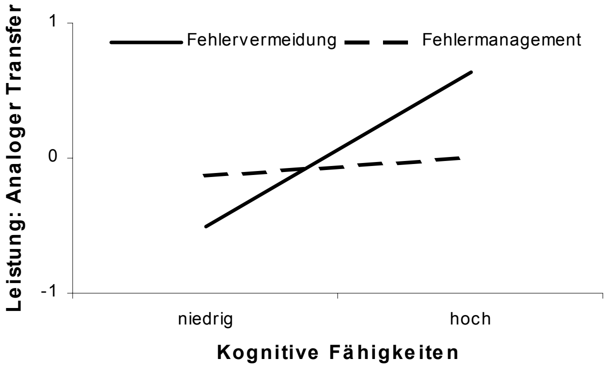
Hypothese 2a: Kognitive Fähigkeiten beeinflussen die Leistung im Training positiv (Haupteffekt von kognitiven Fähigkeiten).

Hypothese 2b: Kognitive Fähigkeiten beeinflussen die Leistung bei analogen Transferaufgaben in der Gruppe mit Fehlervermeidungstraining; in der Gruppe mit Fehlermanagement-Training ist dieser Effekt vermindert (Interaktion von kognitiven Fähigkeiten und Trainingsbedingung).

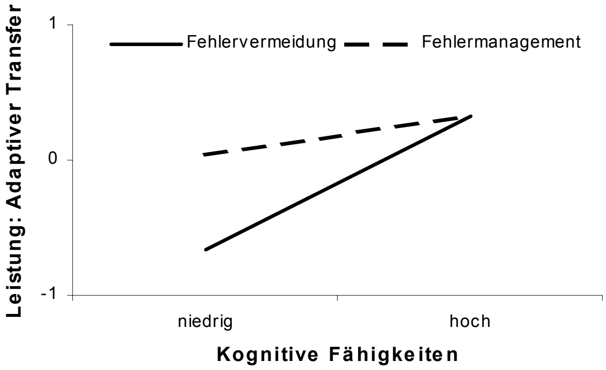
Hypothese 2c: Kognitive Fähigkeiten beeinflussen die Leistung bei adaptiven Transferaufgaben in der Gruppe mit Fehlervermeidungstraining; in der Gruppe mit Fehlermanagement-Training ist dieser Effekt vermindert (Interaktion von kognitiven Fähigkeiten und Trainingsbedingung).



(a) Haupteffekt der Trainingsbedingung und der kognitiven Fähigkeiten auf die Leistung während des Trainings (kein Interaktionseffekt).



(b) Interaktion von Trainingsbedingung und kognitiven Fähigkeiten auf analogen Transfer (kein Haupteffekt der Trainingsbedingung).



(c) Haupteffekt der Trainingsbedingung und Interaktion von Trainingsbedingung und kognitiven Fähigkeiten auf adaptiven Transfer.

Abbildung 2. Haupteffekte und Interaktionen von Trainingsbedingung und kognitiven Fähigkeiten auf die Leistung während des Trainings (a), beim analogen Transfer (b) und beim adaptiven Transfer (c).

3.2 Methode

An dem Trainingsexperiment nahmen 110 Studenten/innen verschiedener Fachrichtungen teil, die das Computerprogramm PowerPoint (vgl. Untersuchung I) unter einer von zwei Bedingungen erlernten: Im Fehlervermeidungstraining erhielten die Teilnehmer/innen genaue Anweisungen zur Aufgabenlösung, während die Teilnehmer/innen des Fehlermanagement-Trainings die Trainingsaufgaben selbständig bearbeiteten. Das Material sowie der Untersuchungsablauf war denen aus Untersuchung I analog (vgl. Abschnitt 2.2). Die Sitzungen wurden allerdings nicht individuell, sondern in kleinen Gruppen und ohne Verwendung der Methode des lauten Denkens durchgeführt. Außerdem wurden jeweils am Anfang der Sitzung die kognitiven Fähigkeiten der Teilnehmer/innen anhand des Zahlen-Verbindungs-Tests (Oswald & Roth, 1987) erfaßt.

3.3 Ergebnisse

Sowohl die Ergebnisse zum Haupteffekt der Trainingsbedingung auf die Leistungsmaße im Training, dem analogen und dem adaptiven Transfer (Hypothesen 1a, 1b und 1c) also auch zur Interaktion der kognitiven Fähigkeiten und der Trainingsbedingung (Hypothese 2a, 2b und 2c) konnten gestützt werden. Die Ergebnisse sind in Abbildung 2 visualisiert. Wie ersichtlich, war im Hinblick auf die Leistung bei adaptiven Transferaufgaben die Trainingsbedingung für Personen mit hohen kognitiven Fähigkeiten nicht ausschlaggebend. Bei Personen mit niedrigerer Ausprägung in kognitiven Fähigkeiten jedoch zeigte sich eine Leistungsüberlegenheit zugunsten des Fehlermanagement-Trainings.

3.4 Diskussion

Die Ergebnisse von Untersuchung II zeigen auf, wie wichtig es ist, zwischen Trainings- und Transferleistung zu unterscheiden. Dies ist keineswegs eine triviale Unterscheidung, wird sie doch in einigen Arbeiten zum Fehlermanagement-Training nicht getroffen (z.B. Gully, Payne, Koles & Whiteman, 2002). Wie die vorliegenden Ergebnisse zeigen, kann eine Vernachlässigung dieser Unterscheidung zu irreführenden Ergebnissen verleiten, etwa der, daß das Fehlervermeidungstraining zu besserer

Leistung führe, wie es in dieser Untersuchung lediglich für die Leistung während des Trainings, nicht aber für Transferaufgaben der Fall war. Des weiteren legen die Ergebnisse nahe, daß das Fehlermanagement-Training ungeachtet der jeweiligen Ausprägung der kognitiven Fähigkeiten der Teilnehmer/innen nützlich für die erfolgreiche Bewältigung adaptiver Transferaufgaben sein kann.

In theoretischer Hinsicht sind die Ergebnisse aufschlußreich, da sie Hinweise über die beim Training ablaufenden kognitiven Prozesse bzw. der Ressourcenabhängigkeit im Verlaufe des Trainings liefern. Zukünftige Untersuchungen, die auf eine direktere Erfassung der Ressourcenabhängigkeit beim Fehlermanagement-Training abzielen, könnten sich des Doppelaufgaben-Paradigmas bedienen. Beispielsweise wäre es möglich, daß die Aneignung von Aufgabenstrategien im Training erschwert und damit der Abfall der prädiktiven Validität (d.h. der Ressourcenabhängigkeit) durch die Bearbeitung einer Zweitaufgabe verlangsamt wird. Außerdem könnte die Hinzunahme von mehreren Leistungsdurchgängen (statt wie hier nur einer einzigen Trainings- und Transferphase) eine detailliertere Verlaufsanalyse ermöglichen.

4 LEISTUNGSEFFEKTE DES FEHLERMANAGEMENT-TRAININGS: EINE META-ANALYSE (UNTERSUCHUNG III)

4.1 Fragestellung

Die Untersuchungen I und II (Kap. 2 und 3) haben sich bereits mit Leistungseffekten des Fehlermanagement-Trainings befaßt. Die vorliegende Untersuchung III hatte zum Ziel, diese Effekte auf eine breitere Basis zu stellen. Außerdem sollten die Bedingungen näher betrachtet werden, die die Effektivität des Fehlermanagement-Trainings fördern bzw. mindern. Dazu wurde eine Meta-Analyse unter Einbeziehung aller bisher vorliegenden Befunde zur Effektivität des Fehlermanagement-Trainings durchgeführt. Auf dieser Grundlage sollte zum einen eine Schätzung für den Gesamteffekt des Fehlermanagement-Trainings vorgenommen werden. Zum anderen wurden verschiedene Untersuchungsmerkmale betrachtet, die diesen Gesamteffekt in seiner Höhe beeinflussen könnte, mit anderen Worten also als Moderatoren des Effekts fungieren könnten.

Zunächst wurde erwartet, daß sich über alle Untersuchungen hinweg ein positiver Effekt des Fehlermanagement-Trainings zeigen würde. Weiterhin wurde erwartet, daß die Evaluationsphase, d.h. ob die Leistungserfassung während des Trainings oder während einer Testphase stattfand, den Effekt moderiert. Wie bereits in Kapitel 3 ausgeführt, ist es während des Trainings möglich, daß die Teilnehmer/innen des Fehlervermeidungstrainings besser abschneiden, da ihnen detaillierte Aufgabenlösungen zur Verfügung stehen. Dieser Effekt sollte sich aber bei Testaufgaben umkehren, da diese Hilfen dort wegfallen; hier sollte der Vorteil zugunsten des Fehlermanagement-Trainings ausfallen. Weiterhin wurde auch in Untersuchung III zwischen analogem und adaptivem Transfer unterschieden und erwartet, daß der Leistungseffekt zugunsten des Fehlermanagement-Trainings bei adaptivem Transfer deutlicher ausfallen dürfte. Außerdem wurde der Informationsgehalt des aufgabenimmanenten Feedbacks als potentieller Moderator angesehen, denn nur dann, wenn die Aufgabe Rückschlüsse über die Folgen des eigenen Tuns liefert sowie die Entdeckung und anschließende Behebung von Fehlern ermöglicht, kann es auch einen positiven Effekt des Fehlermachens im Fehlermanagement-Training geben (vgl. Frese & Zapf, 1994). Schließlich wurde erwartet, daß die Vergleichsgruppe den Effekt des Fehlermanagement-Trainings moderiert. Viele Untersuchungen zum Fehlermanagement-Training haben dieses hinsichtlich der Effektivität mit einem Fehlervermeidungstraining verglichen, welches sich hinsichtlich zweier Aspekte vom Fehlermanagement-Training unterscheidet, nämlich erstens darin, daß keine Fehlermanagement-Instruktionen (positive Aussagen zur Rolle von Fehlern beim Lernen; vgl. Abschnitt 1.1) gegeben werden, und zweitens in der detaillierten Aufgabenanleitung. In einigen Untersuchungen aber wurde das Fehlermanagement-Training mit explorativen Trainingsformen verglichen, die sich nur in einer Hinsicht vom Fehlermanagement-Training unterschieden, nämlich darin, daß sie keine Fehlermanagement-Instruktionen enthielten. Dementsprechend wurde beim Vergleich mit explorativen Trainings ein geringerer Effekt zugunsten des Fehlermanagement-Trainings erwartet als beim Vergleich mit Fehlervermeidungstrainings.

Zusammenfassend wurden folgende Hypothesen überprüft:

Hypothese 1: Fehlermanagement-Training hat einen insgesamt positiven Effekt auf die Leistung.

Hypothese 2: Die Evaluationsphase moderiert die Effektivität des Fehlermanagement-Trainings. In Untersuchungen, in denen die Leistung in der Testphase erfaßt wurden, zeigen sich höhere Effekte als in solchen, in denen die Leistung im Training erfaßt wurden.

Hypothese 3: Die Adaptivität der Transferaufgabe moderiert die Effektivität des Fehlermanagement-Trainings. In Untersuchungen, in denen die Leistung bei adaptiven Transferaufgaben erfaßt wurden, zeigen sich höhere Effekte als in solchen, in denen die Leistung bei analogen Transferaufgaben erfaßt wurden.

Hypothese 4: Die Klarheit des aufgabenimmanenten Feedbacks moderiert die Effektivität des Fehlermanagement-Trainings. In Untersuchungen, in denen Aufgaben mit klarem Feedback verwendet wurden, zeigen sich höhere Effekte als in solchen, in denen Aufgaben mit weniger klarem Feedback verwendet wurden.

Hypothese 5: Die Art der Vergleichgruppe moderiert die Effektivität des Fehlermanagement-Trainings. In Untersuchungen, in denen das Fehlermanagement-Training mit Fehlervermeidungstraining verglichen wurde, zeigen sich höhere Effekte als in solchen, in denen es mit explorativen Trainings (ohne Fehlermanagement-Instruktionen) verglichen wurde.

4.2 Methode

Auf der Basis einer umfassenden Literaturrecherche in gängigen psychologischen Datenbanken, der Sichtung der jeweiligen Literaturverzeichnisse der aufgefundenen Arbeiten sowie der Antworten auf Anschreiben zu den Erstautoren/innen der aufgefundenen Arbeiten wurden (veröffentlichte oder unveröffentlichte) Untersuchungen zusammengestellt, in denen eine Fehlermanagement-Trainingsbedingung mit einer oder mehreren alternativen Trainingsbedingungen hinsichtlich der Wirksamkeit auf die Leistung verglichen wurde. Als Fehlermanagement-Training wurden nur solche Trainings betrachtet, die die folgenden beiden Kriterien erfüllten: (1) Die Teilnehmer/innen erhielten ein Training, bei dem sie dazu aufgefordert wurden, sich die Trainingsaufgaben selbständig zu erarbeiten, und bei dem dementsprechend Fehler bei der Aufgabenbearbeitung zu erwarten waren. (2) Die Teilnehmer/innen erhielten Instruktionen, in denen die positive Funktion von Fehlern betont wurde und in denen die Teilnehmer/innen explizit dazu aufgefordert wurden, Fehler zu machen und aus ihnen zu lernen. Auf diese Weise wurden 23 Untersuchungen mit insgesamt 1981 Untersuchungsteilnehmern/innen aufgefunden, die in die Meta-Analyse eingingen.

Entsprechend der Moderatorhypothesen wurden vier Untersuchungsmerkmale (Evaluationsphase, Adaptivität, Klarheit des Feedbacks und Vergleichsbedingung) kodiert. Die Urteilerübereinstimmung fiel dabei durchgehend zufriedenstellend bis sehr gut aus.

4.3 Ergebnisse

Entsprechend Hypothese 1 zeigte sich über alle 23 Untersuchungen hinweg eine positive mittlere Effektgröße von 0.44 (Cohens *d*). Auch die Moderatorhypothesen konnten weitgehend gestützt werden. Demnach erhöhte sich der Effekt bei Untersuchungen, in denen die Testleistung (statt der Trainingsleistung) erfaßt wurde, sowie bei Untersuchungen, in denen die Testaufgaben adaptiven (statt analogen) Transfer beinhalteten. Außerdem war der Effekt zwar bei solchen Untersuchungen größer, die ein angeleitetes Fehlervermeidungstraining als Vergleichsgruppe hatten; der Effekt blieb aber auch bei den Untersuchungen signifikant, in denen das Fehlermanagement-Training mit einem explorativen Training (ohne Fehlermanagement-Instruktionen) verglichen wurde. Lediglich bei der Variable zur Klarheit des Feedbacks ergaben sich uneindeutige Befunde: Einerseits ließ sich im direkten Test kein signifikanter Moderatoreffekt auffinden; andererseits war die mittlere Effektgröße nur bei derjenigen Subgruppe von Untersuchungen signifikant, die Aufgaben mit klarem Feedback verwendet hatte.

4.4 Diskussion

Die vorliegende Meta-Analyse zeigt auf, daß es sich beim Fehlermanagement-Training um eine insgesamt effektive Trainingsform handelt. Zudem liefern die Ergebnisse der Moderatoranalysen wertvolle Hinweise darauf, welche Faktoren bei der Trainingsplanung und -durchführung des Trainings zu beachten sind, um die Wirksamkeit sicherzustellen. Demnach sollte das Fehlermanagement-Training insbesondere dann zum Einsatz kommen, wenn nicht das Erlernen einer spezifischen Prozedur oder Verhaltensweise das Ziel ist (analoger Transfer), sondern die Entwicklung von Fertigkeiten zur selbständigen Lösung neuartiger Aufgaben (adaptiver Transfer). Weiterhin zeigte sich erwartungsgemäß, daß das Fehlermanagement-Training nicht die unmittelbare Trainingsleistung erhöht – ein Umstand, der bei der praktischen Durchführung und der theoretischen Bewertung des Trainings zu beachten ist, denn man sollte aus einer eingeschränkten Trainingsleistung (die dadurch zustande kommt, daß die Teilnehmer/innen selbständig arbeiten und dabei Fehler machen) nicht fälschlicherweise zu dem Schluß kommen, daß die Teilnehmer/innen nichts lernten und das Training daher nicht effektiv sei.

Ein großer Vorteil der Meta-Analyse ist, daß sie sich auf eine breite Datenbasis stützt und damit Schlüsse zuläßt, die über diejenigen aus Einzeluntersuchungen hinausgehen. Hinsichtlich der Moderatoranalysen ergibt sich jedoch ein Nachteil dadurch, daß die Meta-Analyse ein *post hoc*-Analyseinstrument darstellt: Zwar kann im Falle eines signifikanten Moderationseffekts darauf geschlossen, daß die Effektgröße mit dem Moderator kovariiert. Ob es sich aber tatsächlich um einen Moderator*effekt* im Sinne einer kausalen Beeinflussung handelt, läßt sich in diesem Rahmen nicht überprüfen, da es eine Reihe möglicher Drittvariablen gibt, die mit dem jeweiligen Moderator konfundiert sind und möglicherweise die eigentliche kausale Einflußgröße darstellen. Diese Kausalitätsannahme ließe sich nicht mit der Meta-Analyse, sondern nur experimentell überprüfen.

5 ABSCHLIEßENDE BEMERKUNGEN

Die vorliegende Dissertation beschäftigte sich mit dem Fehlermanagement-Training, einer aktiven Trainingsform, in der Fehler – anders als in den meisten traditionellen Trainingsformen – explizit mit einbezogen werden. In drei empirischen Untersuchungen wurde der Frage nach der Wirksamkeit des Fehlermanagement-Trainings, nach den psychologischen Prozessen, die ihr zugrundeliegen, sowie nach den Bedingungen, die die Wirksamkeit begünstigen oder vermindern, nachgegangen. Dabei bedienten sich diese drei Untersuchungen komplementärer Forschungsansätze. Die erste Untersuchung (Kap. 2) war ein Trainingsexperiment, das eher mikroanalytisch ausgerichtet war: In individuellen Trainingssitzungen waren die Teilnehmer/innen dazu aufgefordert, ihre Gedanken laut zu äußern (Methode des lauten Denkens). Anschließend wurden ihre Aussagen zur Erfassung der theoretisch interessierenden Prozesse verwendet. Untersuchung II (Kap. 3) war ebenfalls ein Trainingsexperiment, hatte jedoch die Interaktion von Trainingsbedingung und kognitiven Fähigkeiten zum Thema. Entsprechend dieser Fragestellung wurde zur Erhöhung der statistischen Test-stärke eine größere Personenstichprobe verwendet. Die dritte Untersuchung schließlich (Kap. 4) war eine Meta-Analyse, in die alle verfügbaren Untersuchungen Eingang fanden, in denen das Fehlermanagement-Training mit einer alternativen Trainings-methode verglichen wurde.

Die drei Untersuchungen erweitern die bisherige Forschung zum Fehler-management-Training in vielerlei Hinsicht. Untersuchung I trägt zum besseren Verständnis der psychologischen Prozesse bei, die für die Wirksamkeit des Fehler-management-Trainings verantwortlich sind. Die Frage nach den Wirkprozessen wurde zwar auch in wenigen vorherigen Untersuchungen aufgegriffen. Diese kamen jedoch zu wenig schlüssigen Ergebnissen (Debowski, Wood & Bandura, 2001; Wood et al., 2000). Untersuchung II liefert einen wichtigen Beitrag zur Frage nach dem Einfluß von kognitiven Fähigkeiten im Fehlermanagement-Training, eine Frage, die bisher ebenfalls nur selten untersucht wurde. Die Meta-Analyse (Untersuchung III) schließlich erlaubt weitreichendere Schlüsse als die bisher vorliegenden Einzeluntersuchungen, da sie von Schwächen oder Besonderheiten dieser zu abstrahieren vermag. Insgesamt zeigen die drei Untersuchungen auf, daß das Fehlermanagement-Training eine wirksame Methode zur Förderung der Leistung bei neuartigen Aufgaben darstellt. Die Ergebnisse legen nahe, daß das Fehlermanagement-Training, oder zumindest Elemente davon, gewinnbringend in Trainingsmaßnahmen eingebaut werden könnten. Indirekt ist damit auch die in der Trainingsforschung häufig vertretene Ansicht widerlegt, daß Fehler beim Lernen störend oder gar schädlich seien und daher tunlichst vermieden werden sollten.

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Erklärung

Ich erkläre: Ich habe die vorgelegte Dissertation selbständig und nur mit den Hilfen angefertigt, die ich in der Dissertation angegeben habe. Alle Textstellen, die wörtlich oder sinngemäß aus veröffentlichten oder nicht veröffentlichten Schriften entnommen sind, und alle Angaben, die auf mündlichen Auskünften beruhen, sind als solche kenntlich gemacht.

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