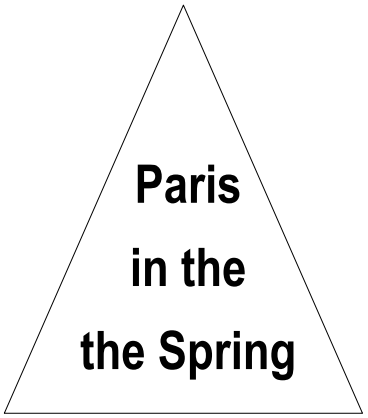


Learning from Errors by Individuals and Organizations

Michael Frese

Univ. of Giessen and London Business School

Talk at APS, Chicago, May 08

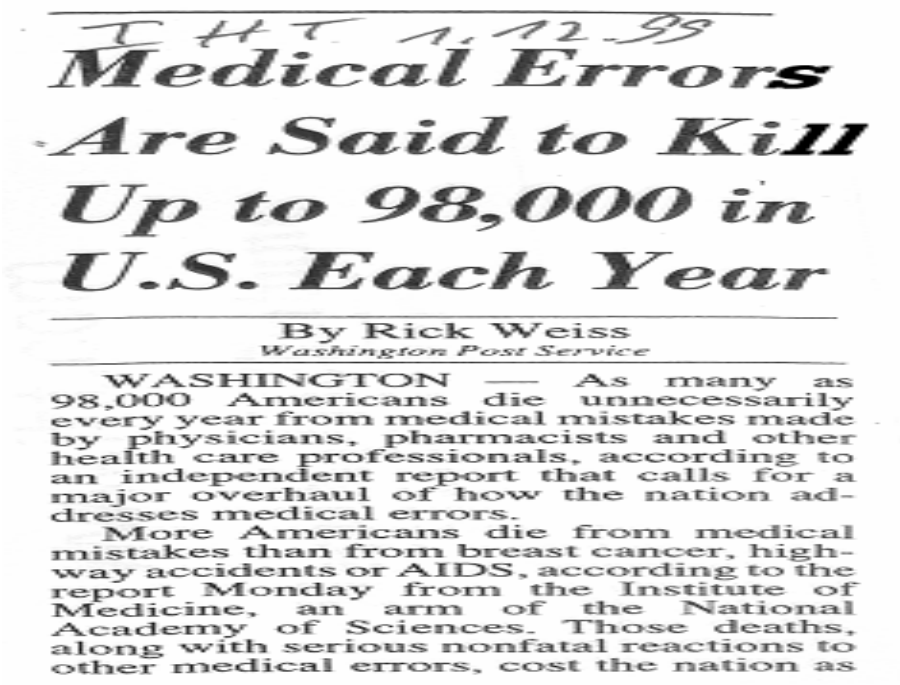
"Experience is simply the name we give our mistakes." **Oscar Wilde**

Outline

1) Action errors – why interesting and the concept
2) Error prevention and Error Management
3) Error Management in training
4) Error Management culture and organizational performance

Errors Have a Bad Name

- We are ashamed of errors
- It is the opposite of good performance: Industry wants "zero errors"
- Cognitive experiments often use number of errors as a measure of bad performance
- And indeed: Errors are the raw material of accidents, catastrophes, quality problems
- They are also stressful and time consuming
- Biases, bad judgments, etc. are based on errors



IHT 1.12.99

Medical Errors Are Said to Kill Up to 98,000 in U.S. Each Year

By Rick Weiss
Washington Post Service

WASHINGTON — As many as 98,000 Americans die unnecessarily every year from medical mistakes made by physicians, pharmacists and other health care professionals, according to an independent report that calls for a major overhaul of how the nation addresses medical errors.

More Americans die from medical mistakes than from breast cancer, highway accidents or AIDS, according to the report Monday from the Institute of Medicine, an arm of the National Academy of Sciences. Those deaths, along with serious nonfatal reactions to other medical errors, cost the nation as

Why are Errors Interesting

- But there are also alternative viewpoints: Learning as a result of errors
- Innovation
- Science: Windows to the mind (Freud)
- Culture development (Festinger)
- Ideological debate in work design: Taylorism and error prevention (reduction of complexity and exact prescription of one best way) vs. alternatives
- My argument today: Errors important for Learning: Structuring learning processes so that errors can lead to learning

Concept of Errors

- Not reaching goal
- "Should have known better"- feeling
- Unintended
- Difference to **inefficiency**: Error when standards of efficiency, not error when no standard
- Difference to **violation**: Intended behavior
- Difference to **fault in a machine or software**: Manifestation of an error that has been badly managed

Outline

1) Action errors – why interesting and the concept
2) Error prevention and Error Management
3) Error Management in training
4) Error Management culture and organizational performance

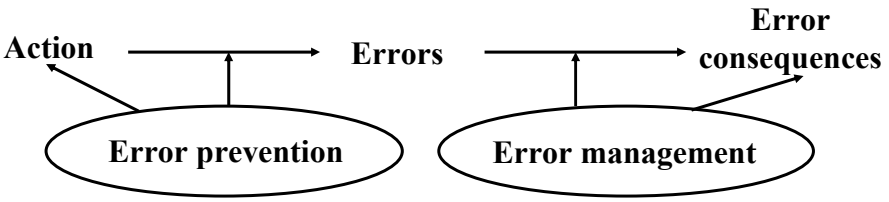
Error Prevention as Natural Response – Error Management as Complement -1-

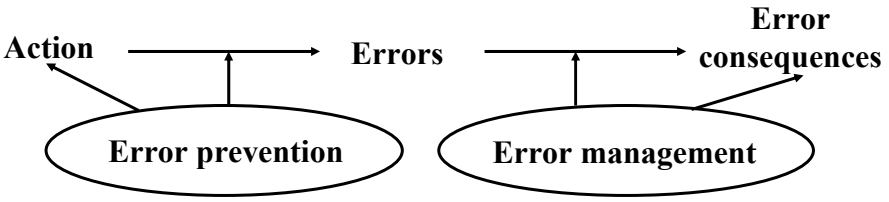
Natural response is error prevention, because of

- attributional bias (if we see somebody making an error, we think it is his fault),
- knew-it-all-along effect ("I could have told you that this would not work well – you should have asked me"),
- performance orientation (an error is a sign of bad performance)

Error Prevention as Natural Response – Error Management as Complement -2-

- Natural response: Minimization of errors under any circumstances
  - o Example: Reduction of user errors in a computer software by user guidance
  - o Example: Reduction of errors to increase quality of products – zero error products
- **Complement** to prevention: Error Management





Error management: Dealing with errors with the goals of

- Avoiding negative error consequences
- Quick damage control (quick detection, quick correction)
- Reducing error cascades
- Reducing the occurrence of this error in the future (secondary error prevention)

Error Management Devices

- Error discovery (reduction of error detection time):
  - Transparency of system
  - Feedback
  - Organizational defenses: e.g., second person intervening (airplanes – cockpit crew training)
- Good error explanation:
  - Context specific help
  - Memory aids
- Error recovery:
  - UNDO
  - Going to a known point
- Make a system learnable:
  - Consistency, learnability of system, simulator training

Why Error Management

- Errors are ubiquitous
- Error prevention has limitations
- Error management can be made useful in training

Error Ubiquitous

- Number of errors in driving a new car: 10/h (Heinbokel & Frese, 1992)
- Errors in using a new washing machine: 60/h (Prümper, Heinbokel, Rohs, 1990)
- Number of faults per 1000 lines of code of software: ca 50 (estimate by Jones, 1987)
- Number of errors of experienced users, doing four spreadsheet tasks (44 minutes): 35/h;
- Unnecessary cursor movements: 18/h (Floyd & Pyun, 1987)
- Number of errors dealing with computers: ca 4/h (not counting mistyping) (Frese, 1991)
- Computer experts: 5.83 vs. non-experts: 3.87/h (Prümper et al., 1992)

Frese's Law of Error Frequency

You make approximately

3 to 4 errors per hour

on every task that you are working on

The Limitations of Error Prevention

- Increase of complexity
- Expectation effects:
  - Reduced expectancy of errors
  - No acceptance of errors
  - Cover up
  - Little learning
- Action to deal with errors not trained and rehearsed

Outline

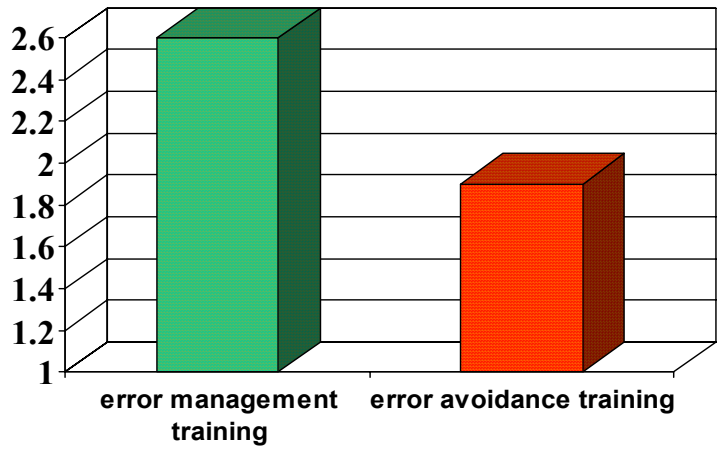
1) Action errors – why interesting and the concept
2) Error prevention and Error Management
3) Error Management in training
4) Error Management culture and organizational performance

Error Management Instructions (Heuristics)

- I have made an error: Great
- There is always a way out of any error situation
- The more errors you make, the more you learn
- Errors are a natural part of the learning process! They inform you what you are still able to learn

APS 08

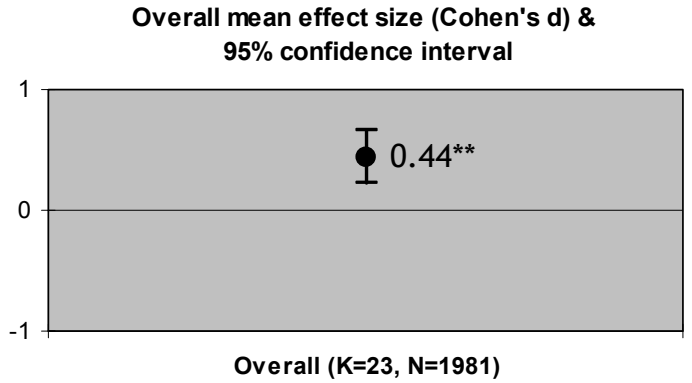
Competence 5-point-training)
difficult task



Frese, M., Brodbeck, F., Heinbokel, T., Mooser, C., Schleiffenbaum, E., & Thiemann, P. (1991). Errors in training computer skills: On the positive function of errors. *Human-Computer Interaction, 6,* 77-93.

APS 08

Meta-analytic results: Overall effect of error management training compared to error-avoidant training



Keith, N., & Frese, M. (2008). Performance Effects of Error Management Training: A Meta-Analysis. *Journal of Applied Psychology, 93*, 59-69.

Mechanisms of Error Training

- Errors may lead to higher motivation (Wood, Kakebeeke, Debowski & Frese, 2000), also Ovsiankina effect
- Errors instigate exploration (Dormann & Frese, 1994)
- Error training leads to better error handling strategies (Micro-process studies)
- Errors instigate metacognitive thinking (Keith et al.2005)
- Error training heuristics control negative emotions (Frese et al., 1991; Heimbeck, Frese, Sonnentag & Keith, 2003)

Difficult Task Performance in Subgroups (Dormann & Frese, 1994)

Error avoidant training	
- Following instruction	2.2
- Exploration inspite of instruction	3.4
Error training	
- Medium exploration	3.7
- High exploration	4.4

Dormann, T., & Frese, M. (1994). Error training: Replication and the function of exploratory behavior. *International Journal of Human-Computer Interaction, 6*(4), 365-372.

Mechanisms of Error Training

- Errors may lead to higher motivation (Wood, Kakebeeke, Debowski & Frese, 2000), also Ovsiankina effect
- Errors instigate exploration (Dormann & Frese, 1994)
- Error training leads to better error handling strategies (Micro-process studies)
- Errors instigate metacognitive thinking
- Error training heuristics control negative emotions (Frese et al., 1991; Heimbeck, Frese, Sonnentag & Keith, 2003)
- Error avoidant training makes it hard to deal with errors for some people (Heimbeck et al., 2003): e.g., high prove and avoidance orientation

Correlations between Error Handling and Transfer Performance (Computer Skills Controlled) (I, N=6, II, N=27, III, N=19)

	Partial Correlations			
	I	**II**	**III**	**Mean/r**
Number of errors	-.16	-.07		-.11
Self-reflective and systematic analysis	.56*	.38*	.68*	.49*
Trial and error analysis	-.42	-.21	-.09	-.19
Helpless analysis	-.51	-.48*	-.24	-.39*

Partial correlations controlling for computer skills, * $p<.05$

I = Merle, unpublished, II = Soose, unpublished,

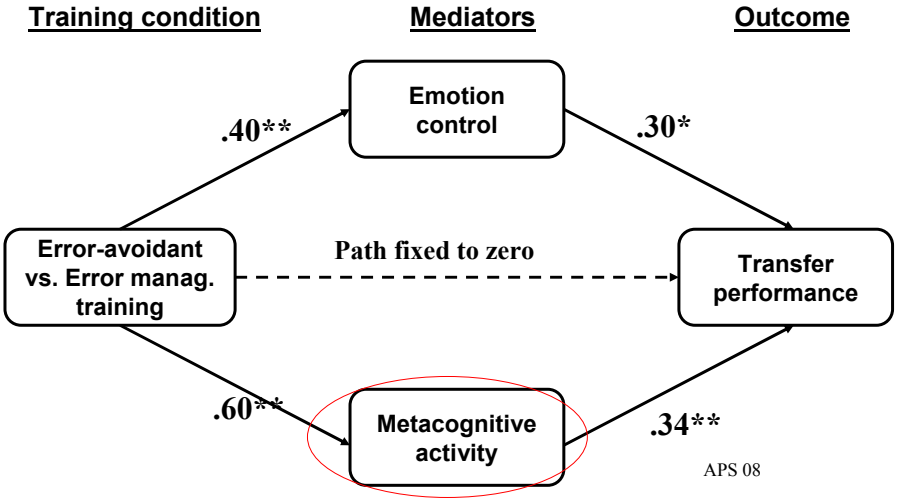
III= van der Linden, D., Sonnentag, S., Frese, M., & van Dyck, C. (2001). Exploration strategies, performance, and error consequences when learning a complex computer task. *Behaviour and Information Technology, 20*, 189-198.

Mechanisms of Error Training

- Errors may lead to higher motivation (Wood, Kakebeeke, Debowski & Frese, 2000), also Ovsiankina effect
- Errors instigate exploration (Dormann & Frese, 1994)
- Error training leads to better error handling strategies (Micro-process studies)
- Errors instigate metacognitive thinking(Keith et al.2005)
- Error training heuristics control negative emotions (Frese et al., 1991; Heimbeck, Frese, Sonnentag & Keith, 2003)

Keith, N., & Frese, M. (2005). Self-regulation in error management training: Emotion control and metacognition as mediators of performance effects. *Journal of Applied Psychology, 90*, 677-691.

Error Management Training (EMT) and Mediation by Metacognition & Emotion Control



APS 08

Mechanisms of Error Training

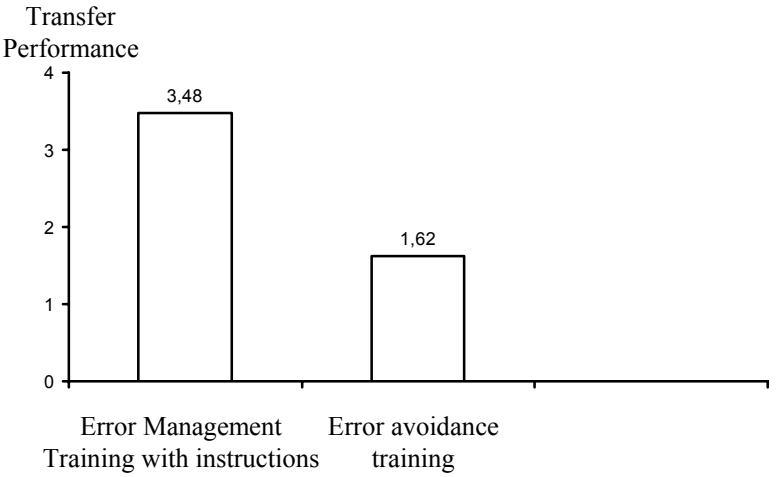
- Errors may lead to higher motivation (Wood, Kakebeeke, Debowski & Frese, 2000), also Ovsiankina effect
- Errors instigate exploration (Dormann & Frese, 1994)
- Error training leads to better error handling strategies (Micro-process studies)
- Errors instigate metacognitive thinking (Keith et al., prep.)
- Error training instructions control negative emotions (Frese et al., 1991; Heimbeck, Frese, Sonnentag & Keith, 2003)

APS 08

Error Management and Stress Management

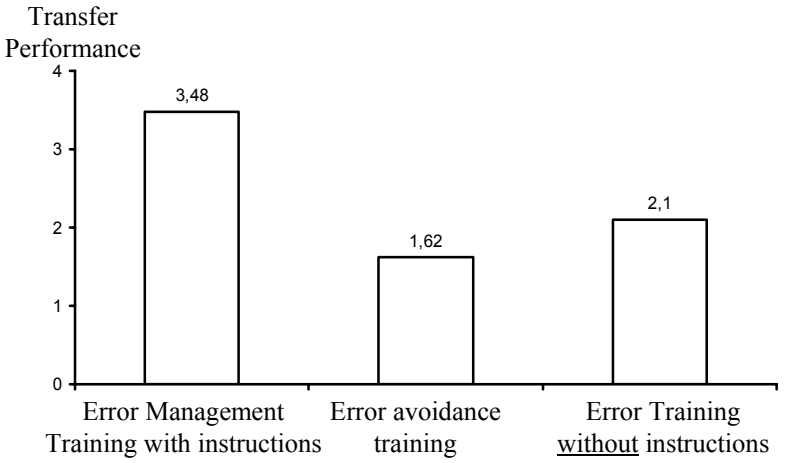
- Errors lead to added tasks (worry, dealing with problem of error)
- Error management training leads to reduced stress when errors appear
- Therefore, easier solution and problem solving and more learning possible

Transfer Performance in Difficult Tasks One Week After Training



Heimbeck, Frese, Sonnentag & Keith, 2003

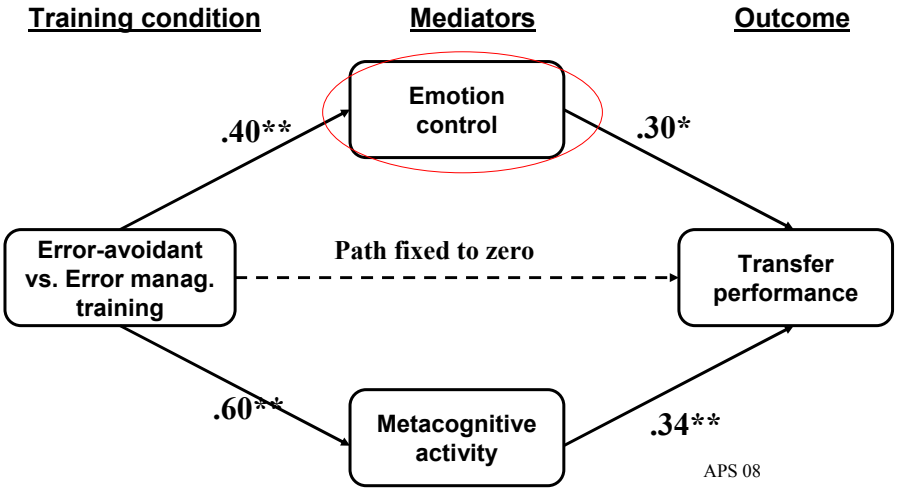
Transfer Performance in Difficult Tasks One Week After Training



Heimbeck, D., Frese, M., Sonnentag, S., & Keith, N. (2003). Integrating errors into the training process: The function of error management instructions and the role of goal orientation. *Personnel Psychology, 56*, 333-362.

Keith, N., & Frese, M. (2005). Self-regulation in error management training: Emotion control and metacognition as mediators of performance effects. *Journal of Applied Psychology, 90*, 677-691.

Error Management Training (EMT) and Mediation by Metacognition & Emotion Control



APS 08

Mechanisms of Error Training

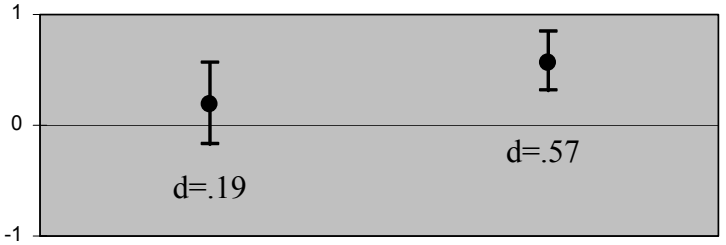
- Errors may lead to higher motivation (Wood, Kakebeeke, Debowski & Frese, 2000), also Ovsiankina effect
- Errors instigate exploration (Dormann & Frese, 1994)
- Error training leads to better error handling strategies (Micro-process studies)
- Errors instigate metacognitive thinking
- Error training heuristics control negative emotions (Frese et al., 1991; Heimbeck, Frese, Sonnentag & Keith, 2003)

Counter-Evidence

- Debowski, Wood, Bandura, 2001(JAP): Error training inferior to guided mastery training
  - o Task: CD-Rom search task
  - o Less feedback-rich and shorter training periods than used by Frese and his group
- Gully et al., 2002 (JAP): Only the smarter students showed higher performance in the error training condition (significant interaction effect); error training is only superior for high cognitive ability and high openness to experience students)

Results of Meta-Analysis: Moderator analysis of clarity of feedback

Mean effect size & 95% CI by moderator *Clarity of task feedback*

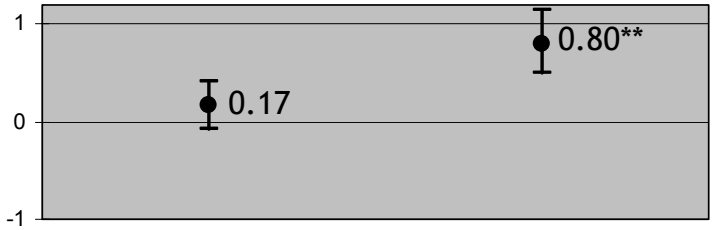


Low clarity (k=7, n=1005) **High clarity (k=16, n=976)**

Keith, N., & Frese, M. (2008). Performance Effects of Error Management Training: A Meta-Analysis. *Journal of Applied Psychology, 93*, 59-69. APS 08

Results of Meta-Analysis: Moderator analysis of near (analogical transfer) vs. far transfer task (adaptive transfer)

Mean effect size & 95% CI by moderator *Adaptivity of transfer task*



Analogical transfer (k=12, N=1445) **Adaptive transfer (k=11, N=536)**

Keith, N., & Frese, M. (2008). Performance Effects of Error Management Training: A Meta-Analysis. *Journal of Applied Psychology, 93*, 59-69. APS 08

Resolution

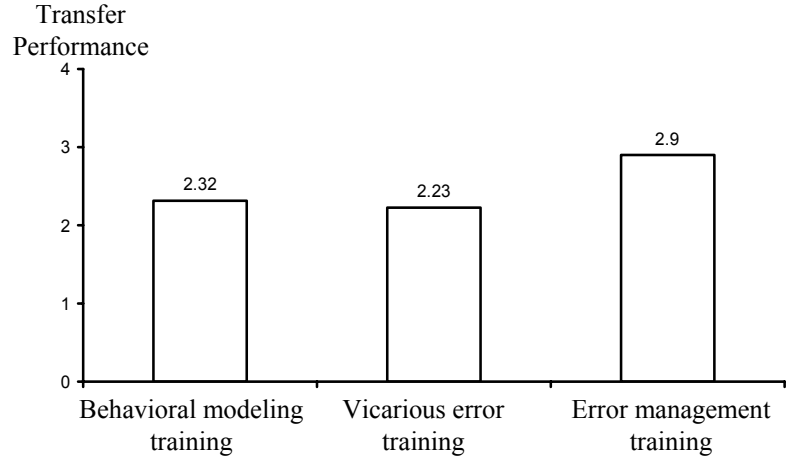
- Error management training is superior only in the long term, also after guided mastery introduction (Wood, Kakebeeke, Debowski & Frese, 2001)
- Thus, error management training not an alternative to good error prevention training, but an important and necessary **complement**
- Error training only useful in feedback-rich environments
- Error training only useful in complex tasks
- Error training useful in every culture?

Keith, N., & Frese, M. (2008). Performance Effects of Error Management Training: A Meta-Analysis. *Journal of Applied Psychology, 93*, 59-69.

Error Management Training in Social Skills Training ?

- More difficult, because lower feedback
- One approach: Provide video-feedback in an untrained situation: people are encouraged to note their errors and discuss which errors they made
- Discuss the errors and what follows from them
- Develop a better mental model through principles of actions (e.g., from leadership theory)
- Withdraw trainer feedback slowly and increase self-feedback
- Compare to a positive model that provides a proven good way of doing a social skill (a la Bandura)

Transfer Performance After Training: Charismatic Communication



Frese, M., Wiegel, J. & Muelhausen, S. (2008). Comparing Bandura's behavioral modelling training with error management training in a social skill task. *Univ. of Giessen, unpublished*.

Error Management Training Used in Real Life Situations

- Continuing education for pharmacists (Schell, K., & Frese, M. (2004). *How to learn from our mistakes: Error management training in pharmacies*: McKessan Corp., Accredited by Council for Pharmacy Education)
- Use of "war stories" to teach fire fighters (Joung, W., Hesketh, B., & Neal, A. (2006). Using "war stories" to train for adaptive performance: It is better to learn from error or success? *Applied Psychology: An International Review, 55*, 282-302.)
- Cockpit resource training (Helmreich, R. L. (2000). On error management: Lessons from aviation. *BMJ, 320*, 781-785.)

Outline

1) Action errors – why interesting and the concept
2) Error prevention and Error Management
3) Error Management in training
4) Error Management culture and organizational performance

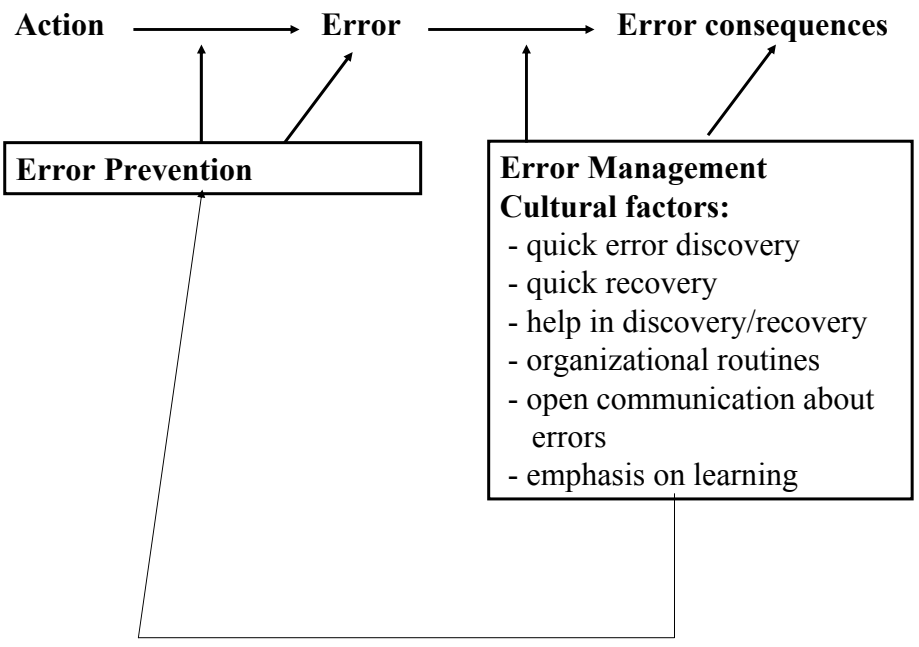
Correlations of Owners' Error Orientation with Firm Performance (Small Scale Start-ups Owners in Germany, N= 196)

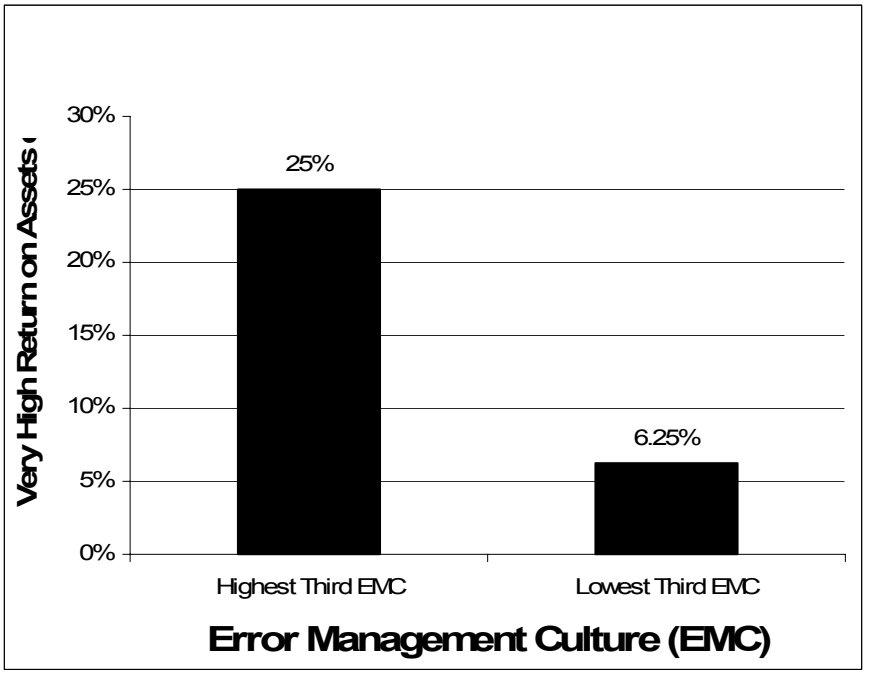
Individual variables:	**Firm's performance**
Error strain (EOQ)	-.27**
Learning from errors (EOQ)	.12*
Error competence (EOQ)	.26**
Action orientation after failure (Kuhl)	.30**

* $p < .05$, ** $p < .01$
(Goebel, 1998, based on EOQ – Error Orientation Questionnaire)

Company Level: Error Management Culture – Examples of Items

- For us, errors are very useful for improving the work process.
- After an error has occurred, it is analyzed thoroughly.
- When mastering a task, people can learn a lot from their mistakes.
- When an error has occurred, we usually know how to deal with it.





Result on Error Management Culture and Profitability

About 20% of profitability is determined by error management culture

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

Error Management Culture: Qualitative Data

Error management culture: Low

"In this organization, we don' t talk about errors"

"But I don't want to discuss errors at great length. [...] I indicated that this shouldn't happen again. And that was the end of it."

Error Management Culture: High

"I try to create an open atmosphere and tell people they should inform me if they have made a mistake, so that we can do something about it. We try to be open and discuss errors, because we believe that is the only way to control damage."

"I have spoken to the responsible manager, and have asked him to use this incident as a learning opportunity in his department."

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

Learning from Errors

Michael Frese
Univ. of Giessen and London Business School

"Life is only error, and death is knowledge"
(Schiller, 1802 – Cassandra)

Outline

1) Action errors – why interesting and the concept
2) Error prevention and Error Management
3) Error Management in training
4) Error Management culture and organizational performance