Human error

- When things go wrong!
- Examples of accidents and incidents
- Searching the reasons
  - Categories of human errors – when evolution sets the limits!
  - Human errors in socio-technical systems – how do we know the correct order of cause and effect?

TMI, Harrisburg
Miracle at Gottröra

M/S Sleipner
Sleipner
before....
....and after

Tjernobyl
The shot down of an Iranian passenger plane

Human error
- Or “the human factor”
- A generic term, meaning:
  - "All occasions and situations, when the result of a number of mental and cognitive actions deviate from the expected outcome, and when these deviations don’t depend on random conditions"
### Signal detection matrix

<table>
<thead>
<tr>
<th>Stimulus</th>
<th>Present</th>
<th>Absent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Participants</td>
<td></td>
<td></td>
</tr>
<tr>
<td>response</td>
<td></td>
<td></td>
</tr>
<tr>
<td>YES</td>
<td>Hit</td>
<td>False alarm</td>
</tr>
<tr>
<td>NO</td>
<td>Miss</td>
<td>Correct rejection</td>
</tr>
</tbody>
</table>

### The cognitive system

- Mainly, a well-adapted and efficient system, but with some limits
- A cognitive balance sheet
  - Cognitive ergonomics
  - Performance
- Error actions manifest themselves in a limited number of types and forms
- Error actions vary, but can also be quite constant

### Classification of errors

- Three different levels of analysis
  - Behavior level
    - Observable errors, focus on consequences
  - Contextual level
    - Limited assumptions about causality
    - Local "triggering" factors that reveal why particular errors appear in specific contexts
  - Conceptual level
    - Errors are classified with assumptions about how cognitive mechanisms work
Intentions and errors

Usage situations contain errors of a number of different types
- Involuntary or non-intentional actions
- Spontaneous or subsidiary actions
- Unintentional actions (slips and lapses)
- Intentional but mistaken actions (mistakes)
- Calculated error actions (violations)

Two categories of errors

Error types
- Actions with origins at different levels of consciousness
  - Judgment errors and mistakes
  - Planning errors
  - Slips & Disregards
  - Storing errors
  - Execution errors

Error forms
- Actions with origins in different cognitive processes, two general forms
  - Similarity-matching: “this situation looks like...”
  - Frequency-guessing: “the most common situation is...”

Error types

Results from studies of users and operators support the three level framework (SRK)
- Skill-based slips and lapses
- Rule-based mistakes
- Knowledge-based mistakes
Train driving

- ATP: It will soon turn green, so I don’t need to brake yet!

Interface design

- One challenge for system developers is to provide users with tools that support the use of **functional** mental models that the user needs in order to complete work tasks.
- Warning: look out for deficient and maladaptive functional mental models!
Functional models

- Many of the mental models we use in everyday tasks are incomplete and deficient
  - Our understanding of physical laws, ecological contexts and biological and chemical processes is limited
    - Intuitive conceptions about forces, motions, currents, developmental trends etc.

Conclusions: error types

- In all situations, the cognitive system is striving for resource-optimization and to reduce cognitive strain
- This gives rise to a number of error types, and the level of consciousness decides the character of the errors

Error forms I

- Humans reason according to the principles of:
  - Similarity-matching
    - Humans rarely or never reason with logic principles, but use principles of similarity to reduce the cognitive strain
    - Rules of thumb based on representativity
  - Frequency-guessing
    - In the same way, humans reason with the help of principles of availability
    - Rules of thumb based on availability
Error forms II

Humans make decisions based on the principles of:

- "bounded rationality"
  - No complete rational analysis, rather an analysis from the specific perspective that you are part of or have access to (keyhole-perspective)
- "satisficing"
  - Good enough is better than the best solution

Downside of representativeness heuristics

- Examples:
  - Base-rate neglect
  - Insensitivity for sample-sizes
  - Lack of understanding for randomness
  - Illusion of validity
  - Lack of understanding for regression, often regression towards mean

Downside of availability heuristics

- Examples:
  - Deviations caused by problems retrieving from memory
  - Deviations caused by lack of efficiency in the search process
  - Deviations caused by lack of ability in conceiving
  - Illusory correlations
The problem of anchoring & adjustment

- Insufficient adjustments
- Deviations in evaluation of conjunctive and dis-conjunctive events
- Deviations caused by insufficient subjective probability estimates

Other rules of thumb

- Confirmation bias
- Fundamental attribution error
- Maladaptive causal schemas
- Avoiding consensus information

Cognitive rules of thumb

- Cognitive operations are always under-specified when there is not enough information directly suggesting suitable measures or actions
- Complex, dynamic and non-transparent problems are such situations
- When cognitive operations are under-specified, the operators’ actions will to a high degree depend on cognitive rules of thumb in terms of contextual adaptation and previously often used measures and actions
Conclusions: error forms

- In all situations, the cognitive system tends to react with med cognitive operations in form of rules of thumb that previously have shown to be useful
- This results in an number of error forms, and these errors manifest themselves on all cognitive levels, no matter the level of consciousness

What rules of thumb does he use?

Human-Machine Discrimination
The role of the driver

- **OPERATIONAL**
  - Spatial perception
  - Visual scanning
  - Attention
  - Concentration
  - Orientation
  - Reaction time
  - Cognitive processing
  - Visual-motor integration

- **TACTICAL**
  - Driving skills
  - Driving behaviour
  - Adapting speed
  - Driving decisions

- **STRATEGIC**
  - Perceptive decisions
  - Planning abilities

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Levels of automation

- **MANAGEMENT MODEL**
  - Autonomous control
  - Monitoring supervision

- **AUTOMATION FUNCTION**
  - Strategic control
  - Monitoring supervision

- **HUMAN FUNCTIONS**
  - Supervision
  - Monitoring

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A succession of remote control and managerial for air traffic controllers.
### Experiments on socio-technical human errors

- Heuristic competence is insufficient.
  - Sufficient systematization
  - Sufficient control of hypotheses and strategies
  - Self-reflection

- Lack of heuristic competence leads to behaviors like:
  - Acting directly on feedback
  - Selective information gathering
  - Selective decision-making
  - "Thematic vagabonding"

### Problems with dynamics

- Time pressure
- Exponential developments
- Delays
- Different time scales

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<table>
<thead>
<tr>
<th>Case</th>
<th>Human contribution and system awareness</th>
<th>Human contribution and competences</th>
<th>Human contribution and situation awareness</th>
<th>Human contribution and system awareness</th>
<th>Human contribution and system awareness</th>
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<td>Yes Yes Yes Yes</td>
<td>Yes Yes No Yes</td>
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Table 1: Summary of results from analyses of the four cases.
Strategies

- Feedback-based direct interaction
  - Cognitively simple operations
  - Perception- or automatized processes
  - Not enough when there are delays, for example

- Feedforward-based model interaction
  - Cognitively heavy operations
  - Mental models or simulations
  - Often necessary when there deviations occur and plans are needed

Heuristic competence

- Ability to plan on a strategic level
- Ability to systematically build up and explore one’s own understanding
- Ability to evaluate ideas, hypotheses and strategies
- Ability to self-critically reflect on results achieved

Maladaptive behaviors

- Lack heuristic competence (causes)
  - To act directly on feedback
  - Insufficient systematization
  - Insufficient control of strategies and hypotheses
  - Lack of self-reflection

- Maladaptive behaviors (effects)
  - Selective information gathering
  - Selective decision-making or measure implementation
  - Intellectual (thematic) vagabonding
Consequences

"Cognitive psychology is the foundation on which all other social sciences stand, in the same way that physics is the foundation for the other physical sciences"

"Neo-classical economics dominated the last century. It completely ignored the cognitive processes of individuals and assumed that one could predict the behavior of markets by assuming that individuals simply behaved in a way to maximize their wealth"


Organizations & Safety cultures

- Basics
  - Safety culture
  - Organization
  - Measures

- Goals
  - Economic
  - Trust & Health

- Organization culture
  - Norms
  - Policies
  - Attitudes
  - Strategies

- Structure
  - Basics
  - Processes

Responses to anomalies

- Suppression
  - "Shooting the messenger". Harming or stopping the person bringing the anomaly to light
- Encapsulation
  - Isolating the messenger. Message not heard!
- Public relations
  - Putting the message "in context", minimize impact
- Local fix
  - Responding to case, but ignoring the possibility of others elsewhere
- Global fix
  - Responding to problems wherever they exist
- Inquiry
  - Attempting to get at the "root causes"
Information processing in organizations  
(Law et al., 2010; Westrum, 2004)

- Pathological
  - Power oriented structure
- Reactive responses
- Bureaucratic (Calculative)
  - Rule oriented structure
- Proactive responses
- Generative
  - Performance oriented structure