Human Error

Performance Levels and Error Types

Introduction

- *Generic error-modelling system (GEMS)*
  - Conceptual framework to locate the origins of the basic human error types
    - *skill-based slips (and lapses)*
    - *rule-based mistakes*
    - *knowledge-based mistakes*
  - Seeks to integrate two distinct areas of error research:
    - (a) *slips and lapses,* and (b) *mistakes*

Slips-Mistakes Dichotomy

- Mistakes
  - level of intention formation
- Slips and lapses
  - Levels of action selection, execution and intention storage
- Mistakes are likely to be more complex than slips and lapses
- Originate from quite different cognitive mechanisms

Oyster Creek (1979)

- ***a***
- An operator, intending to close pump discharge valves A and E,
- Inadvertently closed B and C also.
- All natural circulation to the core area was shut off
- ***b***
- Operators mistook the annulus level 160.8″ for the water level within the shroud

Oyster Creek (1979)

- The two levels are usually the same
- On this occasion, the shroud level was only 56″ above the fuel elements
  - due to the valve-closing error described above
- Low water level alarm sounded 3 minutes into the event and continued to sound
- The error was not discovered until 30 minutes later

Davis-Besse (1985)

- An operator, wishing to initiate the steam and feed water rupture control system manually,
- Inadvertently pressed the wrong two buttons on the control panel and failed to realize the error

Three Mile Island (1979)

- Operators did not recognize relief valve on the pressurizer was stuck open
- Panel display relief valve switch selected closed
  - indicate valve was shut,
  - Switch only activated opening and shutting mechanism

Three Mile Island (1979)

- Did not consider the possibility of mechanism failing independently
- A stuck-open valve could not be revealed by the selector display on the control panel

Ginna (1982)

- Operators, intending to depressurize the reactor coolant system,
- used the wrong strategy with regard to the pressure operated relief valve (PORV)
- They cycled it open and shut, and the valve stuck open on the fourth occasion

Chernobyl (1986)

- Previous operator error
  - Reactor power to below 10 % of max power
- Violation of strict safety procedures
  - prohibiting any operation below 20 % of max power
- Operators and Electrical engineers continued with the planned test program
- Double explosion within the core that breached the containment

Analysis

- Oyster Creek (1979) - a
- Davis-Besse (1985)

} **Slips of Action**

- Ginna (1982)
- Chernobyl (1986)

} **Mistakes**

- Oyster Creek (1979) - b
- Three Mile Island (1979)

} **Both!!!!**

What's BOTH?!!!!

- Mistakes
  - Improper appraisals of system state
- Slip-like features
  - 'strong but wrong' interpretations selected
- Application of inappropriate diagnostic rules
  - *if (situation X prevails)*
  - *then (system state Y exists)*
- Rules proved their worth in the past yielded wrong answers in these extremely unusual emergency conditions

Two Kinds of Mistake

- Rule-based mistakes
- Knowledge-based mistakes

Error Types

Performance Level	Error Type
Skill-based level	Slips and lapses
Rule-based level	RB mistakes
Knowledge-based level	KB mistakes

Distinguishing Three Error Types

- Type of activity
- Focus of attention
- Control mode
- Expertise and the predictability of error type
- The ratio of error to opportunity
- The influence of situational factors
- Detectability
- Relationship to change

Type of Activity

- SB slips precede the detection of a problem
- RB and KB mistakes arise during subsequent attempts to find a solution
- Defining condition for both RB and KB mistakes is an awareness that a problem exists.

Focus of Attention

- Slip of action requires presence of intentional capture
  - Distraction or preoccupation

- In RB and KB mistakes:
  - Limited attentional focus will not have strayed far from some feature of the problem configuration

Control Mode

- Performance at SB and RB levels is feed-forward control
  - emanating from stored knowledge structures (motor programs, schemata, rules)
- Rule or control is selected from previous successful experiences
- Control at the KB level is primarily of the feedback kind

Expertise and Predictability of Error Type

- SB and the RB levels errors
  - 'strong-but-wrong'
  - Predictable
- KB mistakes will be less predictable in their forms
  - hit-and-miss
  - Less predictable
- Important differences between novices and experts found at SB and RB levels

Ratio of Error to Opportunity

- SB and RB errors more abundant than KB errors
- considering relative ratios of error numbers to opportunities for error at each of the three levels of performance.
- % errors in the SB and RB modes will be very much smaller than at the KB level of processing
  - even though their absolute numbers are very much greater

Influence of Situational Factors

- SB slips
  - error-shaping factors are attentional capture and strength of associated action schemata
- RB mistakes
  - rules are arranged in an ordered priority list
  - most available ➔ prevailing state indications
  - nature of task ➔ rules likely to be applied
- KB mistakes take a wide variety of forms
  - performance shaped primarily by extrinsic factors

Detectability

- Mistakes are harder to detect than slips

Relationship to Change – SB slips and lapses

- Error-triggering changes involve a necessary departure from well-established routine
- Occasioned either by an intended deviation from normal practice or by an alteration in the physical circumstances
- Failure to monitor current intention
- Failure to recall earlier situational changes

Relationship to Change – RB Mistakes

- Changes anticipated
  - Past encounters, consideration by instructors or designers, contingency routines
    - within individual's knowledge base
    - written into his or her operating procedures
- Time of occurrence is not known in advance
- Mistake arises from
  - application of a 'bad' rule or
  - misapplication of a 'good' rule.

Relationship to Change - KB Mistakes

- Changes in the world that have neither been prepared for nor anticipated
- Change falls outside the scope of prior experience or forethought and has to be dealt with by error-prone 'on-line‘ reasoning

Table 3.2. Summarising the distinctions between skill-based, rule-based and knowledge-based errors.

DIMENSION	SKILL-BASED ERRORS	RULE-BASED ERRORS	KNOWLEDGE-BASED ERRORS
TYPE OF ACTIVITY	Routine actions	Problem-solving activities	
FOCUS OF ATTENTION	On something other than the task in hand	Directed at problem-related issues	
CONTROL MODE	Mainly by automatic processors (schemata)	(stored rules)	Limited, conscious processes
PREDICTABILITY OF ERROR TYPES	Largely predictable "strong-but-wrong" errors (actions)	(rules)	Variable
RATIO OF ERROR TO OPPORTUNITY FOR ERROR	Though absolute numbers may be high, these constitute a small proportion of the total number of opportunities for error		Absolute numbers small, but opportunity ratio high
INFLUENCE OF SITUATIONAL FACTORS	Low to moderate; intrinsic factors (frequency of prior use) likely to exert the dominant influence		Extrinsic factors likely to dominate
EASE OF DETECTION	Detection usually fairly rapid and effective	Difficult, and often only achieved through external intervention	
RELATIONSHIP TO CHANGE	Knowledge of change not accessed at proper time	When and how anticipated change will occur unknown	Changes not prepared for or anticipated

Generic Error-Modelling System (GEMS)

- Errors (slips and lapses) occurring prior to problem detection are seen as being mainly associated with ***monitoring failures***

- Errors appear subsequently (RB and KB mistakes) are subsumed under the general heading of ***problem solving failures***

Monitoring Failure

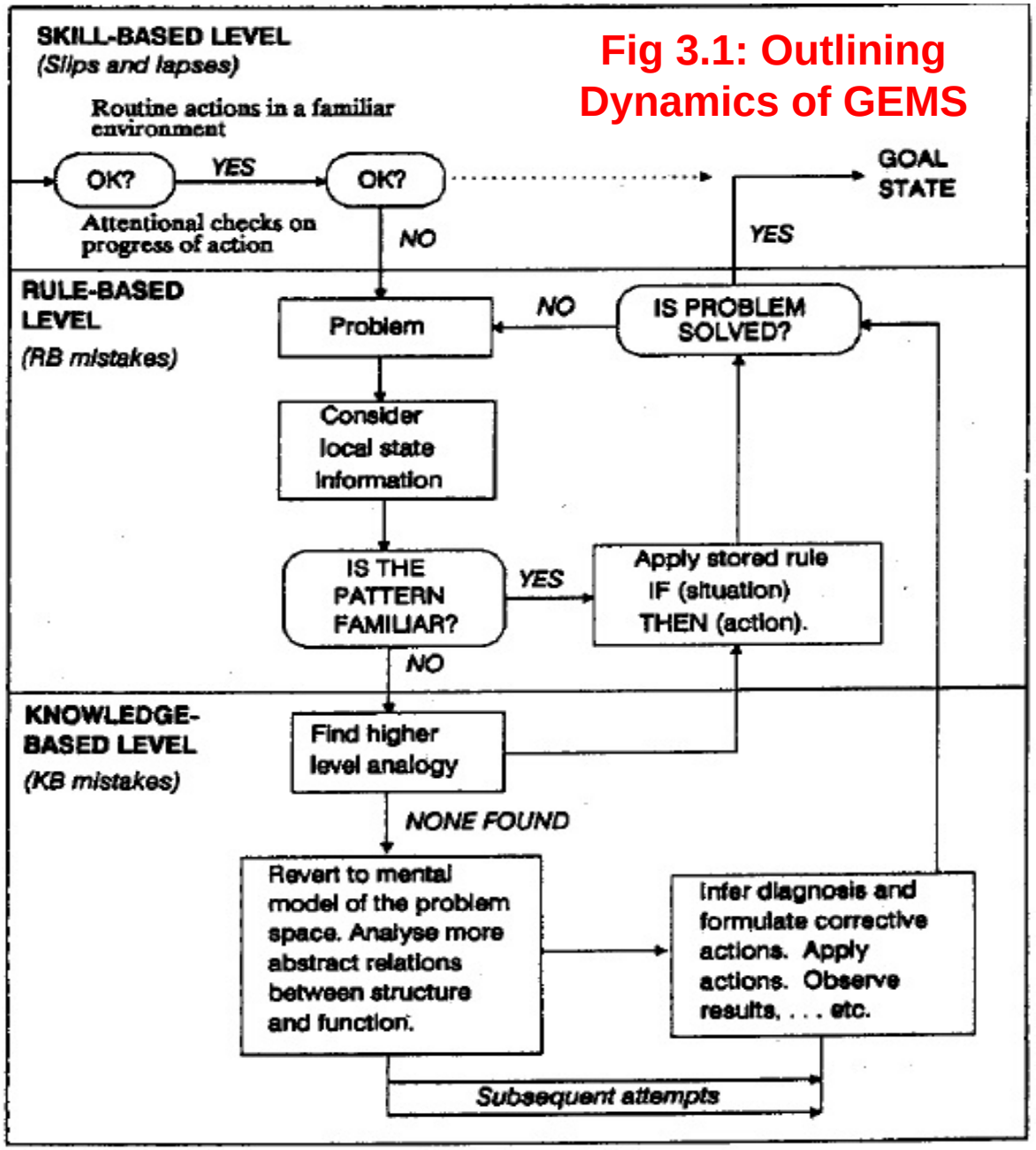
- Attentional checks upon progress
- Higher levels of cognitive system
  - Actions running according to plan
  - Plan still adequate to achieve desired outcome

Monitoring Failure

- Control mode failures
  - Inattention, to make a necessary check
  - Over attention, check at inappropriate point

- Higher levels of cognitive system running open-loop (moment-to-moment control of actions)

Fig 3.1: Outlining Dynamics of GEMS



Problem Solving Failure

- Problem solving elements of GEMS based on
  - "I would prefer to act as context-specific pattern recognizers rather than attempting to calculate or optimize"
  - Matching aspects of the local state information
    - ***if (situation) then (system state), if (system state) then (remedial action).***

- Cycling around this rule-based route fails to offer satisfactory solution
  - KB level take place

Failure Modes – Skill-Based Level

Inattention	*Overattention*
Double-capture slips	Omissions
Omissions following interruptions	Repetitions
Reduced intentionality	Reversals
Perceptual confusions	
Interference errors	

Failure Modes – Rule-Based Level

***Misapplication of good* rules**	***Application of bad* rules**
First exceptions	Encoding deficiencies
Countersigns and nonsigns	Action deficiencies
Informational overload	• Wrong rules
Rule strength	• Inelegant rules
General rules	• Inadvisable rules
Redundancy	
Rigidity	

Failure Modes – Knowledge-Based Level

- *Selectivity*
- *Workspace limitations*
- *Out of sight out of mind*
- *Confirmation bias*
- *Overconfidence*
- *Biased reviewing*
- *Illusory correlation*
- *Halo effects*
- *Problems with causality*
- *Problems With complexity*
  - Problems with delayed feed-back
  - Insufficient consideration ofprocesses in time
  - Difficulties with exponential developments
  - Thinking in causal series not causal nets
  - Thematic vagabonding
  - Encysting