COGNITIVE RESILIENCE APPLIED TO STAMP

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INTRODUCTION TO COGNITIVE RESISTANCE
COGNITIVE RESISTANCE

Definition
The capacity to endure a discrepancy between reality and activated mental schemata, despite salient cues that are essentially perceived.
PERCEIVE & BELIEVE

- How many of each animal did Mozes take along in the Arc?
COGNITIVE RESISTANCE

• We ignore stimuli that do not seem relevant to tasks at hand
  • Saves resources
  • Improves routine operations
• Describes a (real) physiological and neurological process
  • Implicit perception
  • A lag in stimulus matching
  • Sudden explicit perception / reflection, sometimes accompanied by surprise
• Can terminate in two ways:
  • The discrepancy is brought into consciousness (i.e. reflection)
  • Reality realigns itself with the activated mental schema (i.e. the cues go away)

COGNITIVE RESISTANCE IS WELL KNOWN

<table>
<thead>
<tr>
<th>Similar Phenomena</th>
<th>Examples</th>
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<tr>
<td>Looking-but-not-seeing / inattentional blindness</td>
<td>A320 mode input failure, January 20th, 1992</td>
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<td>Cognitive Fixation</td>
<td>Turkish Airlines crash at Amsterdam, February 25th, 2009</td>
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<td>Automation bias</td>
<td>Taxiway take-off, February 10th 2010</td>
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WHY A NEW CONSTRUCT?

- An epistemologically sound definition (hopefully..)
- Describes normal rather than erroneous human behavior
- Focuses on the episodic nature of the phenomenon
RELEVANCE TO STAMP
RECENT CRITICISM OF HUMAN FACTOR IN STAMP

“The human factors element of STAMP is somewhat limited and under-specified. Human error is conceptualised as essentially a failure of the operator’s mental model of the system [...]. The model of human behaviour implicit in STAMP is somewhat deterministic. “

STOCHASTIC MODEL OF COGNITIVE RESISTANCE

EXPERIMENTAL STUDY
EXPERIMENT

- Number Reduction Task
  - 2 rules
  - Time and error limit
- 81 participants
  - Professional engineers
  - Engineering students
- Manipulation: Impossible to meet the task objective while applying the learned rules

TYPICAL RUN

Progress of WARP trials

- Example of learned model
EXPERIMENTAL RESULTS (N=81)

Cumulative frequency of reflection

Test duration (trials)

UNIMODAL LOG-LOGISTIC DISTRIBUTION OF COGNITIVE RESISTANCE

EXPERIMENTAL RESULTS

REINFORCEMENT LEARNING FRAMEWORK FOR COGNITIVE RESISTANCE

EFFECT OF EMOTION ON TERMINATION RATE OF COGNITIVE RESISTANCE

- Reaction to cues:
  - No emotion
  - Surprise
  - Remorse
  - Anger
  - Distress
  - Joy

- Speed of termination:
  - Rapid
  - Moderate
  - None
REPEAT IN MORE PRACTICAL SETTING

Thrust lever malfunction: cues

- N1 axis speed indications
- Exhaust gas temperature
- N2 rotation speed
- Fuel flow
- Rudder deflection
- 6 cues on ECAM page
  - Fuel consumed (2x)
  - Oil pressure
  - Vibrations,
  - Oil quantity,
  - Remaining fuel.
- But not on ECAM
LOG-LOG DISTRIBUTION OF COGNITIVE RESISTANCE – SIM RESULTS (N=27)

CONCLUSION – VALUE OF COGNITIVE RESISTANCE FOR STAMP

• Cognitive Resistance describes human perception performance
  • Stochastic with known probability distribution (unimodal log-logistic)
  • Learning or satisficing process
  • Emotions as reward / penalty mechanism
• Contribution to STAMP
  • Normal rather than erroneous performance
  • Stochastic rather than deterministic
THANK YOU FOR YOUR ATTENTION

Robert J. de Boer, rj.de.boer@hva.nl

Website: http://www.hva.nl/kenniscentrum-dt/onderzoeksthema/aviation/
CONTROL FLAWS

- Inadequate control actions
  - Unidentified hazards
  - Inappropriate etc. control actions
  - Design of control process do not enforce constraints
  - Inconsistent etc. process models
  - Inadequate coordination
- Inadequate execution of control action
  - Communication flaw
  - Inadequate actuator (operator) operation
  - Time lag
- Inadequate or missing feedback
  - Not provided in system design
  - Communication flaw
  - Time lag
  - Inadequate sensor operation

MEASURING COGNITIVE RESISTANCE

Situational Awareness (SAGAT)
- Aircraft state
- Flight path
- Traffic
- Terrain
- Weather
- …

Automation Awareness (AAGAT)
- Equipment state
- Normal / alternate law
- Operational mode
- …