Building Knowledge and Capability

What are our training goals ?
Why are we training them ?

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British Airways   24th May 2001

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Learning is Experience

- Some people fail to learn
- Some people fail to use what they learn
- Some people learn the wrong things
- Some people are unaware they need to learn
- Learning can be an obstacle to learning

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Bad Judgement

- Montgomery - Operation Market Garden
- Evidence about the strength of the local troops
- Evidence about the road layout and potential defensive strength of enemy positions
- Evidence about the need for effective liaison between re-supply and expeditionary force

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Operation Market Garden Thinking Errors

- Persistent belief in invulnerability and ability to overcome - based on past success.

- Distorted judgement about the level of potential variation in performance - failed intention to monitor and review.

- No consideration of alternatives.

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Perseverance

- Continuation with an idea or view of the world despite evidence to the contrary.

- Consider the Tenerife Incident.

- The consistent focus on the need to get to the destination overrode all other information collection.

- It is likely the conviction of the Captain was attributable to their seniority in the company and their role as a training Captain.

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What are our training goals

- Aims of the training course
  - safer flying [Lower risk and better recovery]
  - economical flying [Less maintenance or lower fuel usage]
  - comfortable flying
- Training outcomes for many courses are the
  - capability to apply the knowledge in procedural operation of systems
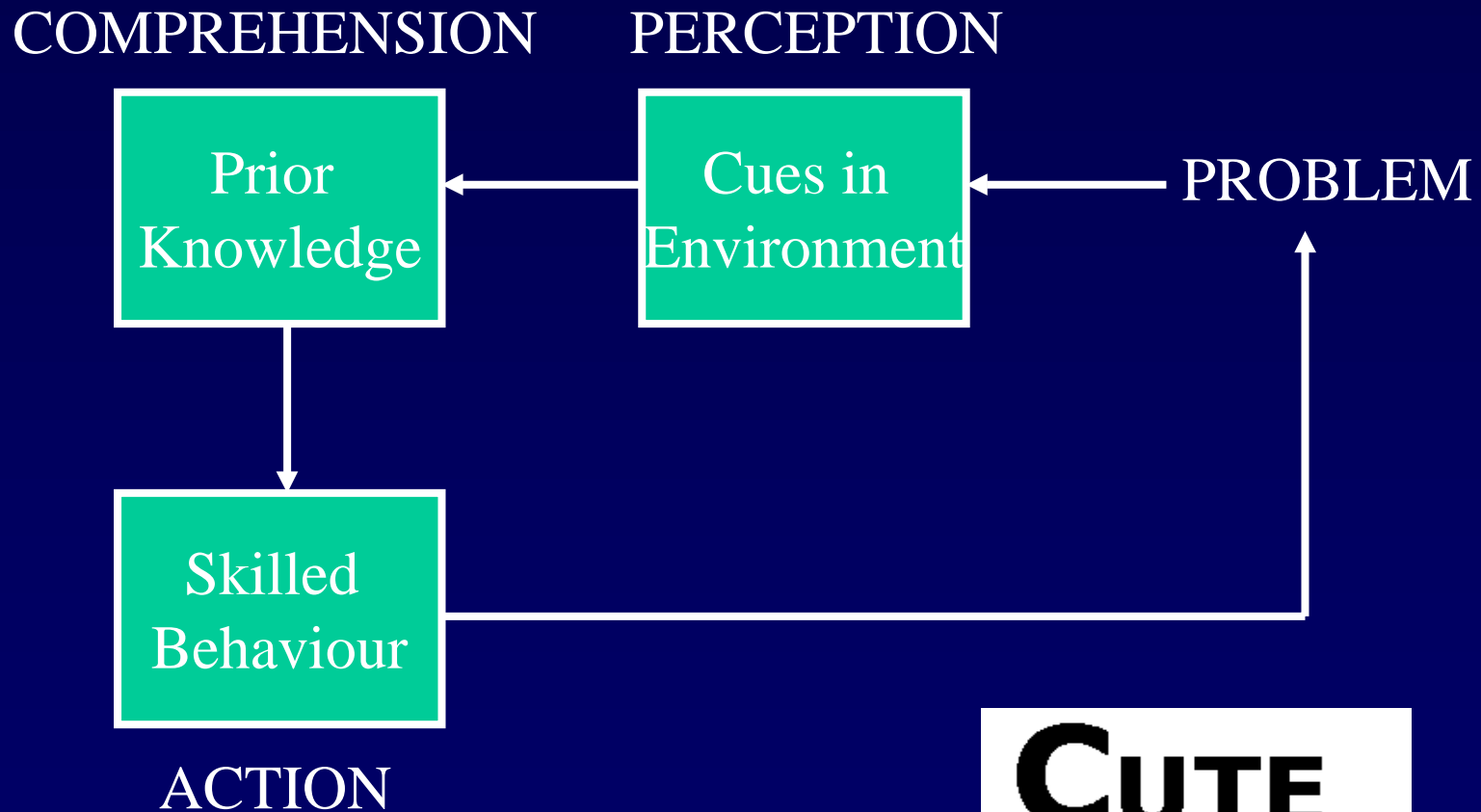
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Understanding the Interaction between Goals

- At what point would you consider doing an action that may save your crew and passengers but increase maintenance costs ?

- Name those situations where you think fuel economy is definitely a secondary issue ?

- At what point do you or cabin staff inform passengers of an minor or major emergency ? How do you explain it ?

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General Model for Training

COMPREHENSION   PERCEPTION

| Prior Knowledge | ← | Cues in Environment | ← PROBLEM |

↓
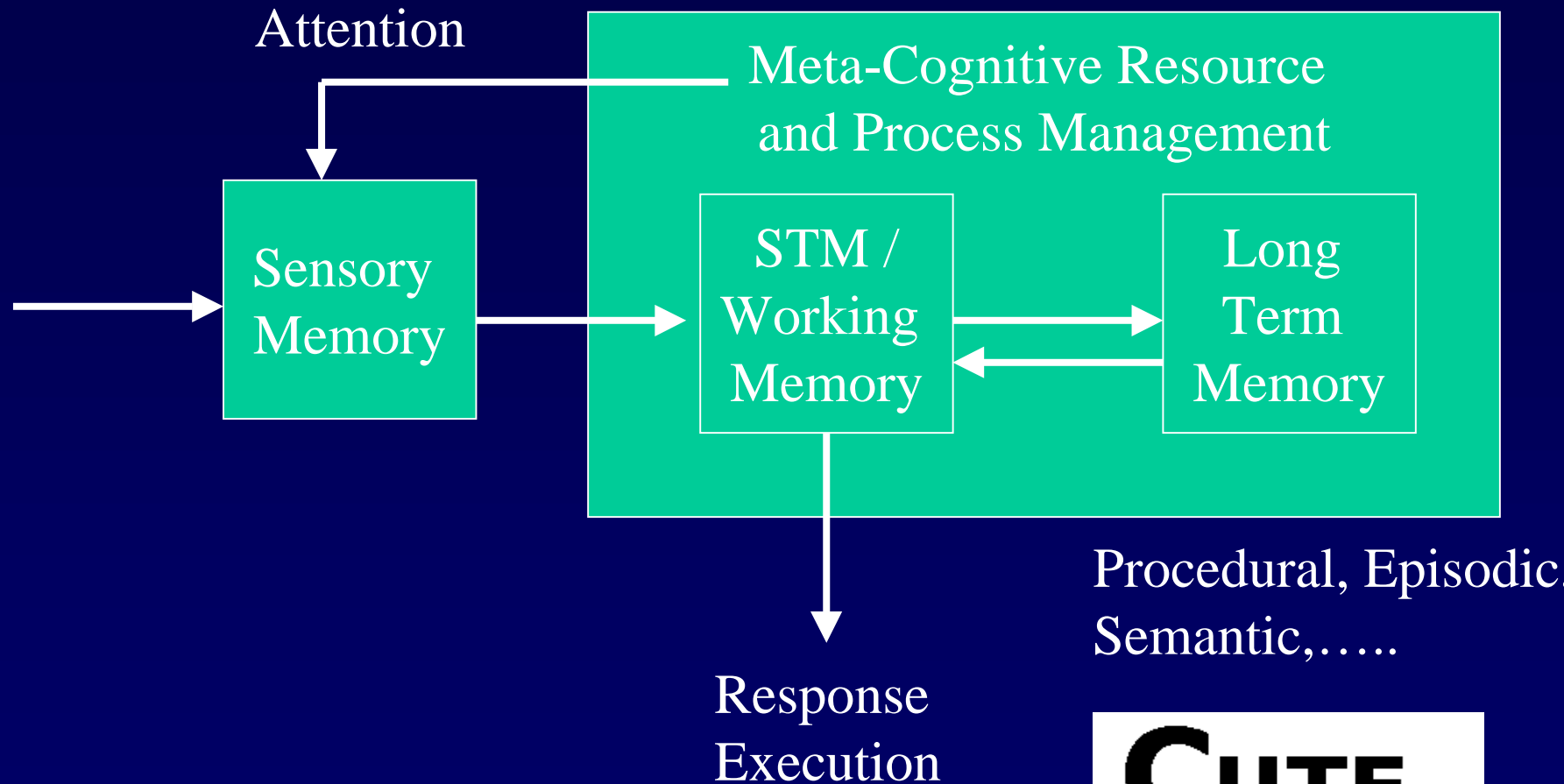
| Skilled Behaviour |

ACTION

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Aircrew Training and Assessment

- Sources of pilots for airlines have changed
- Regulation of civil aviation aircrew training is increasing
- Increased level of cockpit automation
- Crew resource management and line-oriented flight training
- Increased use of civil simulators as training devices

Human Cognition

Attention

Meta-Cognitive Resource
and Process Management

Sensory Memory

STM /
Working
Memory

Long
Term
Memory

Procedural, Episodic,
Semantic,…..

Response
Execution

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Notice Training Benefit

- Better use of attention and sensory memory to select information for further processing - resources are not unlimited.

- Use of skilled long-term memory or chunking to provide better comprehension and retention of information.

- More information to draw upon in understanding the raw data in working memory and to direct search for additional information.

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What is the purpose of training ?

- Knowledge Development
- Expertise Development
- Experiential Development
- Procedural Development
- Process and Resource Management
- **To reduce immediate cognitive demand in tasks by putting in place capability.**

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What does training do ?

- Creates capability - binding knowledge and experience.

- Refines information processing strategies.

- Automates critical responses.

- Increases multi-task capacity.

- Changes information processing and the knowledge used in procedural tasks.

- Increases the opportunity for self-review and monitoring.

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What does collective training do?

- Processing Information
- Structuring of Knowledge
- Common Attitudes
- Shared Expectations
- Develops Effective Resource Management

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Predicted Benefits of Training

- Input is required to calibrate the system - perception of events.

- Effective response selection is based on accurate comprehension.

- Observable outcomes are required to validate the processes set up.

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Examples of Human Errors

- Imperfect mental model of aircraft - shutting down wrong engine.

- Imperfect situational awareness - failing to use full throttle when required.

- High degrees of complacency - failing to check automatic system status.

- Limited consideration of alternatives - poor choice of crash location.

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Many Errors Not Based on Knowledge Errors

- Many errors are based on faulty information processing and not on knowledge.

- Studies indicate that failure to notice, followed by failure to comprehend are the most common types of information processing failure leading to accident development.

- Will practising to automaticity of skills increase the effective management of these problems ?

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Is Knowledge Experience ?

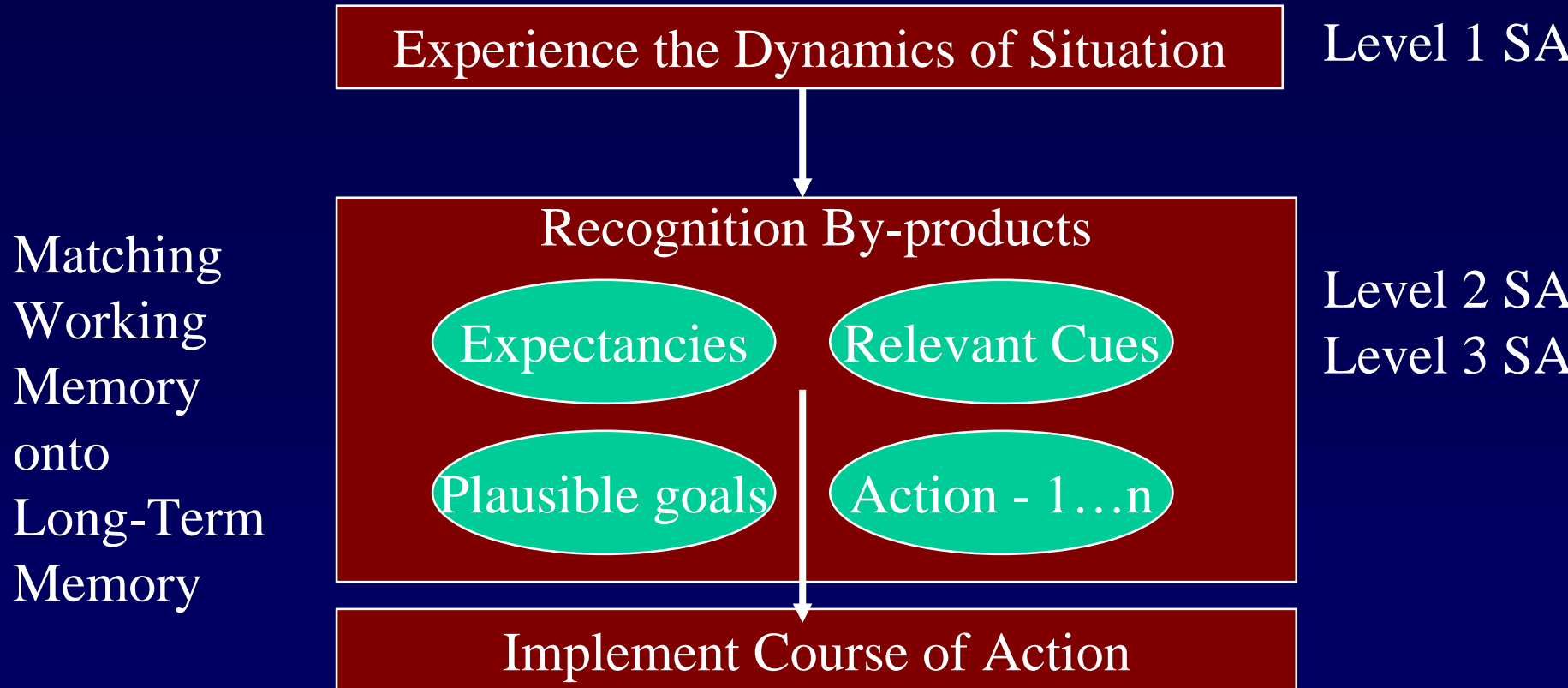British Airways   24th May 2001

Unusual Error Recovery : Based on Experience

- Gimli Glider - use of gliding knowledge and location of closed military bases allowed recovery.

- Dead Stick Landing of Hawk in Norway.

- Souix City Recovery - use of spare pilot capacity and aeronautics to recover after hydraulics failure.

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Building Knowledge and Capability

Klein's Recognition Primed Detection Decision Making Model

Experience the Dynamics of Situation	Level 1 SA

Matching Working Memory onto Long-Term Memory

Recognition By-products	Level 2 SA Level 3 SA

- Expectancies
- Relevant Cues
- Plausible goals
- Action - 1…n

Implement Course of Action

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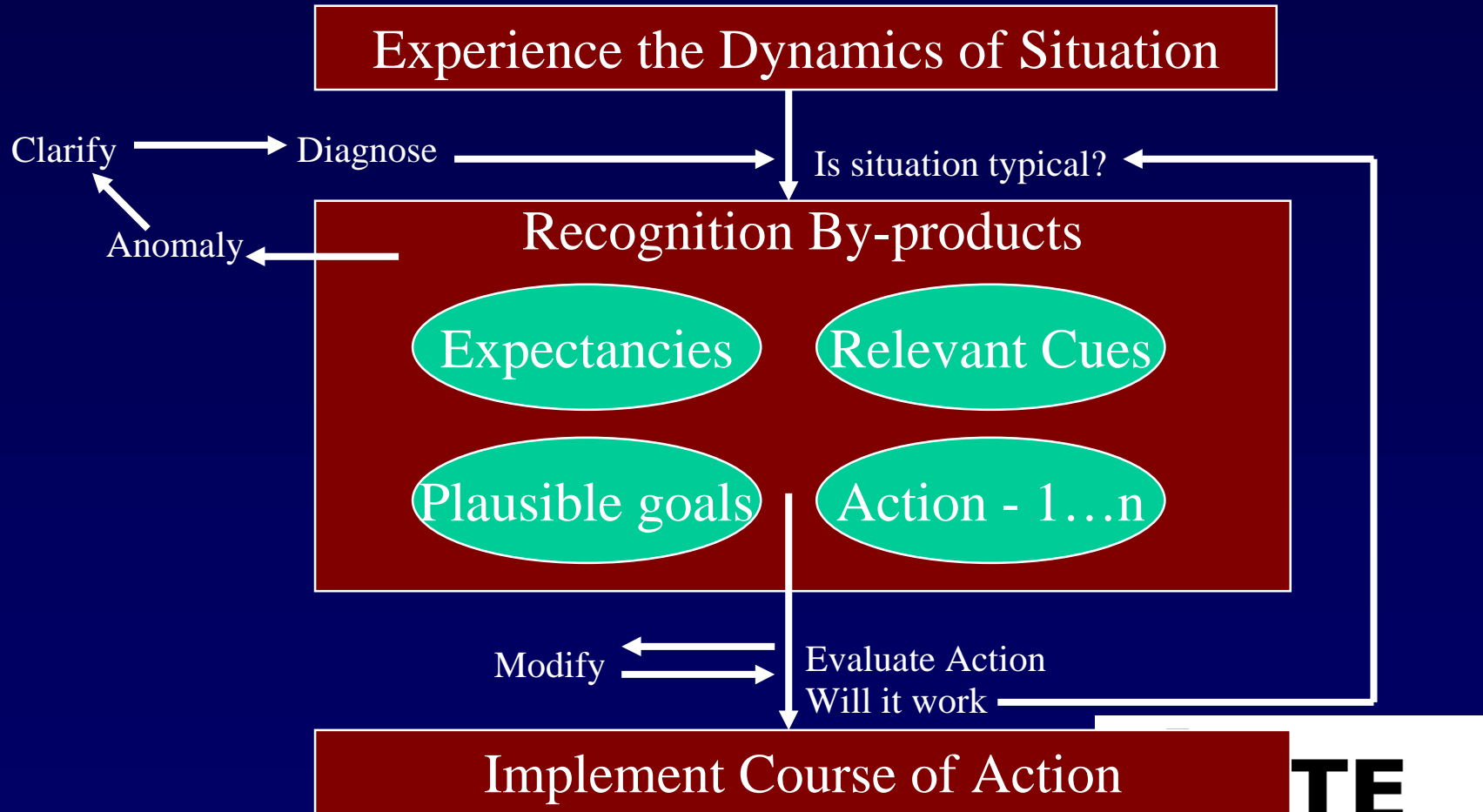British Airways   24th May 2001

Predictions for Training

- Training cue identification results in superior performance.

- Procedural training of actions aids performance by reducing cognitive burden and increasing automaticity.

- Increased diversity of training creates more actions, improved expectancy, better understanding of goals and better identification of critical cues.

- Review of the plausible goals aids the direction of attention in supporting resource usage in perception.

- This mainly applies to familiar events.

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Building Knowledge and Capability

Full-0n Klein

Experience the Dynamics of Situation

Clarify → Diagnose → Is situation typical? ←

Anomaly ←

Recognition By-products

Expectancies   Relevant Cues

Plausible goals   Action - 1…n

Modify ← Evaluate Action
Will it work ←

Implement Course of Action

Implications

- Cognitive Resource Predictions - Use of Resources.
- Early detection of anomalies is less demanding of cognitive resources.
- Failed action evaluation will result in action and observation - not a process re-trace of cognition.
- Additional qualifications - cognitive miser principle and satisficing.

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NDM Training

- Emphasis on situation awareness - choosing between courses of action.

- Emphasis on meta-cognition - concern for managing stress and controlling attention.

- Not a simple focus on practice and feedback.

- Decision strategy processing - no generic decision strategies.

- Identify the critical questions to be trained.

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Why do pilots struggle with decisions ?

- The most common reason is lack of experience.
- High degree of experience to recognize as typical.
- This experience allows unusual events to be detected.
- High degree of experience to build narratives to diagnose and simulate alternative actions.
- High degree of experience to prioritise cues - workload.
- Do we think or just match ?

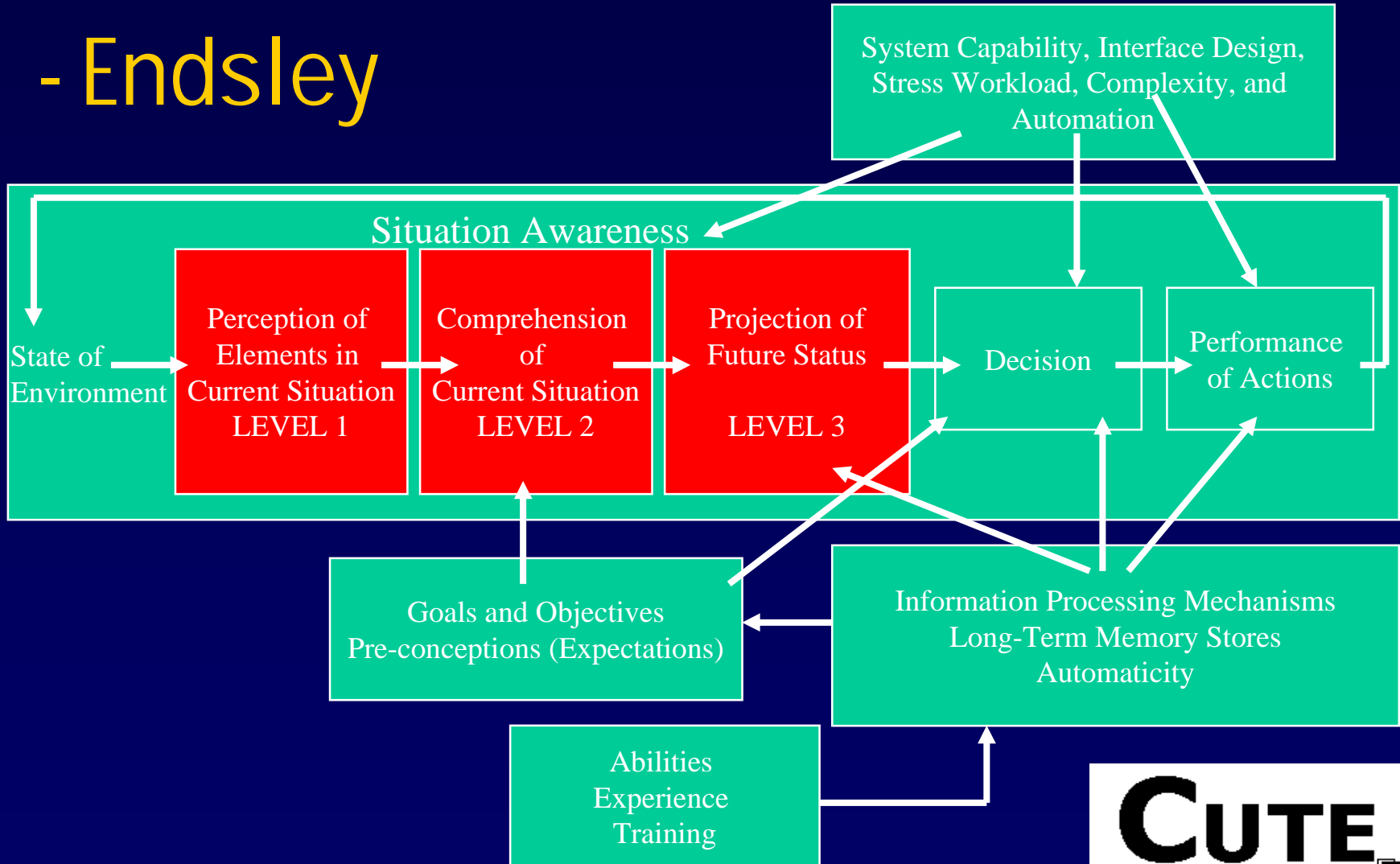British Airways   24th May 2001

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Helping Pilots

- Identify the judgements and decisions needing practice.
- Provide tools to build scenarios to exercise and practice under time pressure and uncertainty.
- Design debriefing checklists to aid in directed learning.
- Show pilots there are coaching methods for accelerating skill development.

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Building Knowledge and Capability
Situational Awareness - Endsley

System Capability, Interface Design, Stress Workload, Complexity, and Automation

Situation Awareness

State of Environment

Perception of Elements in Current Situation LEVEL 1

Comprehension of Current Situation LEVEL 2

Projection of Future Status LEVEL 3

Decision

Performance of Actions

Goals and Objectives Pre-conceptions (Expectations)

Information Processing Mechanisms Long-Term Memory Stores Automaticity

Abilities Experience Training

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Situational Awareness I

- Many failures are attributable to Level 1 SA - failure to notice significant events.

- The second most common cause of failures is Level 2 SA - failure to comprehend the events detected.

- Much effort is put into the training of the system interface to aid perception and comprehension.

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Situational Awareness II

- However, as both a bottom up and top down system human cognition makes errors resulting from - expectation (pre-conceptions) and action-based evidence suggests humans are poor at prediction of the consequences.

- Human operators are reluctant to change their current working hypothesis, perseveration.

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Situational Awareness III

- Relies on skilled memory performance - after repeated exposure to knowledge the encoding of familiar patterns is better - is there evidence that exceptions can be processed well as Klein suggests.

- Top-down and bottom up - but what of meta-cognitive and affective information processing influences.

- Is situational awareness explicit, implicit, declarative, procedural, episodic, semantic, strategic….

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Different Types of Knowledge

- Different memory stores may have different properties affecting -
  - storage
  - retrieval
  - durability
  - transfer
- See Healy and Bourne (1995).

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Training Changes Processing

- Workload Decreases.
- Use of Attention
- Automaticity Increases
- Types of Information Storage
- Affective Experience Changes

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Building Knowledge and Capability

Skill, Rule and Knowledge-Based

Increasing
Skill
Decreasing
Demand

SKILL-BASED

Automaticity
Low Cognitive Resource Demand
Confident and High Certainty

RULE-BASED

Increasing
Anxiety and
Uncertainty

KNOWLEDGE -BASED

Controlled Processing
High Cognitive Resource Demand
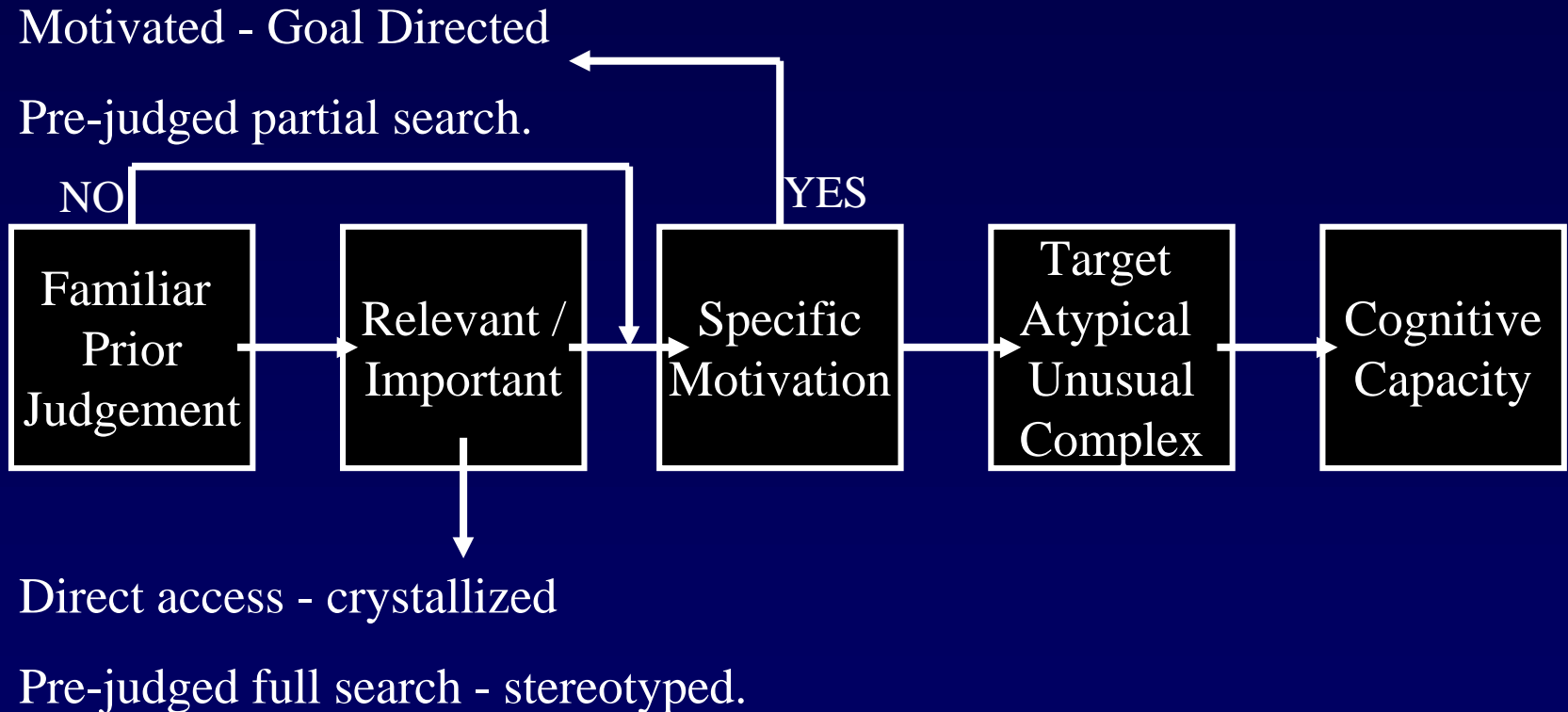Low Confidence and Certainty

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Models of Skilled Behaviour

- Rasmussen's (1983, 1986) model of skilled behaviour.

- Skill-Rules-Knowledge Based Information Processing.

- Cognitive Resource Gradient - encourages human operators to stay in rule- or skill-based processing.

- Affective Experience Gradient - encourages human operators to stay in rule- or skill-based processing.

- Reaction against systems which encourage knowledge based processing and prevent the development of higher levels of skilled processing.

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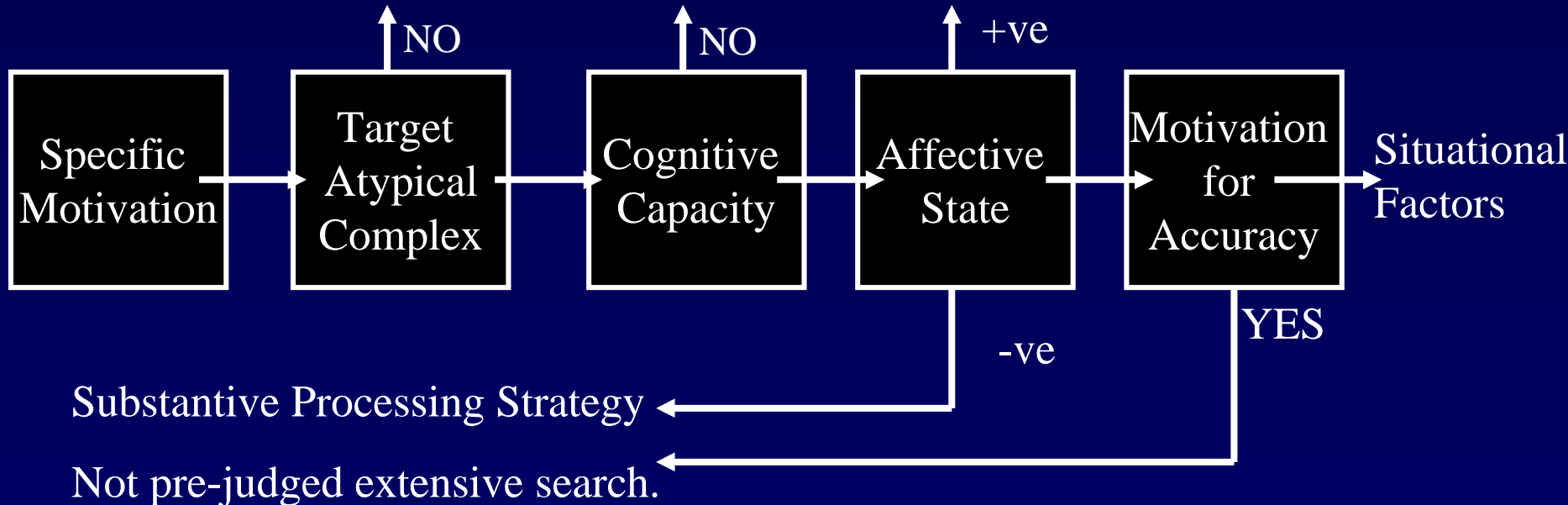
Adapted Decision Strategy

Motivated - Goal Directed

Pre-judged partial search.

NO   YES

| Familiar Prior Judgement | Relevant / Important | Specific Motivation | Target Atypical Unusual Complex | Cognitive Capacity |

Direct access - crystallized

Pre-judged full search - stereotyped.

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Adapted Decision Strategy

Heuristic Processing Strategy

Not pre-judged partial search - affect as information.

| Specific Motivation | → | Target Atypical Complex | → | Cognitive Capacity | → | Affective State | → | Motivation for Accuracy | → Situational Factors |

NO (above Target Atypical Complex)

NO (above Cognitive Capacity)

+ve (above Affective State)

-ve

YES

Substantive Processing Strategy

Not pre-judged extensive search.

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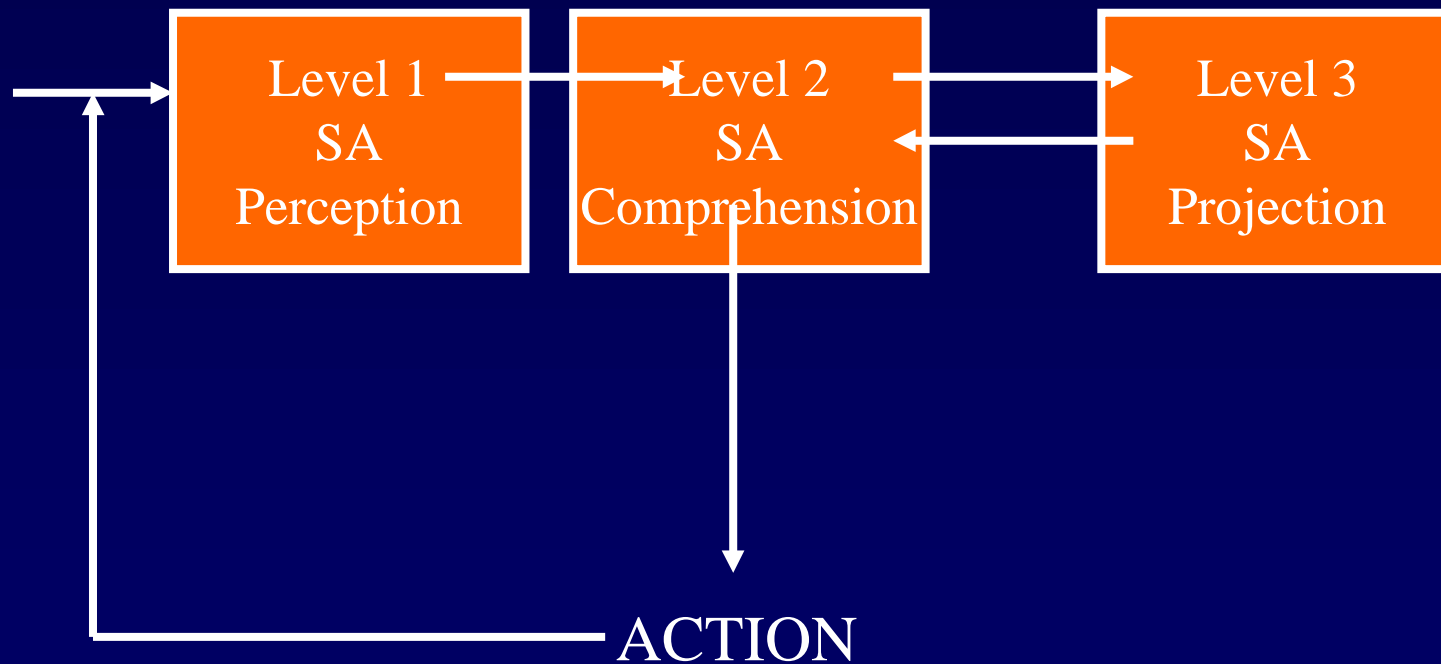
Impulse to Action

Impulse to Action - Predictions

- Anxiety Increases the Likelihood of Poorly Considered Response.

- Cognitive Complexity Increases the Likelihood of Poorly Considered Response.

- Action Selection Decreases Anxiety.

- Action Selection Decreases Cognitive Demands.

- Action Selection Increases the Possibility of Deviation, Expectation Violation.

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Managing Cognitive Transitions

- Novel, Unfamiliar and Unexpected Events create -
  - additional demands on working memory
  - affective responses that influence information processing
  - require the use of social and individual meta-cognitive process management
- Importance of a shared mental model

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Critical Issues

- Automation
  - disengagement
  - undermines SA
  - increases complacency
  - works well, most of the time
  - puts operator into vigilance mode (supervising)
  - reduces skill

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Confidence, Trust and Uncertainty

- Trust - the reliance on another (human or agent).

- Confidence - the degree of certainty that the other (human or agent) will achieve a result.

- Uncertainty - the level of ambiguity (or inverse of familiarity) in the context or situation.

- Predictability - confidence * uncertainty.

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Psychological Issues

- Human Operator makes critical decisions and needs to be kept informed.

- Human Operators need to process information, to generate knowledge in order to make correct decisions and operate at top of SRK model.

- Human Operators like to feel confident in their execution of skilled behaviour (operate at S-Level) and conduct their processing to reduce any uncertainty.

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Summary of Aviation Training

- 1) Theoretical basis for training - shared mental model development.

- 2) The purpose behind human performance measurement.

- 3) Team and cognitive analysis tools should be used.

- 4) Event-based strategy for assessment or critical incident training approach.

- 5) Measures should be multi-level. What happened ? Why did it happen ?

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Summary of Aviation Training

- 6) Performance protocols need to support diagnostic learning.
- 7) Tools must be easy to use.
- 8) Involve the user in training development.
- 9) Training should be available for the instructor.

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Summary of Aviation Training

- Many protocols measure performance but do not provide sufficient detail to increase diagnostic analysis - What you see is all you learn.

- Training analysis tools must be easy enough to allow user and trainer driven exploration.

- The training analysis must be credible.

- The training system should enable the instructor and involve effective training measures related to tangible outcomes.

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Training Disasters

- Training systems must record vital information for diagnostic analysis of user performance - this aids future self-monitoring, review and evaluation.

- Training systems need to give built in feedback at time of action.

- Training systems must require limited expensive subject-matter experts but ensure effective self-tuition.

- Training systems may require effortful cognitive reconstruction of the events in a social environment that will foster effective team SMMs.

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Conclusions

- Being smart is not actually being smart per se.
- Being smart and useful involves maintaining an effective management of resources.
- The interrogative approach to training brings confidence and trust.
- An interrogative approach to operation creates a barrier where the response is pre-emptive and not reactive.

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Conclusions

- Most human interaction with complex systems is adaptive.

- Often processes or procedures to increase the balance of negative and positive outcomes results in re-adjustment to maximize +ve gains (Rasmussen, 1999).

- Adaptation is a slow process of Behavioural Evolution which may go unnoticed in operations.

- Training needs to re-instantiate the willingness to learn.

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Conclusions

- Novel situations can be catastrophic for fixed systems and modes of operation.

- Training can afford the opportunity to train recognition of such events and potential mitigating responses.

- In addition training can create the skills to cope with the experience of such events.

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Goals and Training

- Knowledge

- Cognitive Resource Management

- Self-Awareness and Team-Awareness

- Create Motivation to Learn

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