Background for

Cognitive Models of Operators

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Purpose of Operator Modeling

- Human-Machine System Design
  - To provide rapid prototype simulator to examine human operator performance as a function of human interface design.
  - To provide human-factors-related design requirements input from earlier stage of system concept development.
- Decision Aiding
  - To design intelligent, adaptive operator decision aiding system.
- Training
  - To improve existing operator training material based on the cognition model of skilled operator.

…, And

- Application for Artificial Intelligence (AI)??

Model Types (1) : Normative v.s. Descriptive

- Normative Model
  - describes how people ought to perform cognitive tasks
- Descriptive Model
  - describes how people actually perform cognitive tasks

Ex.: Conjunction Fallacy (Tversky & Kahneman, 1983)

Linda is 31 years old, single, outspoken, and very bright. She majored in philosophy. As a student, she was deeply concerned with issues of discrimination and social justice, and also participated in anti-nuclear demonstrations.

Which statement has higher probability of being true?

A. Linda is a bank teller.

B. Linda is a bank teller and active in the feminist movement.

The statement A always has higher probability than (or equal probability to) the statement B because of joint probability theory ($P(X) \geq P(X\&Y)$); thus A is the correct answer.

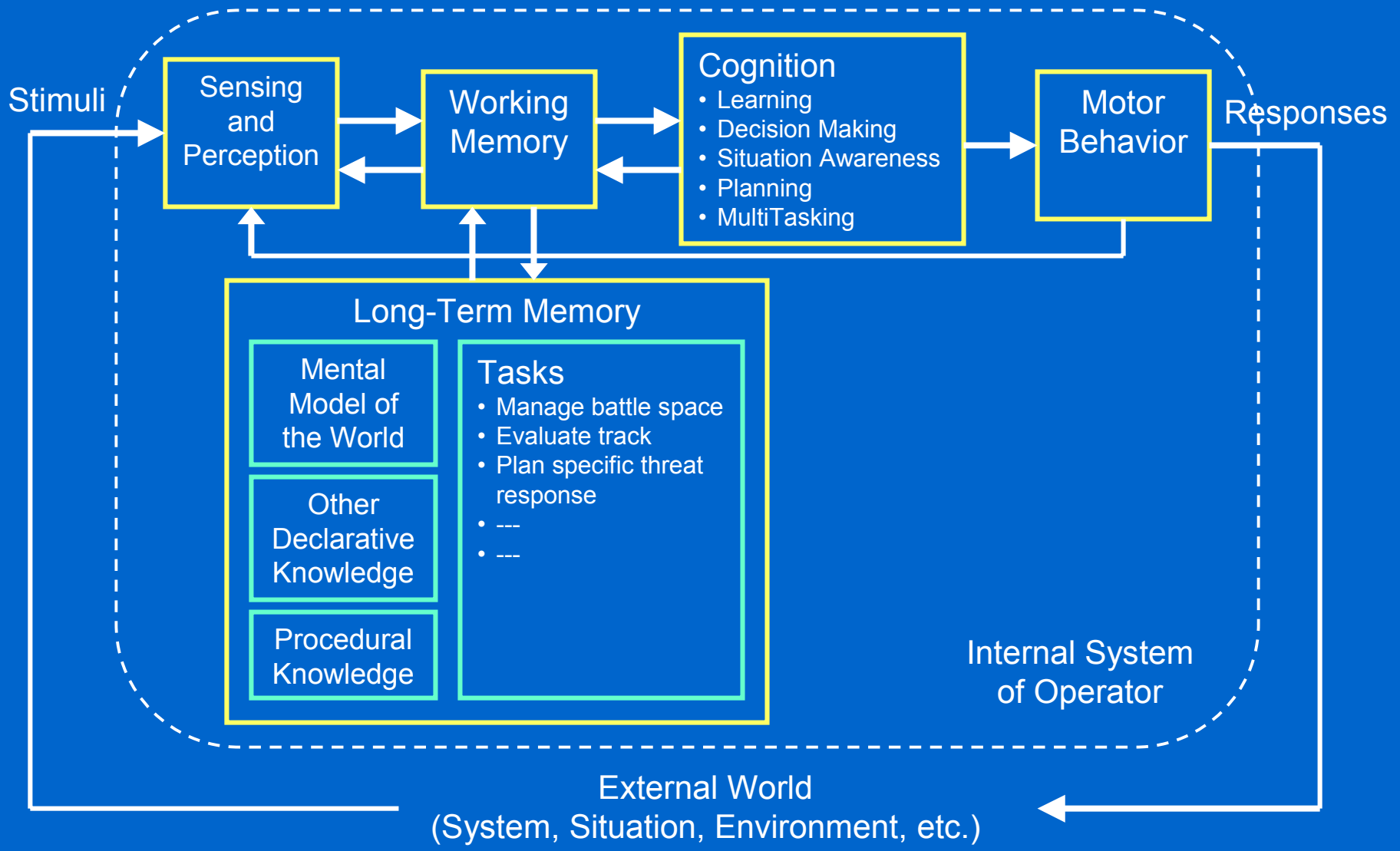
Model Types (2) : Modeling Approach

- Reductionist Model
  - uses human/system task sequence as the primary organizing structure.
  - *Task Network Model (e.g., Micro Saint), Petri Net*

- First Principle Model / Cognitive Process Model / Production System Model
  - is structured around an organizing framework that represents the underlying goals and principles of human performance.
  - *MIDAS, COGNET, ACT-R, EPIC, SOAR*

- Connectionist Model
  - Attempts to find some mathematical relationship between input and output.
  - *Neural Network, Regression*

Typical Model Structure



Various Operator Models

Model	Original Purpose	Application Examples
Micro Saint	Evaluate systems and procedures	Military simulations Automated bank teller system design
ACT-R	Modeling problem solving and learning	Various problem solving models Human memory Learning
COGNET	Develop user models in intelligent interfaces, surrogate users and adversaries	Vehicle tracking Intelligent tutoring system for military Military simulations Teamwork and cooperation simulation Workstation design for telephone operator
EPIC	Develop and test theories of multiple task performance	Dual tracking/stimulus-response task Computer interface menu search Telephone operator call-completion task
MIDAS	Evaluate interfaces and procedures	Military simulations Flight deck, ATC procedure simulations Space shuttle cockpit display improvement
SAMPLE	Evaluate crew procedures, equipment	Airliner cockpit procedure examination Nuclear power plant automation evaluation Air combat situation awareness analysis
SOAR	Model problem solving and learning	Problem solving Learning
Neural Net	Multiple constraints, satisfaction in memory, language, thought, pattern recognition	Unsupervised learning model Pattern recognition

Papers

Micro Saint, MIDAS:

Laughery, K. R., Jr., & Corker, K. (1997)

"Computer Modeling and Simulation"

In *Handbook of Human Factors and Ergonomics*, Gavriel Salvendy (Ed.), pp. 1375-1408.

COGNET:

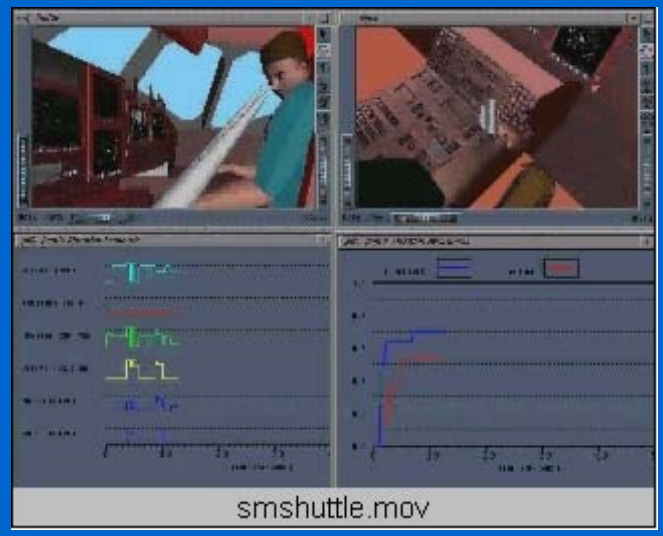
Zachary, W. W., Ryder, J. M., & Hicinbothom, J. H. (1998)

"Cognitive Task Analysis and Modeling of Decision Making in Complex Environment"

In *Decision Making Under Stress: Implications for Training and Simulation*, Cannon-Bowers, J., & Salas, E. (Eds.), American Psychological Association, Wachington, DC.

MIDAS Man-machine Integration Design and Analysis System

http://caffeine.arc.nasa.gov/midas/index.html



SHUTTLE MIDAS

- Developed and supported jointly by the U.S. Army and NASA.
- Aims to
  - reduce design cycle time
  - support quantitative predictions of human-system effectiveness
  - improve the design of crew stations and their associated operating procedures.

COGNET

- Developed by CHI Systems Incorporated, PA
- Original purpose was to develop an intelligent decision-making support system in real-time multi-task environment based on the knowledge of the task domain and the operator's decision-making process.
- Three requirements for the system
  - psychological (i.e., descriptive)
  - computational (i.e., unambiguous)
  - operational
- "Pandemonium" metaphor
  - "shrieking demons" model for attention switching in multi-task situation
  - "blackboard" model for global problem representation
  - "perceptual demons" for changing problem representation by perceptual event

Limitation of Cognition Model

- Each of operator cognition models is tailored for a specific purpose by simplifying the system structure and restricting operation domain, and captures only subset of human behavior. These models are not meant to create a complete replica of human in software form.

Other References

- Summary of various operator cognition models
  - Pew, R. W., & Mavor, A. S. (Eds.) (1998), *Modeling Human and Organizational Behavior: Application to Military Simulations*, National Academy Press, Washington, D.C..
- MIDAS
  - http://caffeine.arc.nasa.gov/midas/index.html
- COGNET
  - Zachary, W., Ryder, J., Ross, L, & Weiland, M. (1992). Intelligent Computer-Human Interaction in Real-Time, Multi-Tasking Process Control and Monitoring Systems, Human Factors in Design for Manufacturability, Helander, M. & Nagamachi, M. (Eds.), pp. 377-401, Taylor and Francis, NY.
  - http://www.chiinc.com/cognethome.shtml