Human Factors in Medical Modeling and Simulation

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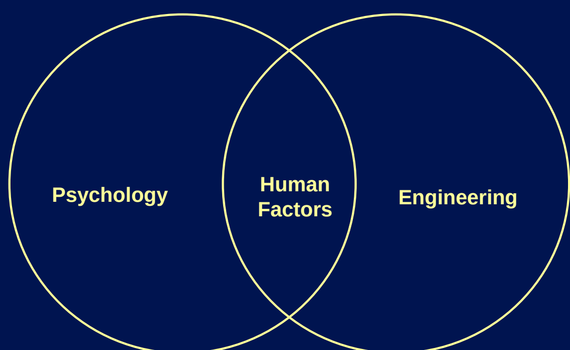
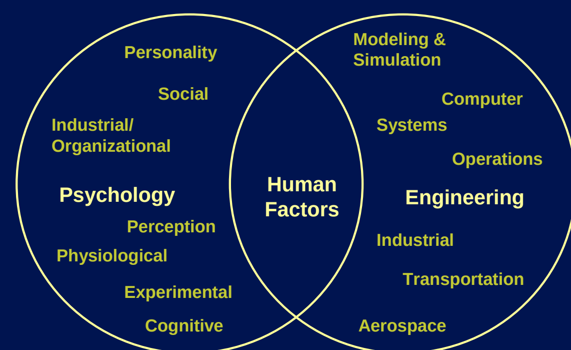
Human Factors Engineering

- ***a discipline concerned with specifying the capacities and limitations of the human and designing machines that accommodate the limits of the human user.***

Human Factors



Human Factors



GOALS OF HUMAN FACTORS

- **reduce errors**
- **increase safety**
- **increase reliability of systems**
- **reduce training requirements**
- **reduce personnel requirements**
- **improve maintainability**
- **increase efficiency**
- **increase productivity**
- **improve the working environment**
- **reduce fatigue and stress**
- **increase human comfort**
- **reduce boredom and monotony**
- **increase convenience of use**
- **increase user acceptance**
- **increase job satisfaction**
- **enlarge the job**
- **improve the quality of life**

Why Human Factors?

Why Human Factors?

- *To the human engineer, man is a thin flexible sack filled with thirteen gallons of fibrous and gelatinous material, inadequately supported by an articulated boney framework. Surmounting this sack is a bone box filled with a gelatinous matter attached to the sack by means of a flexible coupling of bony and fibrous composition (Stapp, 1948).*

Human Factors is just good common sense!

Pop Quiz True or False

1) Assess the user population and design for the average user.

2) When you install a light switch, the lever should move up to turn on the light.

3) Practice makes perfect.

4) Good design means getting it right the first time.

5) Initial performance is a good predictor training success.

Pop Quiz True or False

1) Assess the user population and design for the average user. (False – Bailey, 1996)

2) When you install a light switch, the lever should move up to turn on the light. (False – Wickens, 1992)

3) Practice makes perfect. (False – Schneider, 1985)

4) Good design means getting it right the first time. (False – Gould et al., 1987)

5) Initial performance is a good predictor training success. (False – Schneider, 1985)

History of Human Factors

- The early 1900s:
  - Taylor, Gilbreth – Task analysis and work efficiency studies
  - Mayo - Hawthorne studies of lighting and work productivity
- 1940s:
  - WWII, the problem of vigilance
  - AT&T Bell Laboratories
- 1960s:
  - Aerospace program
- 1970s – 1980s:
  - Human-computer interface
  - Usability engineering
- 1990s - 2000
  - World Wide Web and e-commerce

Major Human Factors R&D Topics

- Accidents, Safety, & Human Error
- Aerospace Systems
- Attentional Processes
- Automation, Expert Systems
- Biomechanics, Anthropometrics, and Work Physiology
- Cognitive Processes
- Cognitive Engineering
- Communication Systems
- Computer Systems
- Consumer Products, Tools
- Displays & Controls
- Health & Medical Systems
- Individual Differences
- Macroergonomics and the Environment
- Manufacturing, Process Control Systems
- Psychological States
- Psychomotor Processes
- Sensory & Perceptual Processes
- Simulation & Virtual Reality
- Surface Transportation Systems
- Training, Education, & Instructional Systems

Human factors methods for simulation and training

Problems in Medical Simulation

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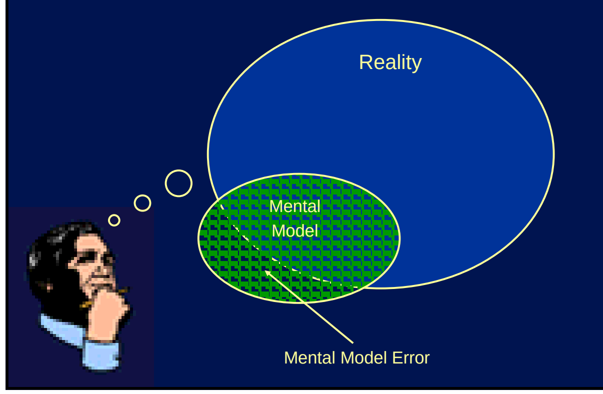
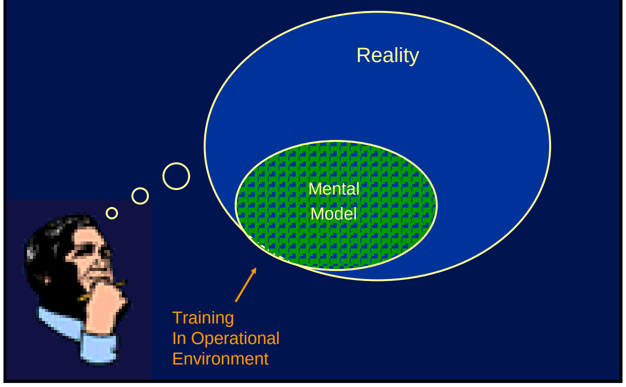
Training Transfer

Reality, Training, Mental Models, and Simulation



Reality, Training, Mental Models, and Simulation



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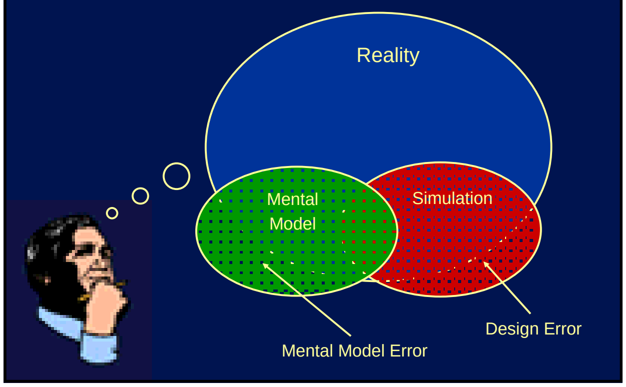

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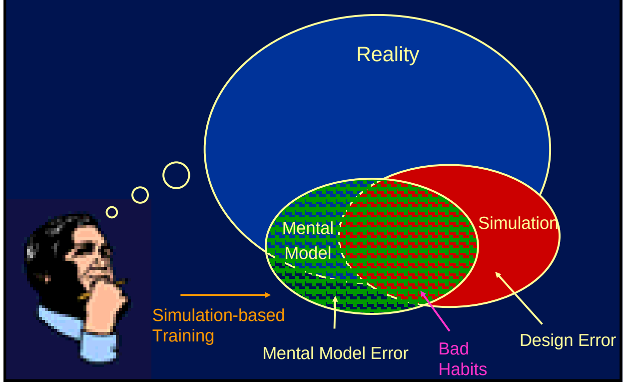

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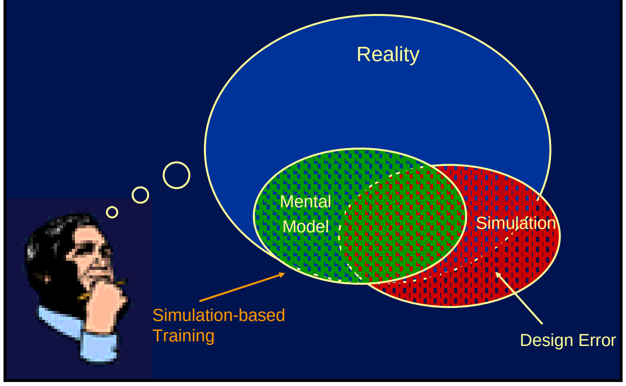

Training Transfer

- Identical elements
- Transfer through principles
- Fidelity
  - Physical
  - Functional

Training Transfer

- Learning theory
- Individual differences
- Goals
  - Skill acquisition
  - Retention

Measuring Training Transfer

- Time savings
  - $(Z_{control} – Z_{train})/Z_{control}$ X100
- Transfer Effectiveness Function
  - $(Y_{control\text{-}criterion} – Y_{train\text{-}criterion})/X_{simulator\text{-}train}$
- Transfer Cost Ratio
  - Cost in Op. Env./Cost with Simulator

A Comparison of CathSim™ and Simulated Limbs for Training Phlebotomy

(Scerbo, Bliss, Schmidt, & Thompson, in press)

Problems in Medical Simulation

- Prior to 2002 – no data regarding validity of medical simulators
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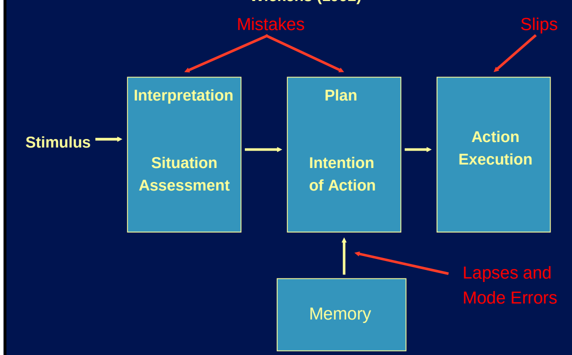
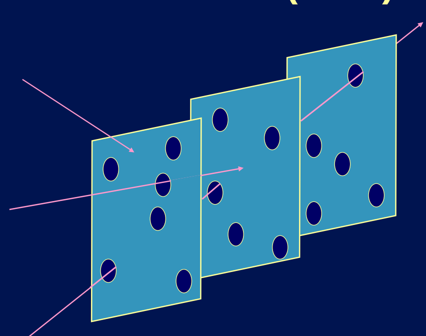
- Focus on performance improvement without understanding the nature of human error

Model of Human Error

Wickens (1992)



James Reason's (1990) Model

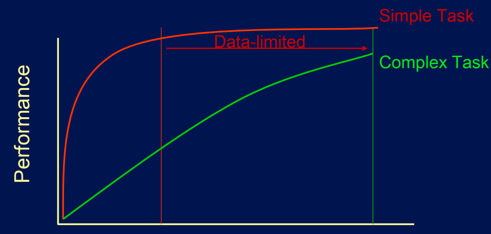


Planes of Unsafe Acts

Attentional Resources and Workload

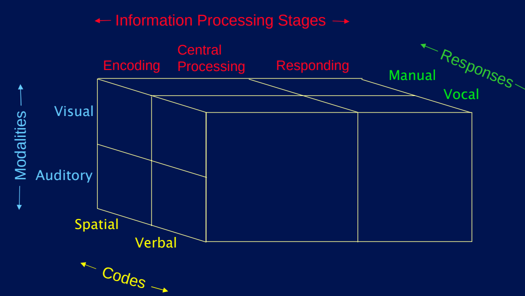
Performance Resource Function

(Norman & Bobrow, 1975)



Multiple-Resource Theory

(Wickens, 1984)



Problems in Medical Simulation

- Prior to 2002 – no data regarding validity of medical simulators
- Post 2002 – focus on validity, *not* training transfer
- Focus on performance improvement without understanding the nature of human error
- On the horizon…

Problems in Medical Simulation

- Drive toward more complex automated surgical systems.

Complex Automated Systems

Be careful what you wish for!

Complex Automated Systems

- Increase passive monitoring demands at the expense of active involvement.
- Can induce complacency.
- Often result in “automation surprises”.
- Fail in a less predictable manner.
- Problems propagate more quickly through highly couples subsystems.

The Big Picture

Improving Human Performance

Improving Human Performance

- Enhancement
- Augmentation
- Removal of impediments

Improving Human Performance

- Enhancement – training and education
- Augmentation – external aids
- Removal of impediments – work environment

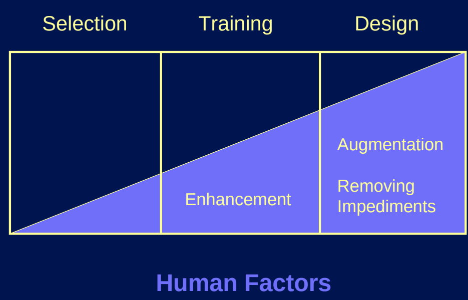
Improving Human Performance

Selection	Training	Design

Improving Human Performance

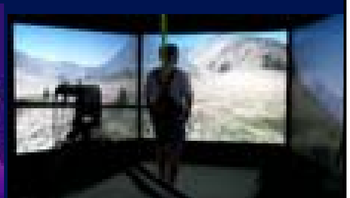
Selection	Training	Design
	Enhancement	Augmentation Removing Impediments

Improving Human Performance



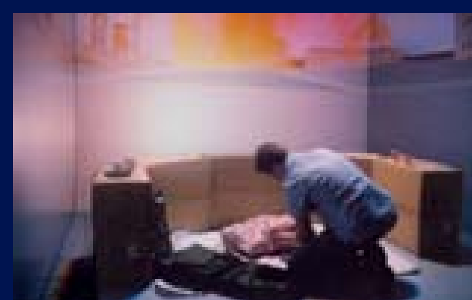
Performance within the Work Environment

CAVE Immersive Virtual Environment



An Examination of Surgical Procedures under Simulated Combat Conditions

(Scerbo, Weireter, Bliss, Schmidt, & Hanner-Bailey, 2005)



Virtual Environments

- Virtual environments (VEs) allow us to study training, external aids, and the work environment all one place. VEs can be developed to address an unlimited range of scenarios including:
  - Operating rooms
  - Trauma/emergency rooms
  - Intensive care operations
  - Mobile emergency medical response
  - Natural and man-made disasters resulting in mass casualties

Thank You!

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