Human Factors Engineering and Patient Safety in the Clinical Setting

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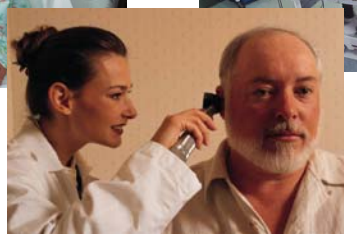
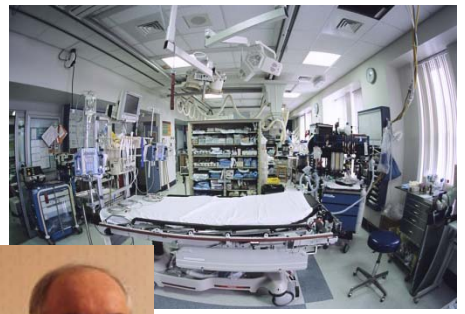
Human Factors Engineering and Patient Safety in the Clinical Setting

- Objectives for today:
  - Understand basic human factors concepts
  - Understand how to assess clinical processes/areas related to human factors in order to reduce errors

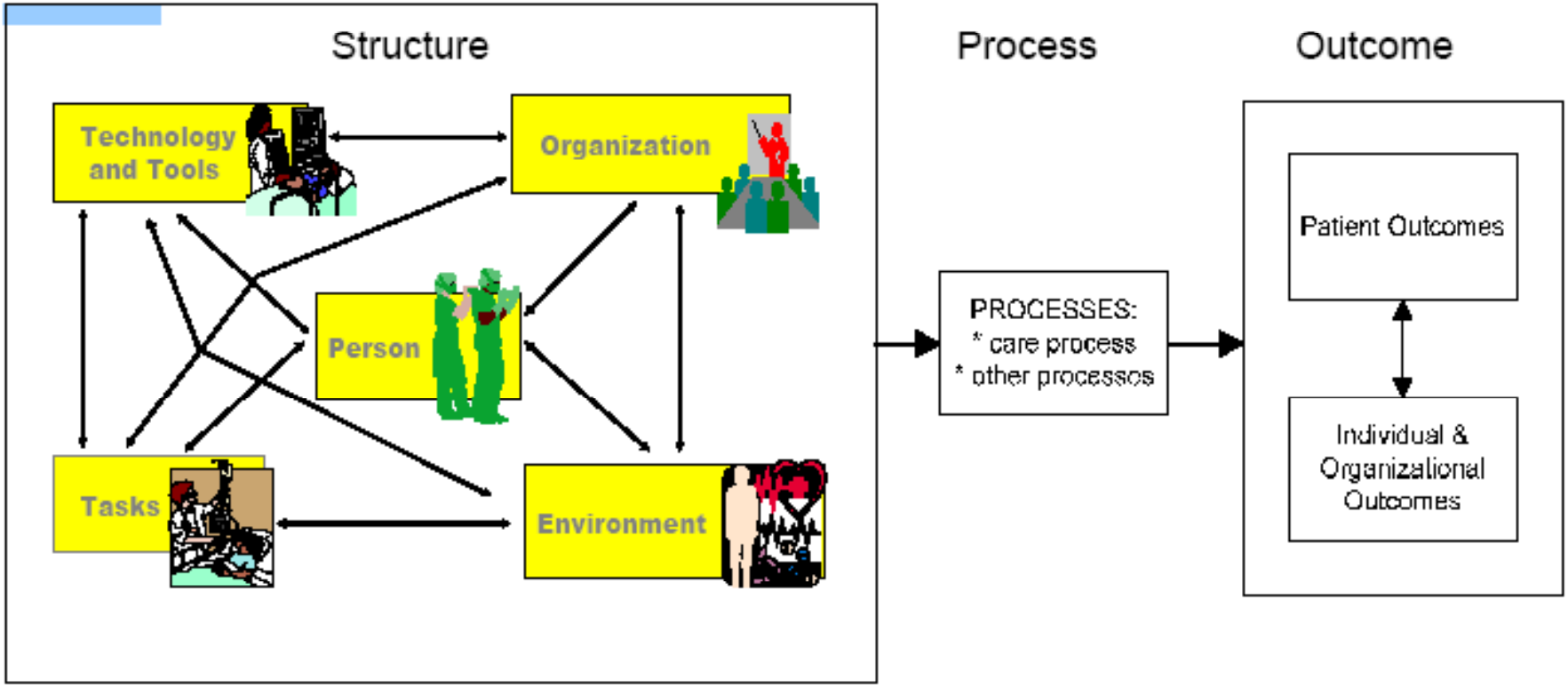


Patient Safety Frameworks

- Latent and active failures – Reason/Rasmussen
  - Active =slips/trips/mistakes vs. Latent = decisions made by management/engineers/designers
- Organizational accident model – Vincent et al
  - Latent failure model; workload, supervision, communication, equipment, knowledge & skill ; Operating at near maximum capacity – production pressure
- International classification
  - Incidents categorized – HAI; medication & blood products
- High Reliability Organization (HRO) Approach – mindful interactions; continuously preoccupied with failure
  - Reporting of errors/near misses; Learning from failures; Changing and uncertain work systems
- System Engineering Initiative for Patient Safety (SEIPS) model – structure, process, outcome

SEIPS System Model



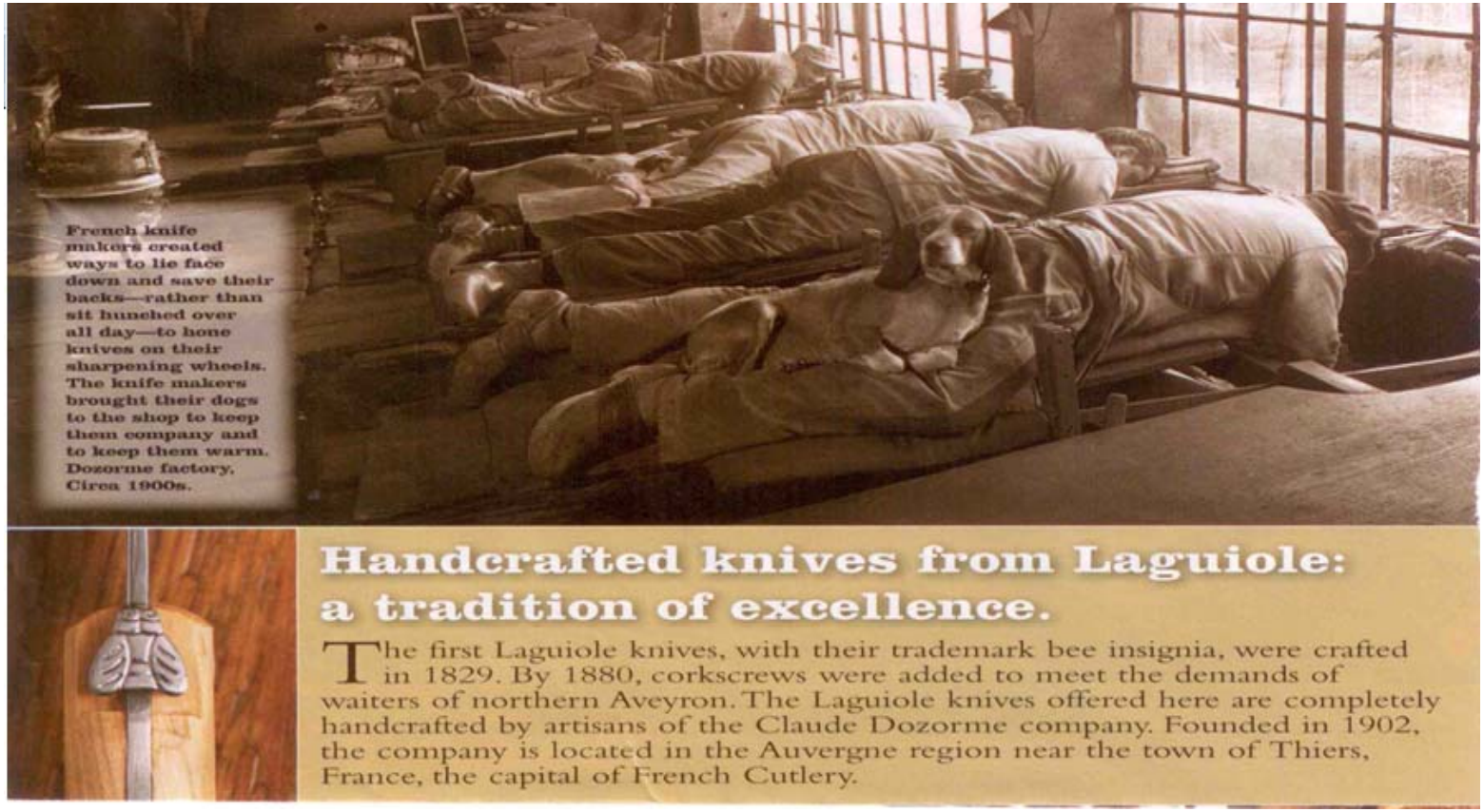
Carayon, P., Alvarado, C., Brennan, P., Gurses, A., Hundt, A., Karsh, B., and Smith, M., (2003). Work system and patient safety. Proceedings of Human Factors in Organizational Design and Management-VII 583-588.

Human Factors Engineering

- What Is It?
  - Discovers and applies information about human behavior, abilities, limitations and other characteristics to the **design** of tools, machines, systems, tasks, jobs, and environments for productive, safe, comfortable and effective human use.
  - Designing the fit between people and products, equipment, facilities, procedures, and environments (Karsh, 2007)
  - **Objective:** Reduce errors, fatigue, stress, and injuries at work
    While....
    Improving productivity, ease of use, safety, comfort, acceptance, job satisfaction, and quality of life (Karsh, 2007)
- Recognizes that humans are fallible, and often overestimate their abilities and underestimate their limitations.

Human Factors Engineering

- Changing the world to fit the human being…not changing the human to fit the world in order to decrease the opportunity for errors



Human Factors Engineering and Patient Safety in the Clinical Setting

- Three major elements in the production of errors:
  - Nature of task and the environment
  - Performance of task
  - The individual/human being

- At the center.....people
  - "Highly variable"
  - "Flexible"

"Highly Variable"
"Flexible"

Physical size and shape → *Anthropometry* – the physical measure of man

Sleep
Nutrition
Perception (Input)
Environmental Tolerance
→ Biology and Physiology

Information Processing → Psychology

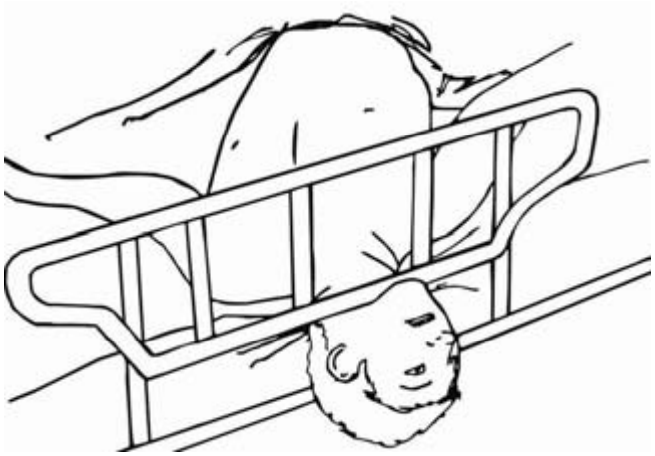
Actions (Output) → *Biomechanics* – Quantification of loads and forces on the human body during work

"Highly Variable"
"Flexible"

Physical size and shape → *Anthropometry* – the physical measure of man

FDA Hospital Bed Dimensional Limit Recommendations

Zone 2 – under rail, between rail <4 ¾"



Head:
Female 5th Percentile

Zone 4 - under rail, at ends of rail <2 3/8"

Neck:
Female 1st Percentile

Courtesy of VA NCPS

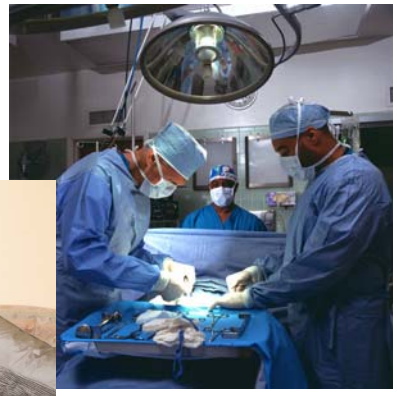
"Highly Variable"
"Flexible"

Physical Size and Shape
Basic Biomechanical Concepts

- Transferring patients from one location to another was the most stressful tasks ergonomically
  - Toileting; Bed transfers/bed-chair transfers; Bathing
- HFE solution:
  - Enough lift equipment
  - Workloads to allow for assistance from others
  - Lift equipment hard wired into place

Physical Size and Shape Biomechanical Issues Examples

- Others at risk in multiple settings due to:
  - Repetitive movements
  - Materials handling -moving heavy equipment/trays/Lifting excessive weights
  - Working postures– (surgery; home health; nursing; others)
  - Static loading
  - Workplace layout

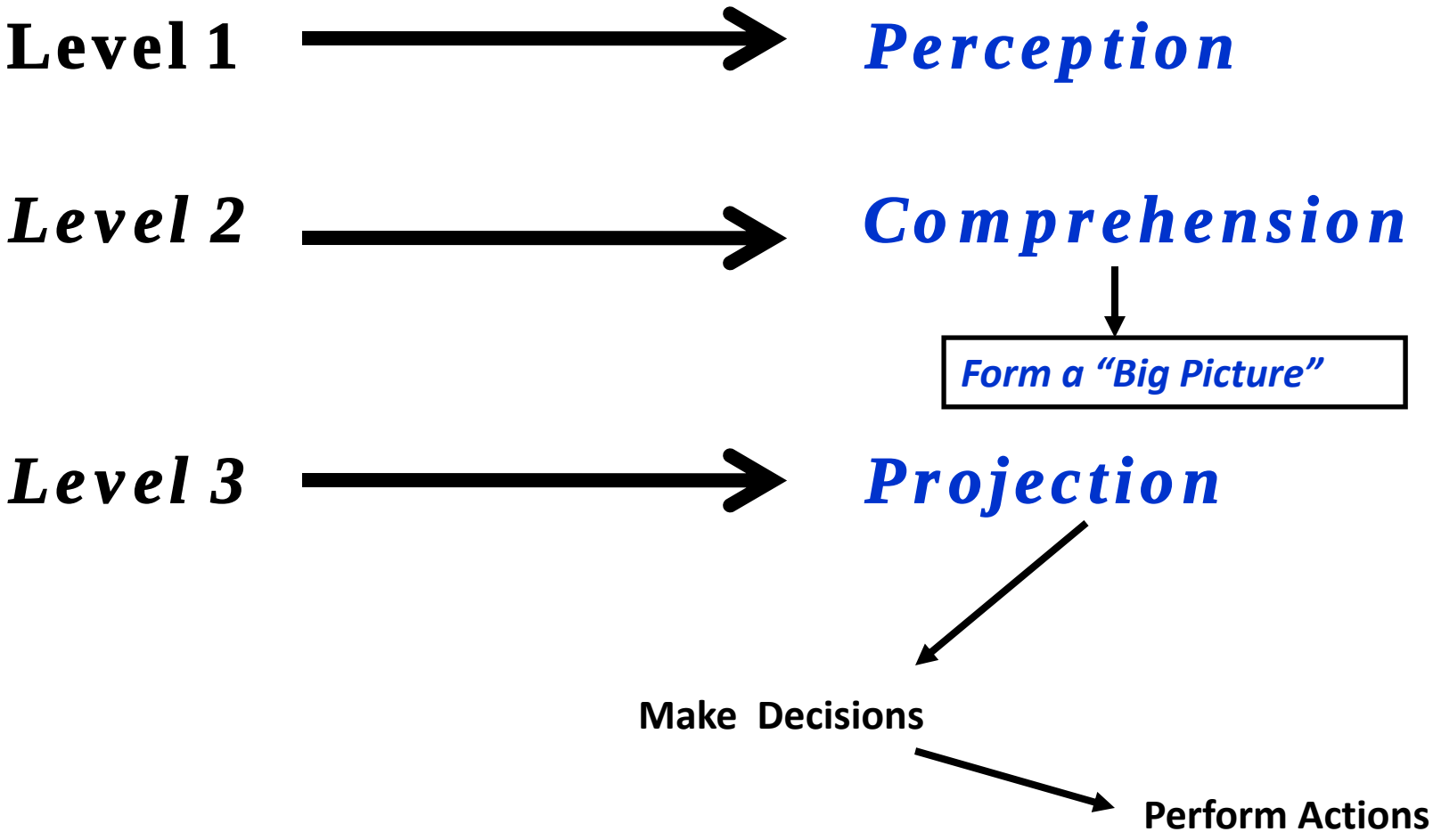


Information Processing

Human

“Highly Variable”
“Flexible”

Levels of Situational Awareness



Level I

Perception

Level II

Comprehension

Human Attention
Attentional
Capture
&
Selective Attention

Working Memory
The amount of information we can maintain and manipulate mentally at any point in time

Attention and Working Memory affect each other

Limited Resource

Limited Resource
Approximately 5 - 7 "chunks"
Rehearsal Interference
Decay rates < 20 seconds

Courtesy of VA NCPS

Attentional Narrowing

Eastern Flt 401 December 29, 1972 **Fatalities 99**

Courtesy of VA NCPS

Threats In The Clinical Environment

Stressors in the Clinical Environment

→

Noise
Fatigue
Interruptions
Patient Load
Emergencies

↓

↓

Limited
Attention
Working Memory

↓

Attentional Narrowing

←

Mis-Diagnosis

Medication Error

Fall with Injury

Wrong Site Surgery

Failure to Rescue

Courtesy of VA NCPS

HFE Solution:

Supporting Attention & Working Memory

- Put knowledge in the world vs. head
  - Checklists
  - Links to information embedded in EMR
- Reduce linguistic interference
  - Background music - lyrics to songs
  - Overhead paging
  - Conversations
- Avoid similar information (creates confusion)
  - 693 – 1392 vs. NYE – 1392
  - “look alike” / “sound alike”

HFE Example:
ARE THESE MEDICATIONS THE SAME?

HFE Solution:
BCMA Eliminates These Errors


BAUSCH & LOMB
NDC 24208-585-64
Tropicamide Ophthalmic Solution USP, 1%
STERILE OPHTHALMIC SOLUTION
Rx only
15 mL
BAUSCH & LOMB
NDC 24208-735-06
Cyclopentolate Hydrochloride Ophthalmic Solution USP, 1%
STERILE OPHTHALMIC SOLUTION
Rx only
15 mL
BAUSCH & LOMB
Tropicamide Ophthalmic Solution USP, 1%
Rx only
15 mL
BAUSCH & LOMB
Cyclopentolate Hydrochloride Ophthalmic Solution USP, 1%
Rx only
15 mL

HFE Solution:

Supporting Attention & Working Memory

- Support “Chunking”: 999 – HELP
  - Avoid > 5 chunks
  - Letters generally better than digits
- Allow for frequent “dumping” of working memory after rehearsal
  - Process and equipment
- Adequate Resources
  - Task Load Division

Supporting Long Term Memory

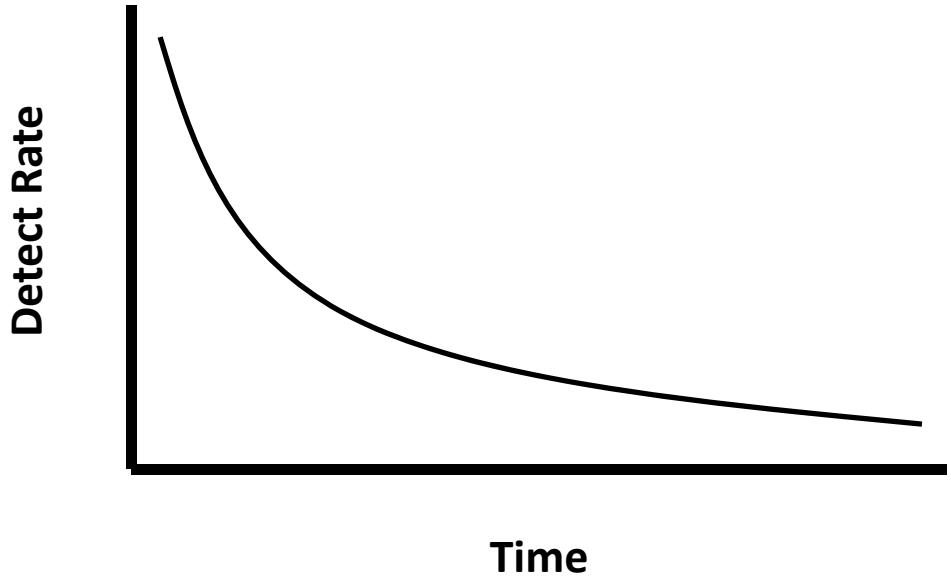
- Checklists
  - Put information in the environment vs. in the head
  - Recognition is better than recall

- Checklist Philosophy
  - “Read and Verify” checklists
  - “Read and Do” checklists

Human Vigilance

- Overall not effective

- **Vigilance Decrement –** the decrease in probability of detecting a signal



Vigilance Degraded By:

- Event happens infrequently
- Low probability event
- Salience of event
- Fatigue

HFE Solution:

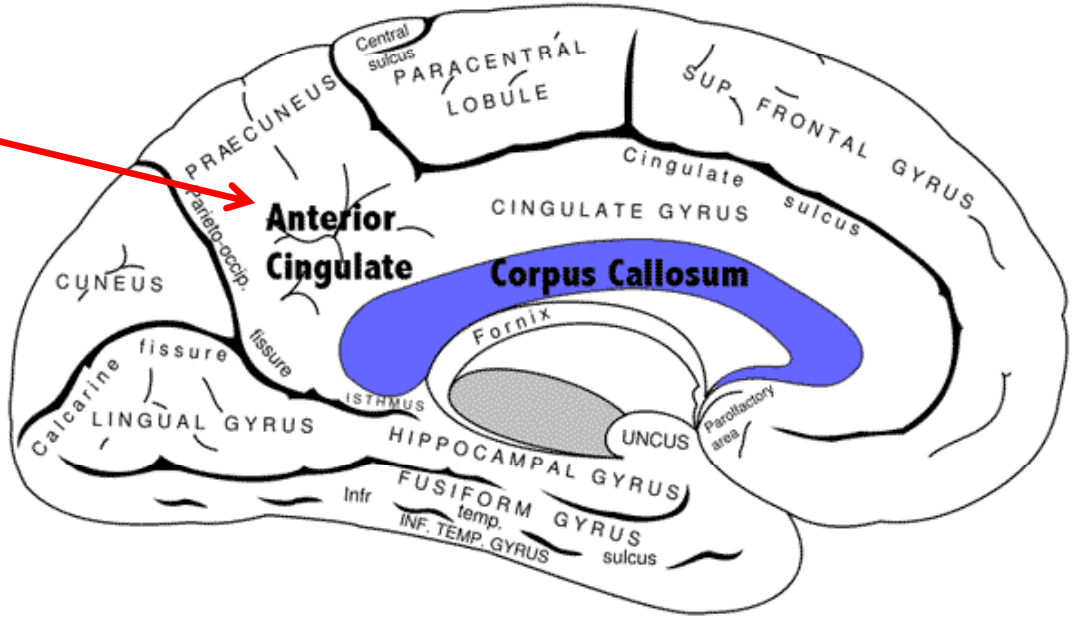
Alarms and Alerts Maximizing Attention Capture

- Rotate personnel
  - e.g. monitor techs/security cameras
- Visual alerts should flash and be close to person's forward view ⟶ **Better**
- Sounds and Tactile
- Abrupt onset - should convey urgency
- Graded alerts
- Meaningful – should provide **Raw Data**
- Threshold dilemma
  - Tornado warning false alarm rate for NWS = .76
  - Fire Alarms

Information Processing

Stroop Effect

Conflict resolution



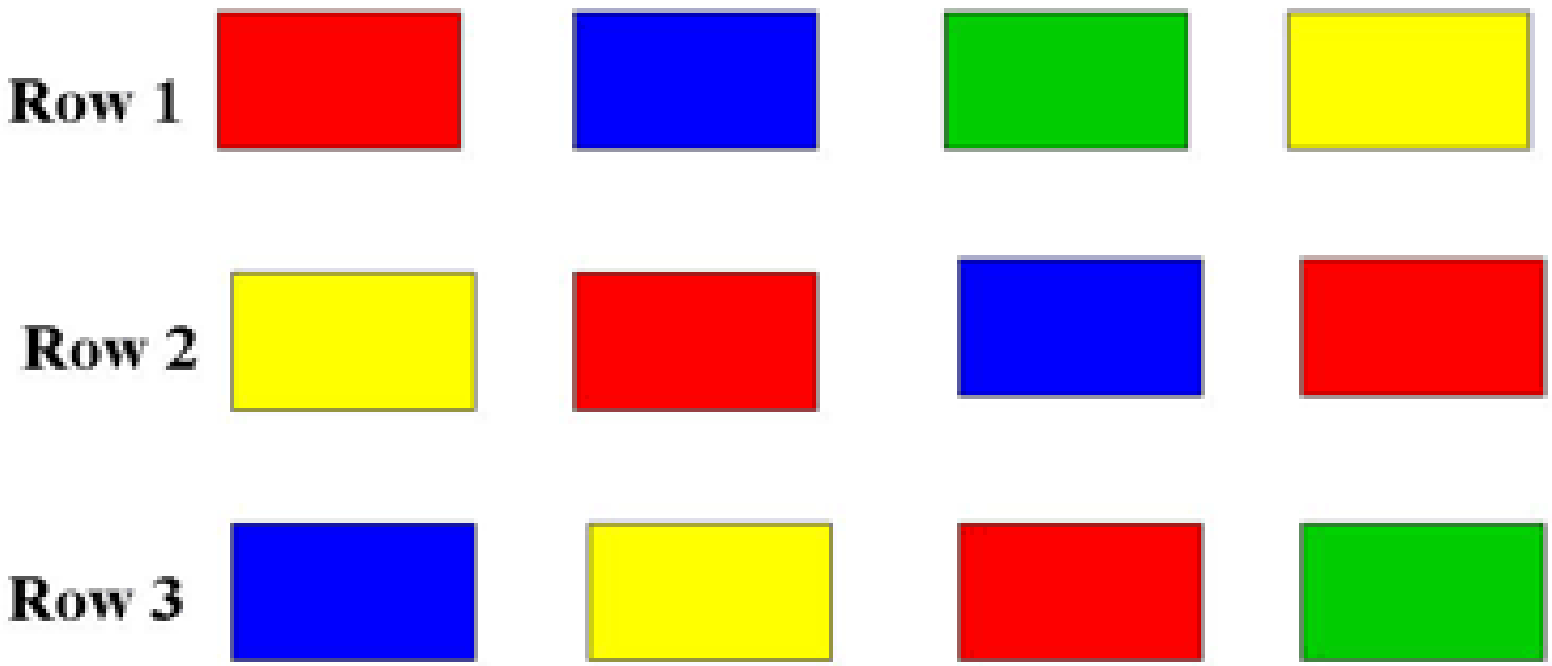
- **Automatic Processing vs. Conscious Purposeful Processing**

- Conflict creates interference and requires that we direct and manage our attention = **delay and error**

- Interpreting written language in the context of conflicting visual stimuli

Demonstration: Stroop Test

State the colors as fast as you can



From John Gosbee, MD, MS, VA National Center for Patient Safety

Now state the colors as fast as you can

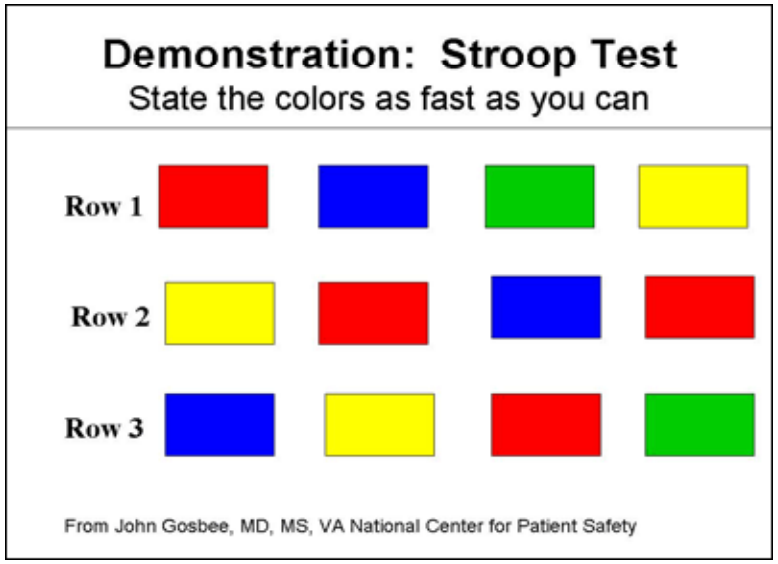
Row 1	Red	Blue	Green	Yellow
Row 2	Yellow	Green	Blue	Red
Row 3	Green	Red	Yellow	Blue

From John Gosbee, MD, MS, VA National Center for Patient Safety

Again, state the colors as fast as you can

Row 1	Red	Blue	Green	Yellow
Row 2	Yellow	Green	Blue	Red
Row 3	Green	Red	Yellow	Blue

From John Gosbee, MD, MS, VA National Center for Patient Safety



6.9 seconds

3.9 seconds

7.8 seconds

HFE Solution:

Stroop Effect

- Monitor the clinical area for the way information is presented
  - Are there tasks that require a large amount of directed attention that could be simplified?
  - Are there conflicts in the way information is presented?
  - Does the symbology make sense?

Labels

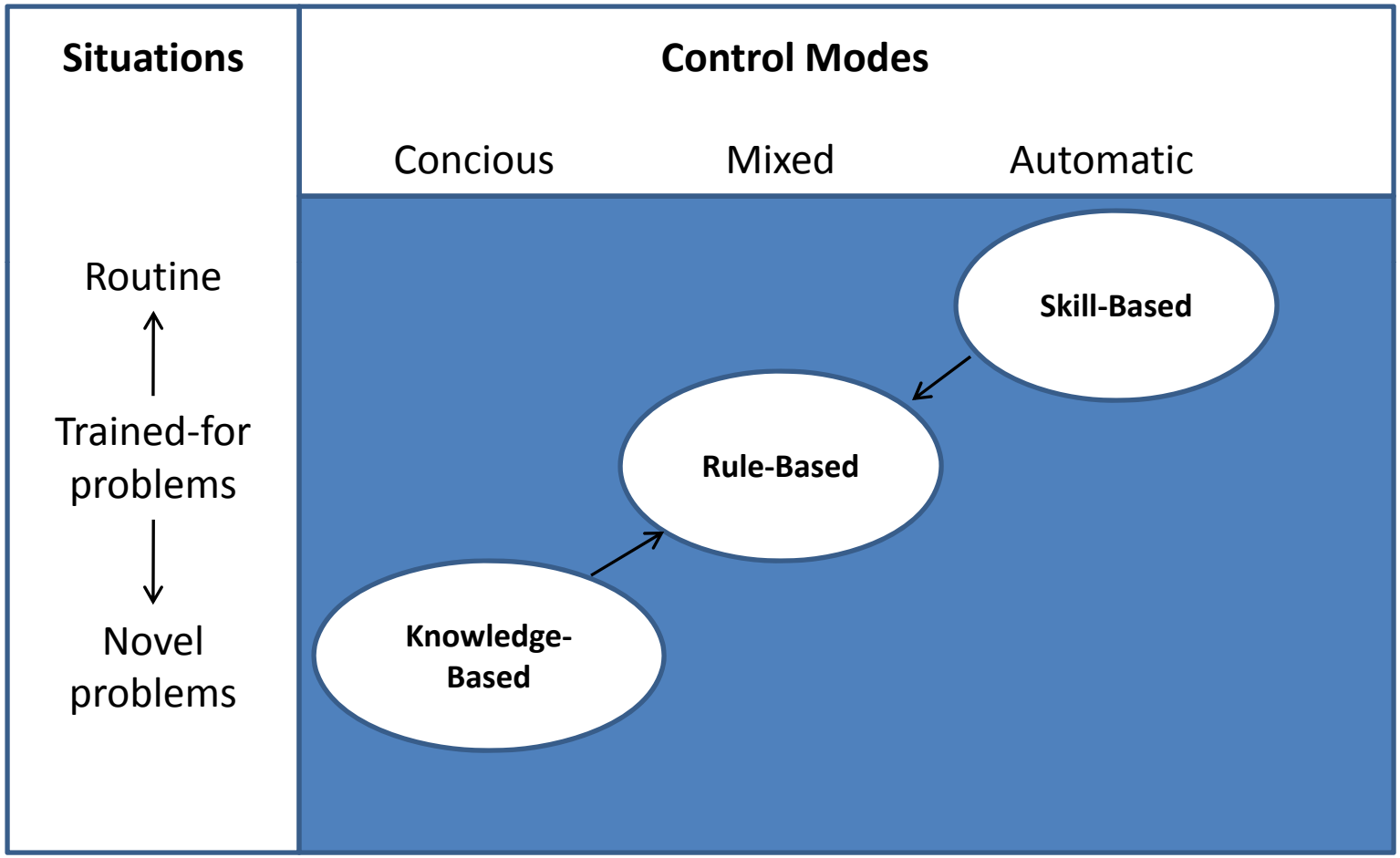

ISAGEL
Drug Facts
Active ingredient
Purpose
Uses
Warnings
Coloplast
DISPENSING SYSTEM


ALCOHOL
HAND
GEL
Coloplast
DISPENSING SYSTEM

Tasks - How We Perform

- Conscious Mode – what we do when we “pay attention” to a task
  - Restricted capacity, slow, sequential, error prone, potentially very smart
  - Used for “paying attention”
  - Attention is limited; if used for one thing, it is withdrawn from another
- Automatic Mode – opposite of conscious mode in all respects/largely unconscious
  - Virtually limitless capacity; very fast; does many things at once rather than sequential; handles recurrences of everyday life; not a general problem solver

Tasks - How We Perform
Three Dimensions of Performance



James Reason Managing the Risks of Organizational Accidents (1997)

Slips/Lapses & Mistakes

- Slips/lapses - Inadvertent, unconscious lapses in performance of an automatic task
  - Forgot to put the bed alarm on….patient falls
  - Meant to stop to buy shoes on the way home and discover you have driven straight home instead
  - Occur most often when we put an activity on “autopilot” so we can manage new sensory inputs, think through a problem, or deal with an emotional upset
- Mistakes result from incorrect choices
  - Don’t blunder into them when distracted
  - Result from insufficient knowledge, lack of experience or training, inadequate information, or applying the wrong set of rules to a decision

Perception and Attention Implications for Design

Example:
Nurse administers wrong type of insulin to patient. Insulin bottles look identical except for one letter/symbol on the label.

Example:
Nurse hangs insulin rather than heparin on the bedside infusion pump.
Both IV bags are the same size, shape, and clear liquid color. Labels are cluttered and use small font.

HFE Solutions:

Reduce distractions during critical tasks

Labeling


DANGER!
THIS MAGNET IS
ALWAYS ON

Would this get your attention?

Another Safe Guard

Novel approach to “helping” staff remember to wash their hands.

Hardware and Design

Evaluating Design, Displays and Controls

Human

“Highly Variable”
“Flexible”

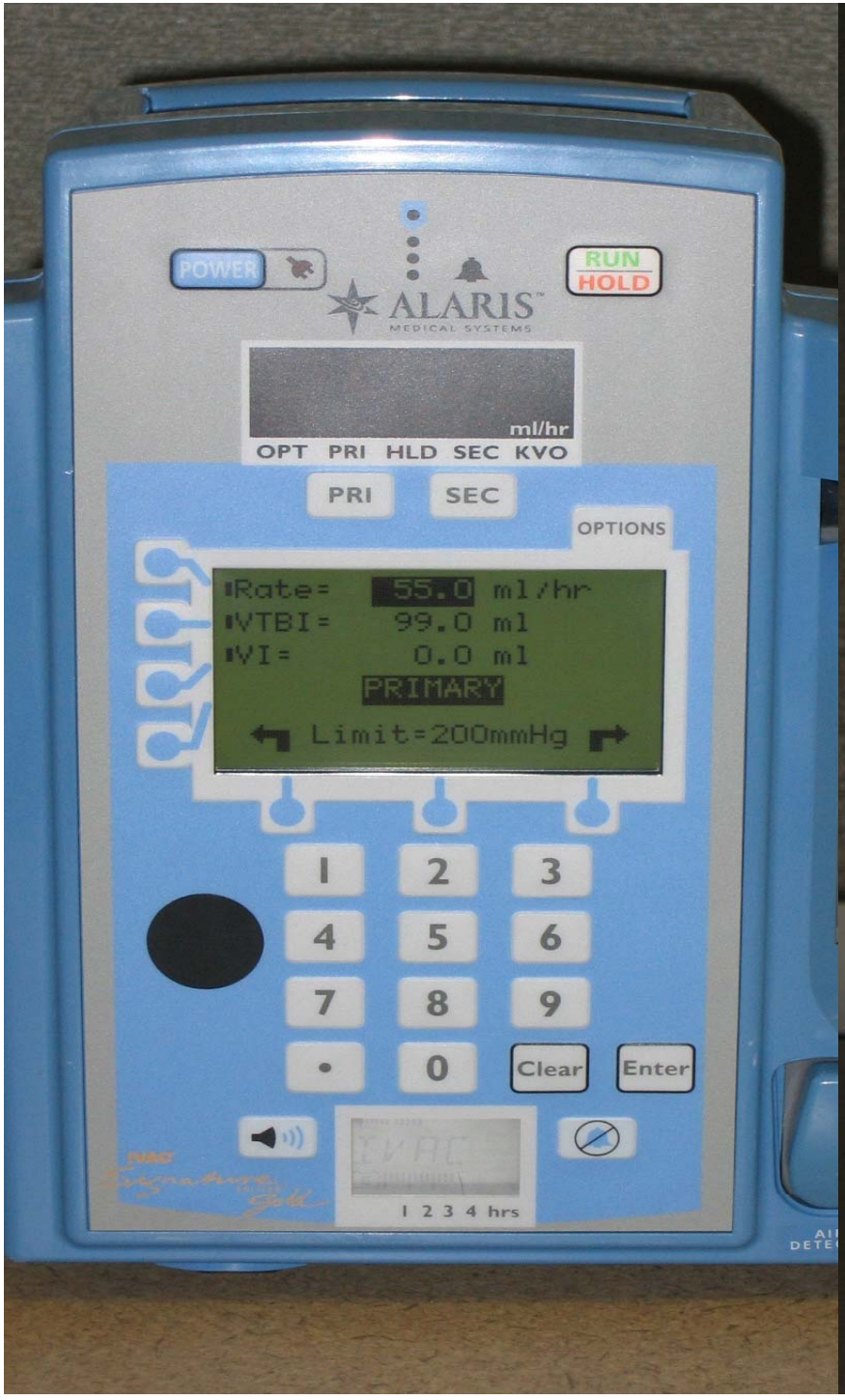
Standardization / Unknown Design Changes

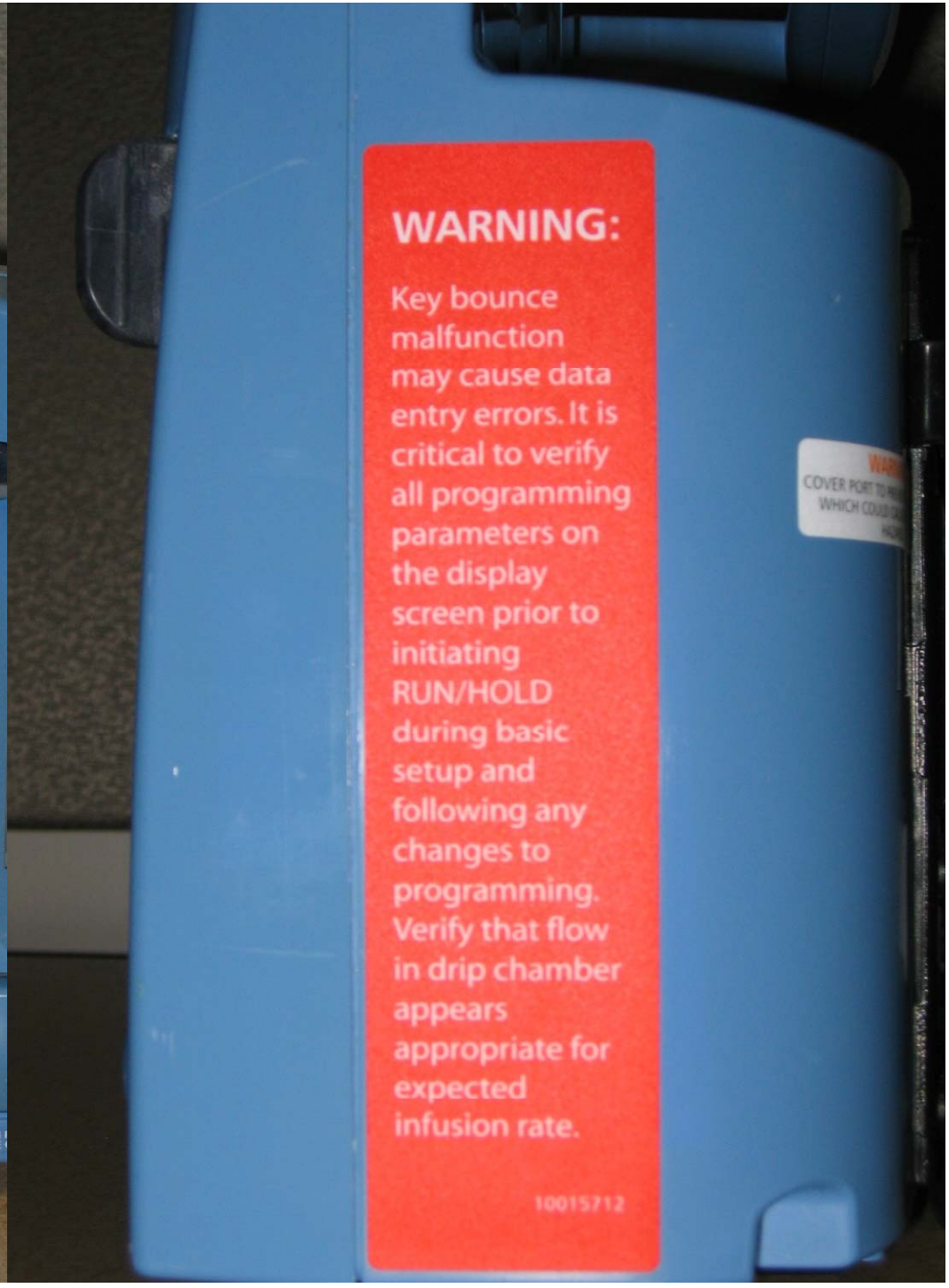
Clinical Information Center (CIC) physiological monitoring –

"Factory" design has *'Alarm Silence' key in* upper right

'Power' button in the same spot on replacement Keyboard

Peter A. Doyle Ph.D. Clinical Engineering Services
The Johns Hopkins Hospital


POWER
RUN
HOLD
ALARIS
MEDICAL SYSTEMS
ml/hr
OPT PRI HLD SEC KVO
PRI
SEC
OPTIONS
Rate= 55.0 ml/hr
VTBI= 99.0 ml
VI= 0.0 ml
PRIMARY
Limit=200mmHg
1 2 3
4 5 6
7 8 9
• 0
Clear
Enter
1 2 3 4 hrs


WARNING:
Key bounce malfunction may cause data entry errors. It is critical to verify all programming parameters on the display screen prior to initiating RUN/HOLD during basic setup and following any changes to programming. Verify that flow in drip chamber appears appropriate for expected infusion rate.
10015712

www.webmm.ahrq.gov

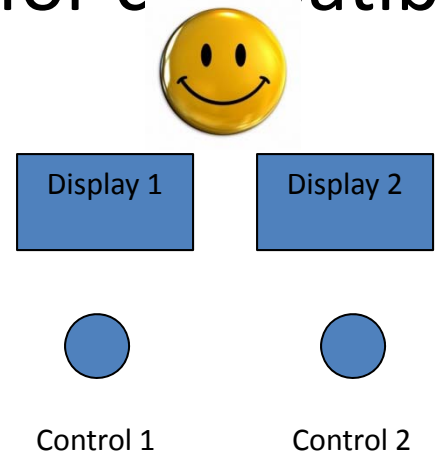
Natural Mapping and Devices

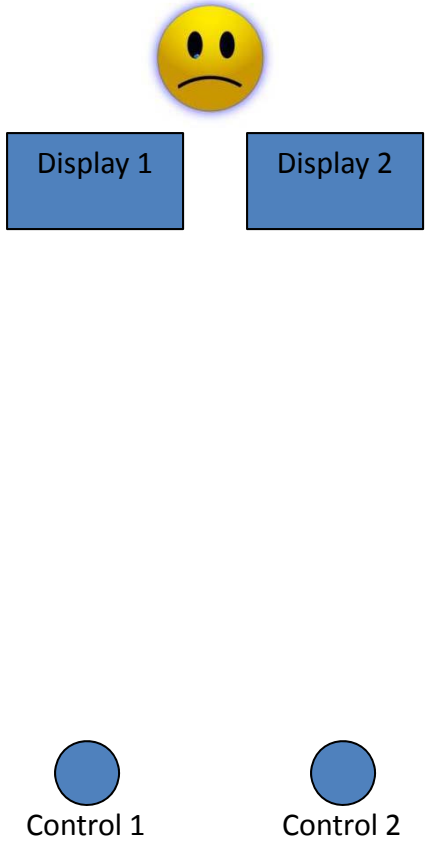
- Mapping
  - The relationship between a **control** and its **movement** and the **result** in the world

- Natural Mapping
  - Designing a device in a manner that leads to **immediate understanding** of which control to move, and how to move it, to obtain a desired result

Device Display – Control Compatibility

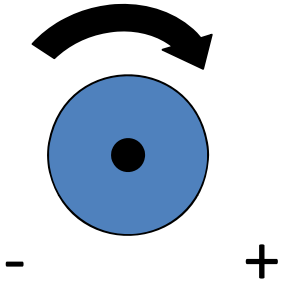
- Proximity of displays to controls should allow for compatible mapping





Device Controls

- Consistency of Actions



- **Distinct Controls** should look different and be separated

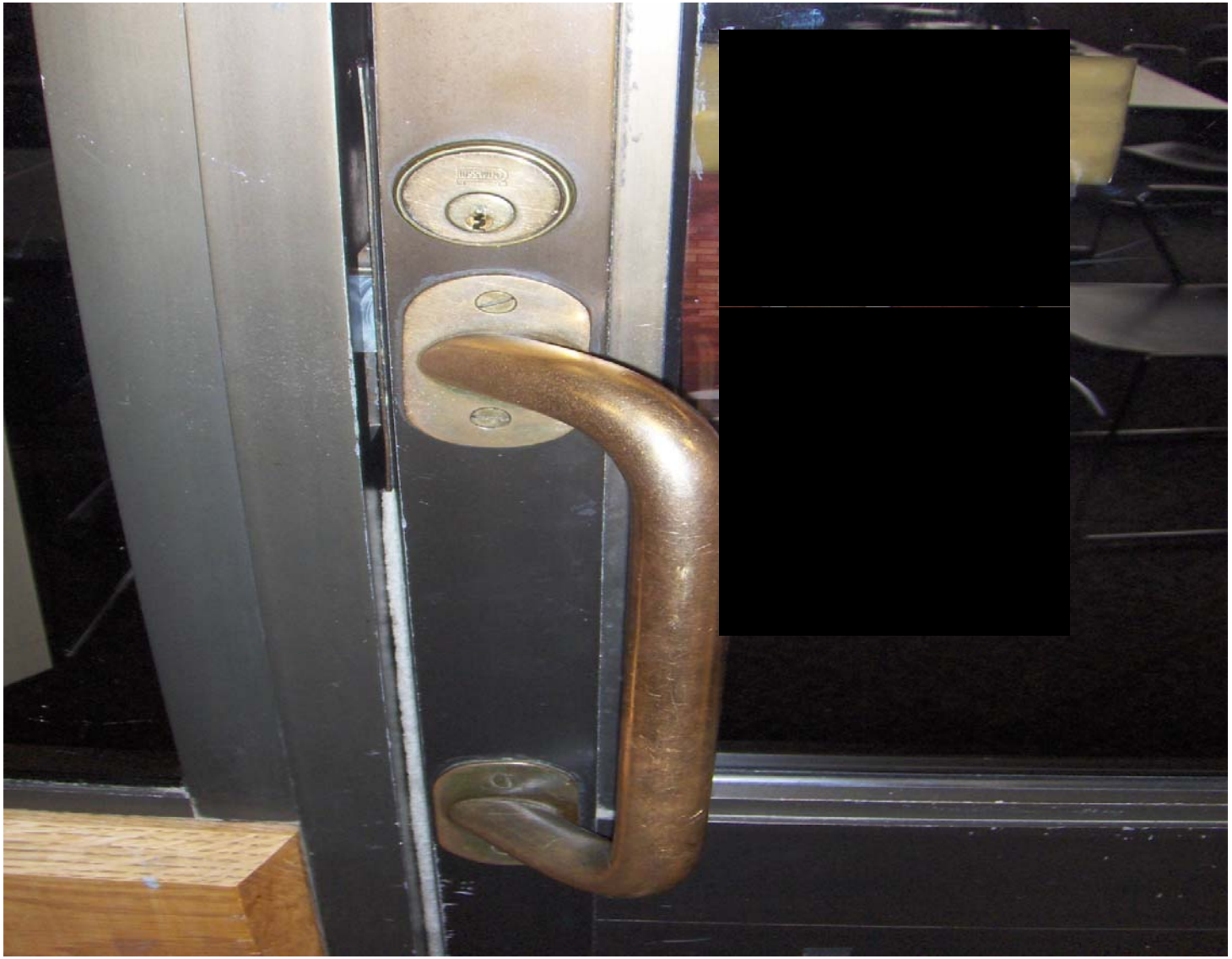
Affordances and Constraints

- Affordances – clues about how to use an object

- Constraints – Limit alternatives in how to use an object or device
  - Interlocks
    - forces operations to take place in a proper sequence
  - Lockout
    - Keeps user from performing a dangerous action

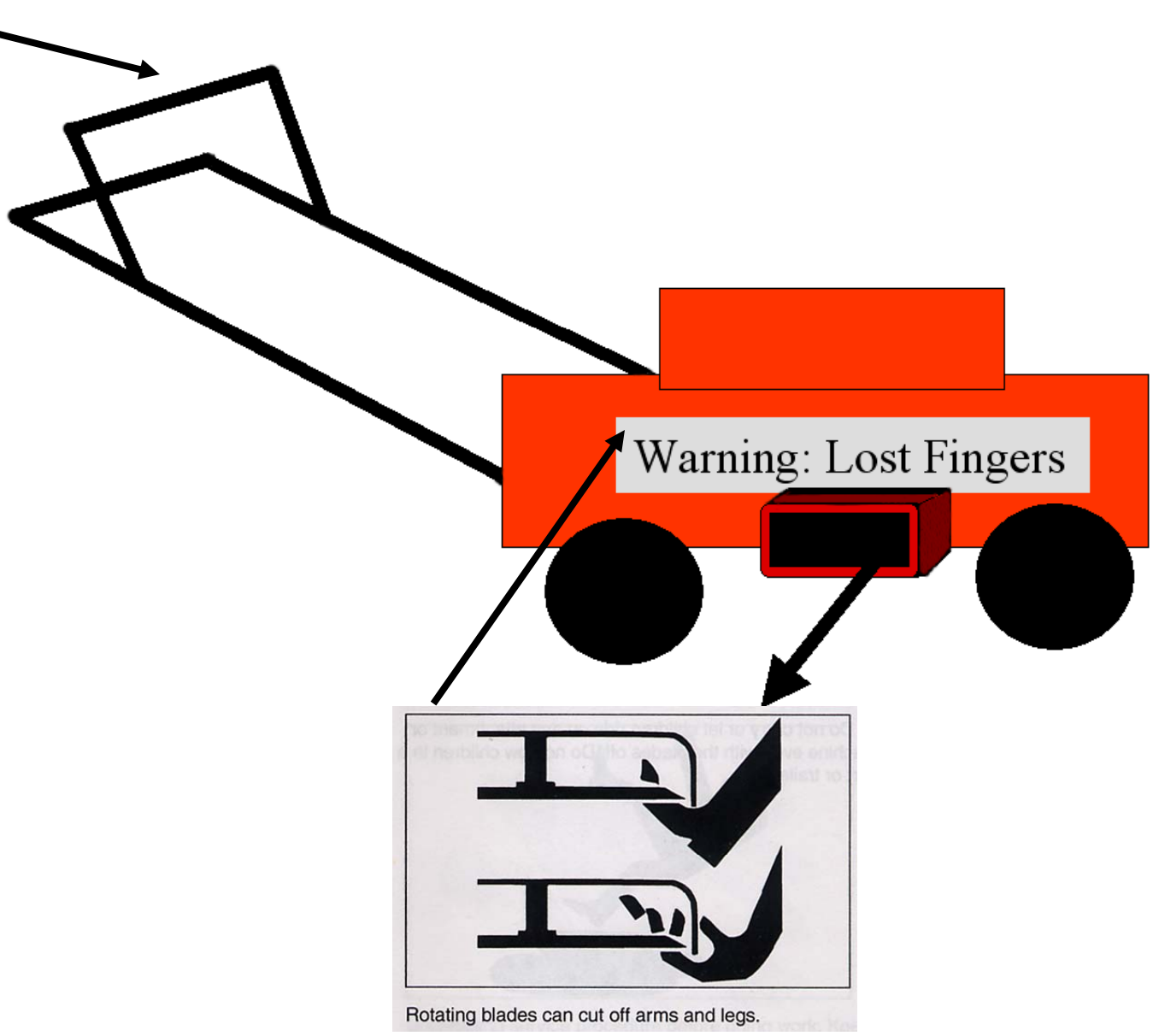
Affordance

Affordance



Affordance

Interlock


Warning: Lost Fingers
Rotating blades can cut off arms and legs.

Feedback

- Information sent back to the user about what action has been accomplished

- When you move a switch or make an entry, is there
  - Visual message
  - Sound
  - Tactile

- Feedback delays as short as ¼ second can be disruptive

FIGURE 131. Hourglass

Evaluating Medical Devices (Hardware)

1) Usability Testing

- Gathering data about the usability of a design or product by a specified group of users for a particular activity within a specified environment or work context.

Preece 1994

- Should include:
  - Real end user
  - Real tasks
  - Real environment

Does Hardware fit the Work??

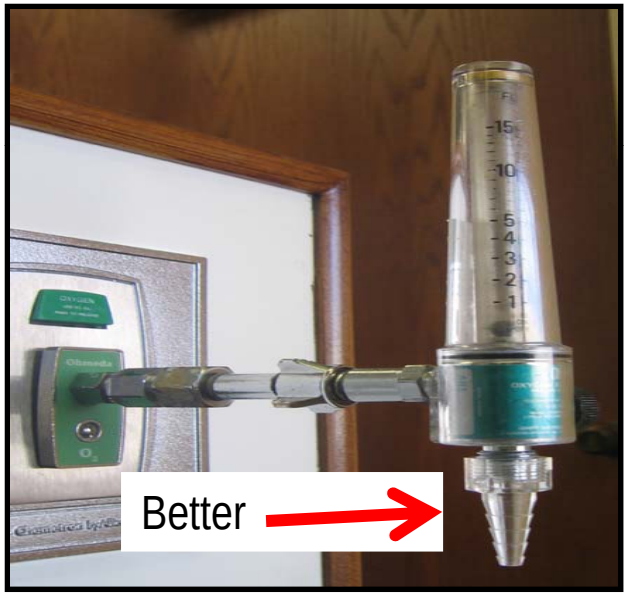
Color Associations – Can Be Dangerous

“Tell the nursing student to attach the oxygen mask and tubing to the green spigot”

Remember, this is air!

Color Associations – Can Be Dangerous

Make **sure** to use the correct color adaptor!?



Oxygen Humidification Bottles

Courtesy of VA NCPS


Thermo Forma
Blood Bank Refrigerator
MAGNETIC DOOR LATCH - PLEASE SHUT GENTLEY. "DO NOT SLAM"
GLUCOTROL XL
(glipizide)
As with all sulfonylureas, hypoglycemia may occur.

Environment

Human

“Highly Variable”
“Flexible”

HFE Solution
Engineering Control Change

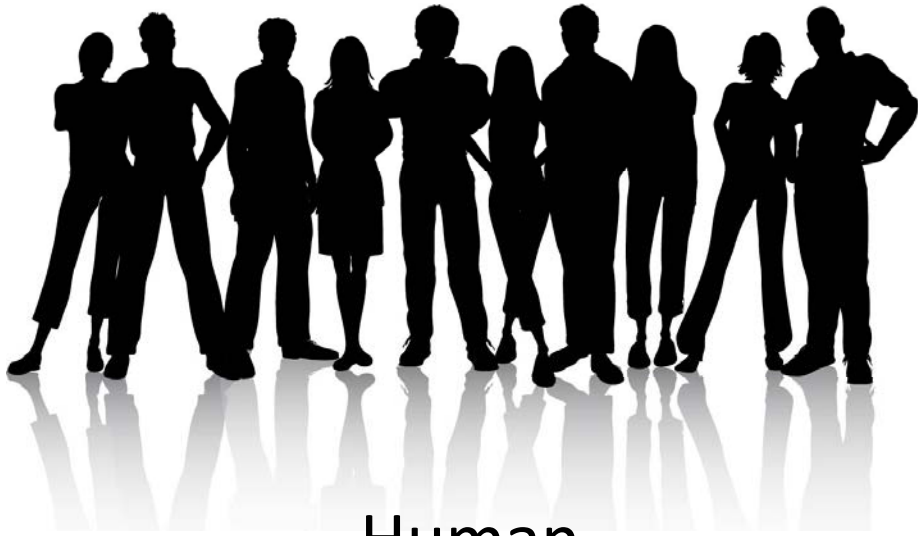
- Environmental
  - Controlling temperature, noise, vibration, air quality etc.
- Work Area Redesign
  - Modification, relocation, or rearrangement

Baseline Drawer (“Laundry hamper”)

Code Cart Drawer **Fifth Version**

Designing The Environment for Patient Safety

Culture and Communication



Human

“Highly Variable”
“Flexible”

Distractions / Interruptions

- USP (2009): 45% of all medication error
- Distractions on nursing units:
  - Interruptions by physicians and other staff
  - Interruptions by visitors
  - Requests from other patients
  - Phone calls
  - Resolving missing or incorrectly dispensed medications
  - Nearby conversations
  - Loud noise(s)
  - Expectation to complete extraneous functions
  - Emergencies
  - Lighting
  - Physical design

IOM, 2003; Pape, 2003; Pape, 2005 Schaubhut & Jones, 2000)

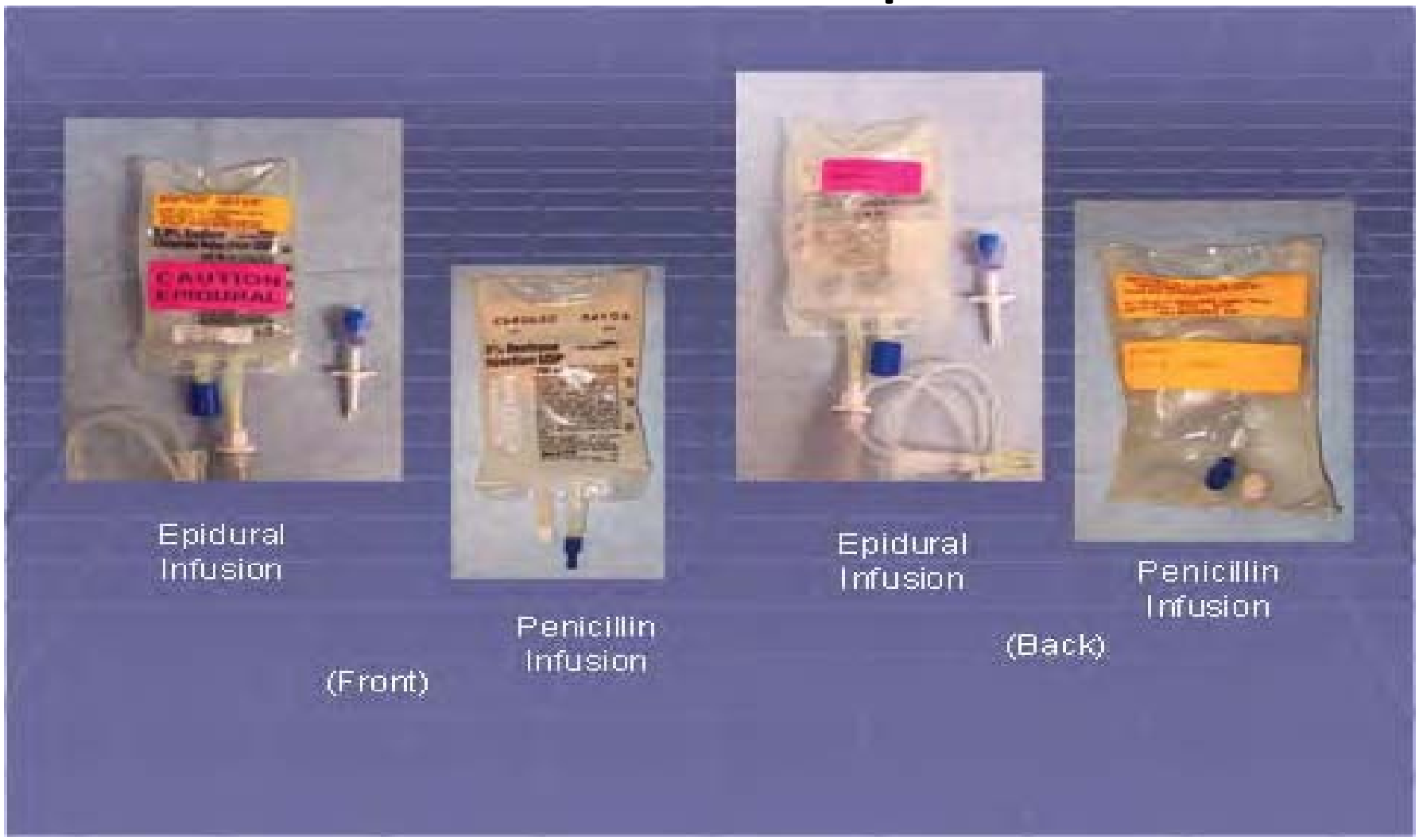
Courtesy of VA NCPS

Intimidation and Hostility

- AACN, 2006
  - 4000 critical care nurses (17.5 years average experience)
  - 65% verbal abuse
    - Physician
    - Nurse Mangers
    - Other Nurses

Courtesy of VA NCPS

Fatal Mix Up


Epidural
Infusion
Penicillin
Infusion
(Front)
Epidural
Infusion
Penicillin
Infusion
(Back)

HFE Solution

Culture and Communication

- Team Training
  - Leadership
  - Feedback / Communication Tools
    - SBAR
    - Assertive Advocacy and Inquiry
    - Read back
  - Briefings
  - Debriefings

Now What? Or How Do I Use This Information:

- Draw on staff and patient experiences/comments
  - Identify HFE issues e.g. related to medical devices; medication labeling; information systems
- To identify device-related issues, talk to biomed or clinical engineers
  - Which devices do staff label as “broken” even if nothing is found wrong
- Ask nurses/clinical educators which devices generate confusion in training sessions
    - Especially if you are thinking “why doesn’t this training help?” Or “Why are they all so stupid?”
- In the hospital or clinic setting:
  - keep your ears tuned for people swearing or saying “what is it doing?” or “why is it doing that?” when using devices or software.

Gosbee J.W., Gosbee L.L. : Pearls of HFE Practice in Healthcare. Ann Arbor, MI: Red Forest Consulting, 2009

Now What? Or How Do I Use This Information:

- Review work areas, tools, software using a heuristic evaluation tool as a cognitive aid
- Identify HFE issues with devices or software in home care or care of patients with chronic conditions
  - Ask nurses or patient educators about HFE issues; e.g. diabetes educators/familiar with patient experiences with glucometers
- Always visit and observe for yourself
  - Don't assume anything about the nature and depth of HFE issues
- Watch for sticky notes, after-market signs and labels when you visit and observe clinical areas

Gosbee J.W., Gosbee L.L. : Pearls of HFE Practice in Healthcare. Ann Arbor, MI: Red Forest Consulting, 2009

Heuristic Evaluation Tool

Product

- Is it obvious what the device is at a glance?
- Is it obvious how to use it at a glance?
- Does the device work the same way as previous models or similar brands? Does this help or hinder the user?
- Does the device look like another device? Is that helpful in telling the user how to use it?
- Is the name of the device helpful in telling the user what it is, or how it's used?

Feedback and Displayed Messages

- Is it easy to tell what the device is doing at any given moment?
- When completing a task, is it obvious when you are successful vs. unsuccessful?
- At any given point in operating the device, can you tell exactly what you need to do next?
- If you hand the device to someone, can they figure where you've left off and what they need to do next?
- Can you understand the meaning of messages, symbols, sounds, or lights that are displayed?

Gosbee J.W., Gosbee L.L. : Pearls of HFE Practice in Healthcare. Ann Arbor, MI: Red Forest Consulting, 2009; Red Forest Consulting

Heuristic Evaluation Tool

Functionality of Controls

- Is it obvious what each button, dial, or switch will do?
- Are the controls grouped in a logical and helpful manner?
- Are the primary controls located in a way that makes them easy to access and operate?
- Do buttons look like buttons?
- Do any nonfunctional features of the device look like buttons or controls?
- Are critical controls differentiated from other controls?
- Does the size or shape of the buttons, dials, or switches make them difficult to use?

Labels and Warnings

- Can you easily see all the important labels and warnings?
- Are they located in an appropriate and relevant spot?
- Are the warning labels legible?
- Is the language understandable? Symbols meaningful? Or is special knowledge needed to interpret it?
- Do any labels obscure critical controls, lights, or parts of the device?
- Do any labels create visual clutter that might cause confusion?

Gosbee J.W., Gosbee L.L. : Pearls of HFE Practice in Healthcare. Ann Arbor, MI: Red Forest Consulting, 2009; Red Forest Consulting

Now What? Or How Do I Use This Information:

- Apply principles when conducting root cause analyses
    - Assists in developing strong action plans
- Action Hierarchy:

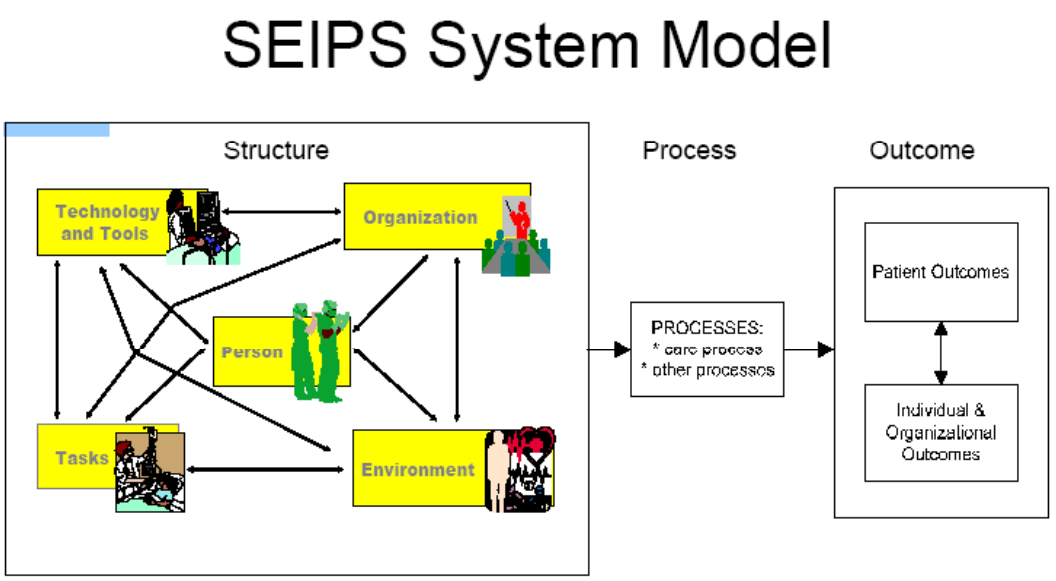
Stronger Actions	• Architectural/physical plant changes • New devices with usability testing before purchasing • Engineering control or interlock (forcing functions) • Simplify the process and remove unnecessary steps • Standardize on equipment on process or caremaps • Tangible involvement and action by leadership in support of patient safety
Intermediate Actions	• Redundancy • Increase in staffing/decrease in workload • Software enhancements/modifications • Eliminate/reduce distractions (sterile medical environment) • Checklist/cognitive aid • Eliminate look and sound-alikes • Readback • Enhanced documentation/communication
Weaker Actions	• Double checks • Warnings and labels • New procedure/memorandum/policy • Training • Additional study/analysis

VA Triage Cards – Human Factors

http://www.patientsafety.gov/faq.html#triagecards

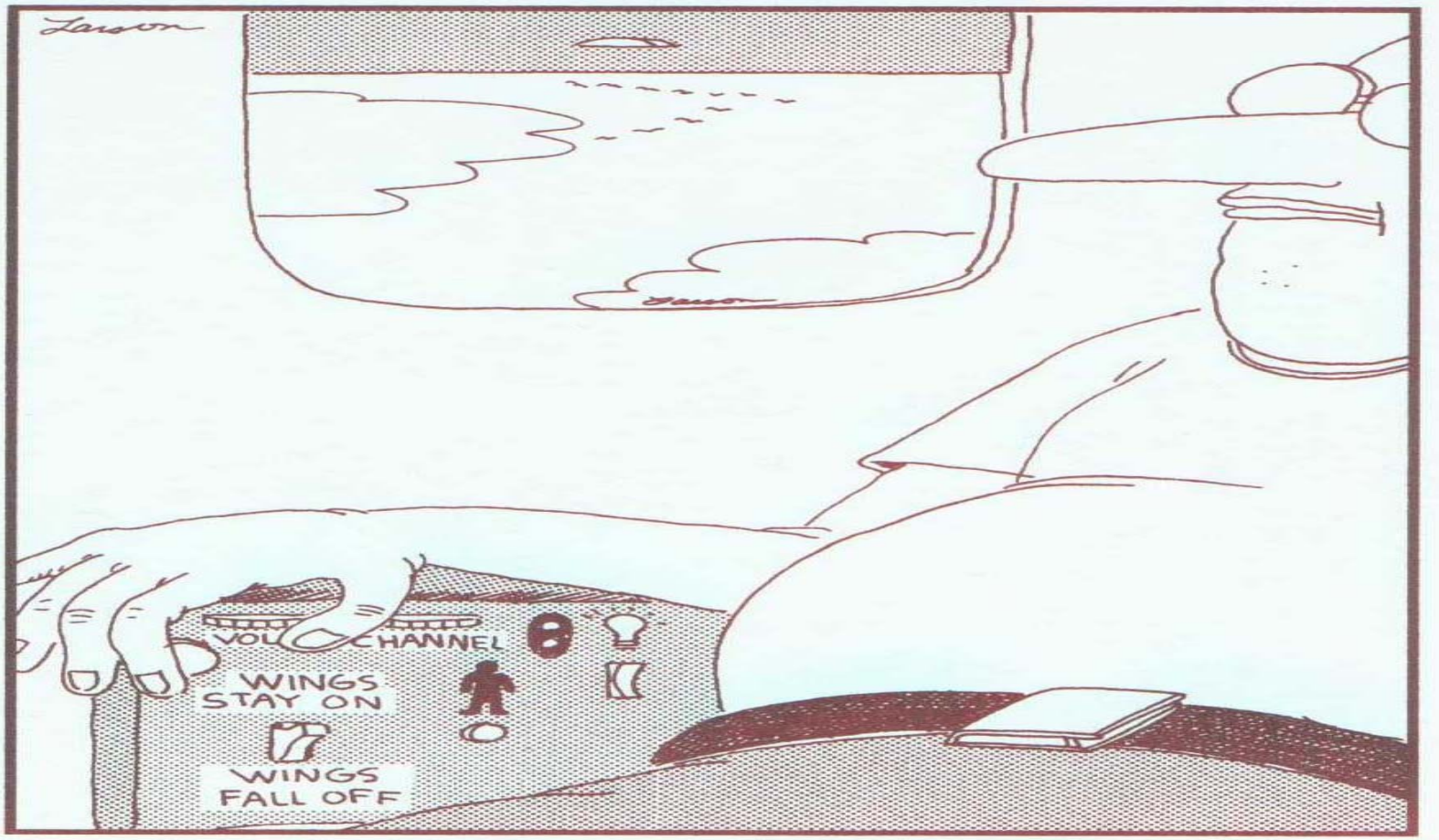
SEIPS COURSE

http://cqpi.engr.wisc.edu/



Carayon, P., Alvarado, C., Brennan, P., Gurses, A., Hundt, A., Karsh, B., and Smith, M., (2003). Work system and patient safety. Proceedings of Human Factors in Organizational Design and Management-VII 583-588.

Questions?



Fumbling for his recline button,
Ted unwittingly instigates a disaster.