# Usability and Human Factors

## Unit 4c

### Human Factors and Healthcare

## Effects of Heavy Nursing Workload

<table>
<thead>
<tr>
<th>Mechanisms</th>
<th>Description</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Time</strong></td>
<td>Insufficient time to perform tasks safely, apply safe practices, or monitor patients, and may reduce their communication with physicians.</td>
<td>Little time to double-check medications</td>
</tr>
<tr>
<td><strong>Motivation</strong></td>
<td>Dissatisfied with job, thus affecting their motivation for high-quality performance.</td>
<td>Frustration and negative attitude toward job</td>
</tr>
<tr>
<td><strong>Stress and burnout</strong></td>
<td>Stress and burnout, which can have a negative impact on their performance.</td>
<td>Reduced physical and cognitive resources to perform adequately</td>
</tr>
<tr>
<td><strong>Errors in decision making (attention)</strong></td>
<td>Contribute to errors, such as slips and lapses or mistakes.</td>
<td>Forgetting to administer medications</td>
</tr>
<tr>
<td><strong>Systemic/organizational impact</strong></td>
<td>Could affect the safety of care provided by another nurse.</td>
<td>A charge nurse may not be available to help other nurses with their patients when needed</td>
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</tbody>
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## Mental Workload

- Multidimensional construct
  - Task demands
  - Expectations regarding the quality of performance
  - Person effort
- Can vary across persons and situations
- Difficult to measure
NASA Task Load Index

- A multi-dimensional rating procedure
- Provides overall workload score based on a weighted average of ratings on 6 subscales:
  - Mental demands
  - Physical demands
  - Temporal demands
  - Own performance
  - Effort
  - Frustration

NASA TLX Index: Rating Scale Definitions

<table>
<thead>
<tr>
<th>MENTAL DEMAND:</th>
<th>PHYSICAL DEMAND:</th>
<th>TEMPORAL DEMAND:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low/High</td>
<td>How much physical activity was required (e.g., pushing, pulling, turning, controlling, activating, etc.)?</td>
<td>Low/High</td>
</tr>
<tr>
<td>How much mental &amp; perceptual activity was required (e.g., thinking, deciding, calculating, remembering, looking, searching, etc.)?</td>
<td>Was the task easy or demanding, simple or complex, exacting or forgiving?</td>
<td>Was the pace slow and leisurely or rapid and frantic?</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>EFFORT:</th>
<th>PERFORMANCE:</th>
<th>FRUSTRATION LEVEL:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low/High</td>
<td>How successful do you think you were in accomplishing the goals of the task set by the experimenter (or yourself)?</td>
<td>Low/High</td>
</tr>
<tr>
<td>How hard did you have to work (mentally and physically) to accomplish your level of performance?</td>
<td>How satisfied were you with your performance in accomplishing these goals?</td>
<td>How satisfied were you with your performance in accomplishing these goals?</td>
</tr>
</tbody>
</table>
Medical Devices

• Healthcare products, excluding drugs, which are used for human beings for the purpose of prevention, diagnosis, monitoring, treatment or alleviation of an illness
• Center for Devices and Radiological Health, a division of the Food and Drug Administration
• Common source of medical error
  – Operator error (incorrectly entering a drug cartridge concentration)
  – Patient error
  – Mechanical problems
• 60% deaths & serious injuries attributed to operator error

Patient Controlled Analgesics

• Method of pain relief which uses disposable or electronic infusion devices and allows patients to self-administer analgesic drugs as required
• Patients determine when and how much medication they receive
• Abbott Lifecare PCA Plus II is the Markey leader
  – Used in more than 22 million patients


• Purpose: redesign a PCA user interface according to HF techniques and principles
  – Improve efficiency and safety
• Cognitive task analysis was used to evaluate and redesign the system
• Experiment involving 12 student nurses programming the device
CTA Findings

- Structure of many subtasks in programming sequence is unnecessarily complex
- No global view of decision process
- Lack of external representation of dialog structure
  - No overview of how many parameters
  - Order sequence
  - Steps that have been completed and those that remain
  - Misleading visual grouping of controls
- Limited amount of feedback on small screen

Redesign of Interface

- System structure simplified by minimizing the number of message display screens
- Choices presented in parallel rather than serially

Experimental Evaluation

- Programming the new interface was 15% faster
- The average workload rating for the old interface was twice as high
- New interface led to 10 errors as compared to 20 for the old one
- Medical equipment can be made safer and more efficient by adopting human factors design principles
Mobile Health Devices

- Handheld devices used in healthcare context by clinician, patient or health consumer
  - Palm PDAs, Pocket PC, Smart phones (Treo 650) and Blackberries
  - ePocrates, LexiDrugs, Up-to-Date, PalmCIS
  - Mobile Patient Monitoring, Glucowatch, Electronic Health Diaries, & advanced function glucose meters
- Improve information access
- Enhance workflow
- Communication
- Promote evidence-based decision making & empower patients
- Lack of a stable interaction paradigm, especially on patient side

UltraSmart Meter

- Hierarchical menu
- Nonlinear/tangled
- Max depth of 5
- Breadth 2-8 (items on a single menu)
- Input: button press

Hierarchical Menu Systems

- Flow of control between human and device
- Interactive style provides visible options to user
- Structure of system can be fairly transparent
  - Constrained path of options
- May require minimal training
- Learning by exploring menu structure
- Breadth-depth tradeoffs
Objectives of Study

• Usability and learnability of LifeScan UltraSmart
  – Identify aspects of device facilitate or impede productive use
  – Determine whether older adults could develop basic competency (learnability)
    • Autonomously perform or learn to perform the range of tasks through experience and/or reading the instructional materials
  – Characterize prerequisite competencies, knowledge and skills
    • Robust Mental Model of System

Mental Models

Mental representation of how things work

• Anticipate events
• Reason about outcomes
• Project backwards from event to explain
• Try to reconstruct episodes from memory

Running of a model corresponds to a process of mental simulation

• Generate possible future states of system
• For example, “if I click OK on this button, what will happen next?”

Temporal and spatial reasoning

Mental Model of Cell Phone

Older adults had inferior mental models of phone menu than younger adults (Ziefle & Bay, 2004)

• Shallower notion of menu’s depth
• Lack of understanding of hierarchical representation associated with poor performance

Lack of a mental model can lead to disorientation in menu selection tasks

• Repeatedly open the same node
• Follow suboptimal paths
• Increase time to locate information
Glucose Meter Usability Evaluation

Cognitive task analysis
- Performed by 3 coders

Usability Testing with 5 older adults
- Two sessions video and audio taped
- Adults were given a week to learn to use the glucose meter

Summary of Usability Testing

All subjects experienced significant problems in the first session
- Data entry tasks

Demonstrated degree of improvement in second session
- Highly variable

Subjects exhibited trial and error
- Perseverated through fruitless searches
- Wrong place

Observed Problems

Limited visibility of system state

Inadequate prompts
- Not informative guiding subjects to next step

Errors result from following the wrong path
- Error correction—returning to prior state is nontrivial

Confusing task-action mappings
Conclusions

• UltraSmart™ offers wide range of resources to support self-management in patient with diabetes
• Steep learning curve, especially for older adults
• Most would experience difficulty in developing a sufficiently robust mental model to negotiate menu structure
  – Taxing on Memory
• Difficult design problem
• Empirical testing can yield more effective design solutions