Cognitive Engineering Applications in Health Care

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Why Health Care?

- Complexity
  - Time pressure, high risk, uncertainty
  - Numerous interacting systems
    - Patients
    - Provider teams and organizations
    - Financial and regulatory bodies
  - Different and often competing goals
  - Range of information sources and technologies
  - Limited resources (time, $, space)

Why Cognitive Engineering?

- Information technology is rapidly being implemented in medical environments
  - Often as a replacement for traditional, “manual” methods of collecting, transmitting, and storing medical information
- Heath care IT is seen by many as a solution to efficiency and safety problems in the medical environment
- Benefits may not accrue if the use and functional role of manual technologies, and the work practices of health care are not understood and accounted for in design
- Often, designs are driven “top down” by administrators and IT specialists with different goals than practitioners

Example: Lack of Fit

- Design: Computer system for recording triage information enforces the order in which information must be entered
- Reality of work: Patients often change their answers, or remember pertinent information
- Potential Result: duplication of records (paper & electronic), errors due to missed information, system abandonment

Example: Unintended effects

- Design: Function is added to order entry system to “force” physician to renew restraint orders at a particular time
- Reality of work: Physicians may be involved in a time critical task; evaluating patient & restraint orders takes time
- Potential result: Errors occur due to interruption; treatment is delayed; restraint orders renewed reflexively

Current Research Threads

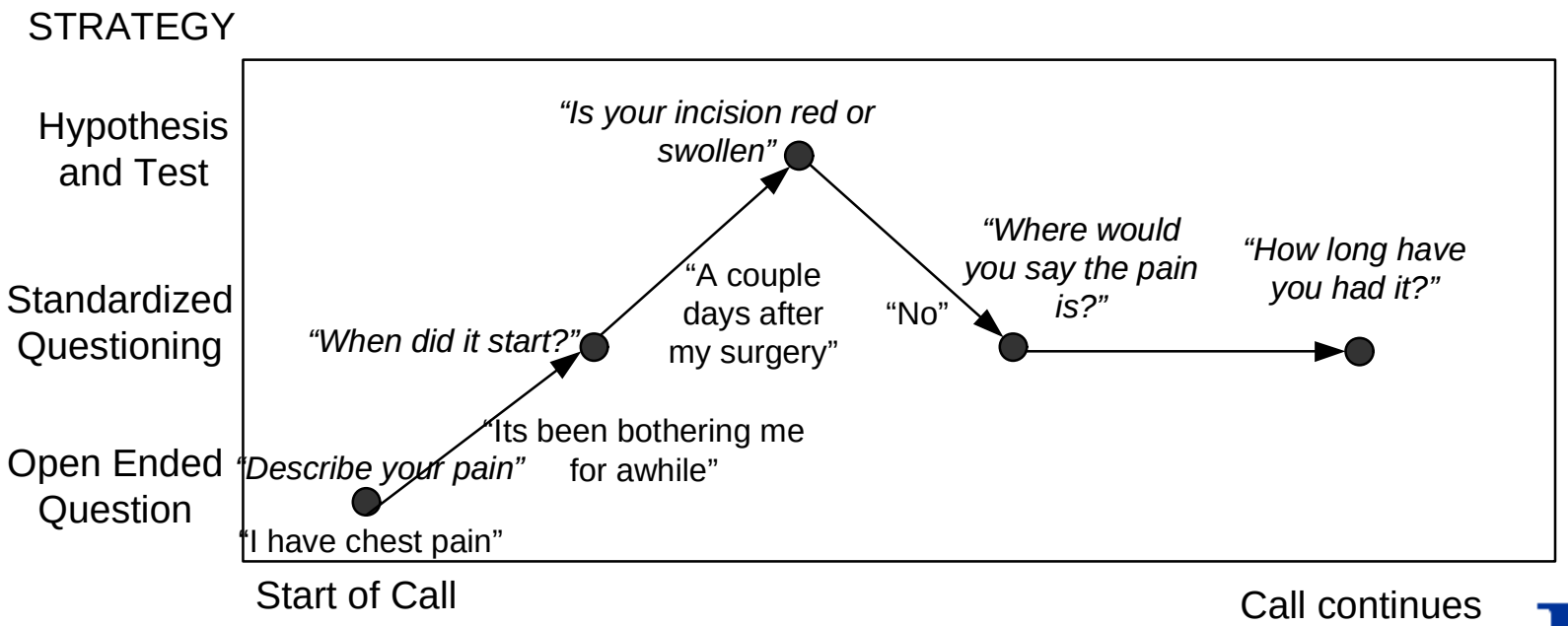
- Characterizing Complexity
  - Demands of the environment
  - Knowledge and strategies of practitioners
- Understanding Impacts of New Technology
  - Potential for unanticipated, and sometimes undesirable, effects
- Analyzing Role of Current Work Activities and Artifacts
  - Support the design of new systems which maintain key functions and support roles

Characterizing Complexity

- Modeling functions, processes, physical structure, and means for control of patient systems
  - Identified relationships between high level functions and balances, processes, & functions which support neonatal oxygenation (e.g., pulmonary gas exchange)
  - Led to information needs and new display forms which supported monitoring and diagnosis (Sharp and Helmicki, 1998)

Characterizing Complexity

- Strategies used by caregivers for diagnosis and problem solving



(Burns, Enomoto and Momtahan, in press)

Characterizing Complexity

- Communication of information and coordination of work across team members
  - "Public" sources of information such as whiteboards can support task coordination (Pennathur et. al 2007)
  - Training surgeons on communication strategies can have a positive effect on activities such as pre-operative briefings (Guerlain et al. in press).
  - Communication during a shift change can avert errors (e.g., because incoming staff may identify an alternative diagnosis); but could also lead to error (e.g., if the state of orders is misunderstood) (Wears et al. 2003)

Impacts of New Technology

- New artifacts change the work that they are intended to support, and new needs are created ("task-artifact cycle") (Carroll and Campbell 1989)

- Designed artifacts embed (implicitly or explicitly) theories about the work that they support (Carroll and Campbell, 1989) (Kirlik, 1995)
  - That theory might not always be correct
  - Often, computerized artifacts are based on normative, rationalized descriptions of work processes Sachs (1995), Button and Harper (1993), Bisantz and Ockerman, (2003)
  - Work performance suffers

Impacts of New Technology

- Users accommodate problematic aspects of new technologies by “task tailoring” and “system tailoring”
  - Clinicians developed procedure to insert “sham module” in integrated operating room monitoring system to insure key information is not covered up by window (Cook and Woods 1996)
  - Bar code system for medication administration led to work-arounds such as using secondary wristbands and pre-pouring medications to increase efficiency (Patterson, Rogers, Chapman, and Render, 2006).

Role of Current Activities and Tools

- What functions do current technologies (both high and low-tech) support, so that functions, rather than form, can be included?
  - Paper form to track patient information in ICU allowed flexible rather than sequential information entry; unstructured annotations (both in place, and form); grouped information to support comparisons; but couldn't do automatic calculations (Bauer et al., 2006)

Role of Current Activities and Tools

- Emergency Department “White Boards”
  - Being replaced with computerized systems and displays
- Investigate the transition from manual to electronic status boards in emergency departments in two hospitals
- Document status board contents, perceptions of use, changes to work practice

Background: ED Status Boards

- Centrally located and publicly available to all ED staff
- Locally constructed and therefore not standardized
  - Information, symbols, colors
- Began as simple location tracking systems, and were annotated with additional information over time

Whiteboard in Context

Whiteboard Information & Functions

- Contents:
  - Demographic information
  - Caregiver information
  - Medical information regarding symptoms, status, processes, and plans
  - Information about patients not currently present (pending transfers, other hospital areas)

- Functions
  - Assignment of patients to locations (beds)
  - Caregiver “memory”
  - Communication among caregivers
  - Coordinate tasks among caregivers
  - Overall status of ED (full or empty)
  - Status of beds/rooms

Results: Observation & Interviews

- May provide support for administrative and clerical work
  - *If someone walks up, can ID the nurse. Keeps us closer to the phone (don't have to get up and go to white board.*
  - *Great for the administration to track meaningless numbers (gave example of hours here – doesn't say that they were in waiting room Y hours vs. overall time here, or that they are waiting for a scheduled sonogram, etc.)*
  - Unanticipated use for tracking diet/meal information

Results: Observation & Interviews

- For clinicians, reduced awareness of overall state of ED , important information; negative changes to workflow and efficiency
  - *Now use stickers. All of us had a system for keeping track {on white board} – now writing on a sheet. Have to log in to sign up for a patient. Used to just look on board.*
  - *Nothing has made the job easier. It is slowed now. I'm a visual person: there isn't anything visual. Now have to sit in front of a computer. Used to be able to walk through and check the whiteboard.*
  - *In the comments box, still have to stop to take time to pull out information. Have to sit down at computer. Only 3 comments can be seen at a time and you have to click on another page to see all the comments, which may have information that needs to be acted upon immediately.*
  - *Numbers and symbols don't mean anything.*

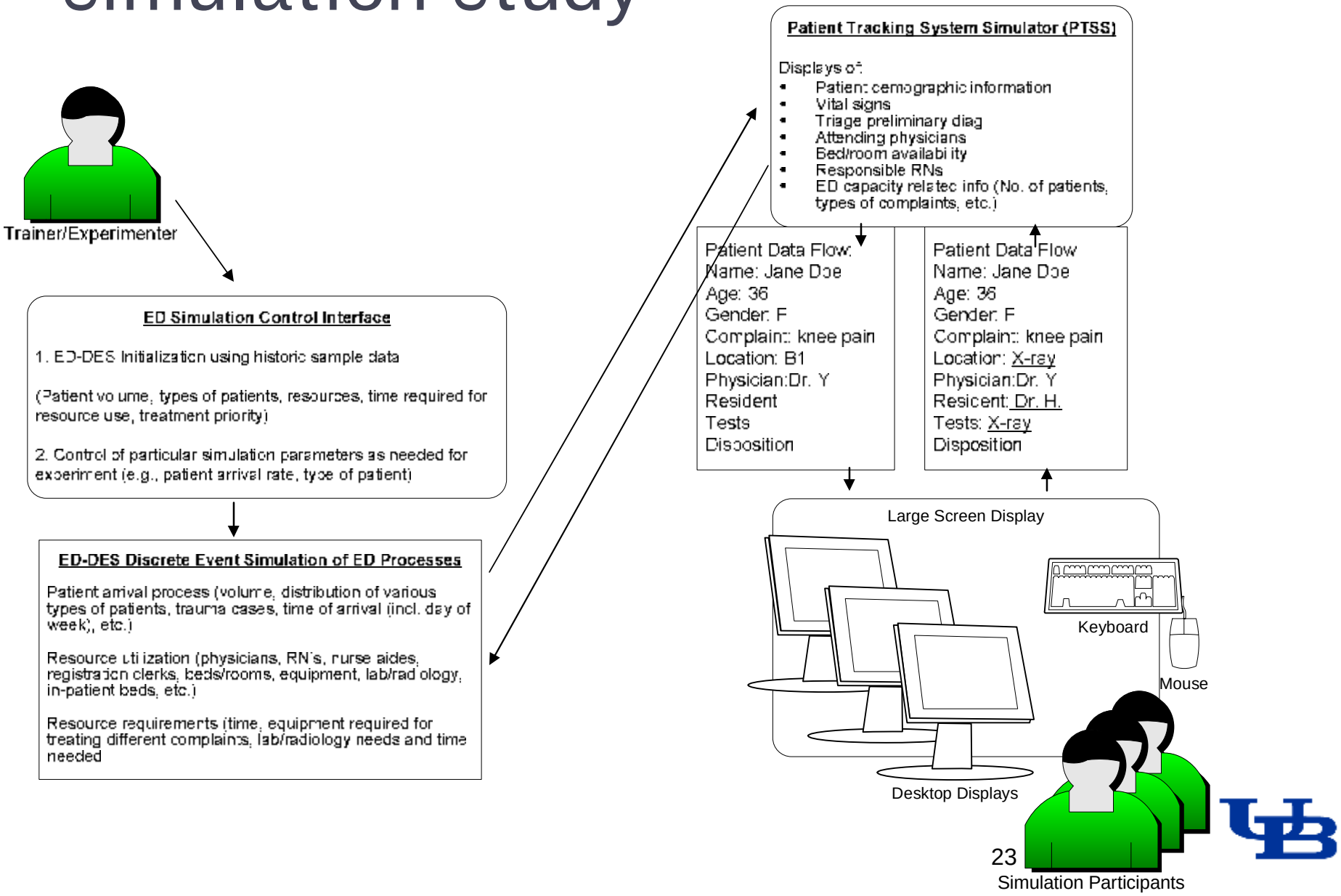
Chief Complaint Entries

Type	Definition	Example
Alert	Special alerts to caregivers (e.g., allergies)	"LATEX"
Arrival mode	Mechanism of arrival to the ED	"MERT" *(in hospital team)*
Desired visit outcome	Visit is planned and expressed as an outcome	"Stitch removal" "Needs Rx Refill"
ED Coordination	Work requests, movement, disposition plans	ADMITTED *(admitted to hospital)* EKG *(patient needs an EKG)*
Laterality	Description of side of body/limb affected	"L Shoulder Inj" *(Left Shoulder injury)*
Mechanism of injury	Description of how the injury(ies) occurred	"Fall" "MVC" *(Motor Vehicle Crash)*
Medical History	Information regarding past medical history (often qualifying a symptom or diagnosis)	"2m p-delivery" *(2 months post delivery)*
Pertinent symptoms	Positive or negative indicators that are relevant to a diagnoses	"- LOC" (no loss of consciousness)
Presumed diagnoses	Presumed cause of patient problem	"Asthma" "Kidney Stone"
Primary symptom	Complaint described by patient	"Chest pain" "Shortness of Breath"
Problem	General description of problem	"Ankle injury" "Dental problem"
Qualifier	Indication of uncertainty regarding entry	"UTI Possible" *(urinary tract infection)* "? Neuro Prob"
Rule-out diagnoses	Possible diagnoses that should be ruled out (often, a set of differential diagnoses)	"R/O MI" *(rule out heart attack)* "R/O PNA" *(rule out pneumonia)*
Signs	Information gathered through observation such as lab values and clinical observations	"Bloody Stool" "Increased heart rate"

Simulation Study

- Goals
  - Test impact of tracking system on user performance
    - Workload, situation awareness, time to respond to events
    - Screen size, display enhancements
    - Nurses/secretaries; residents
- Probe events introduced to test awareness, response
  - Patient names disappear, screen blanks, similar name issue, critical lab value
- Discrete-event simulator used to generate ED activities
  - Utilize in future studies where other interactions may be simulated (full-scale ED simulation)

Simulation Study



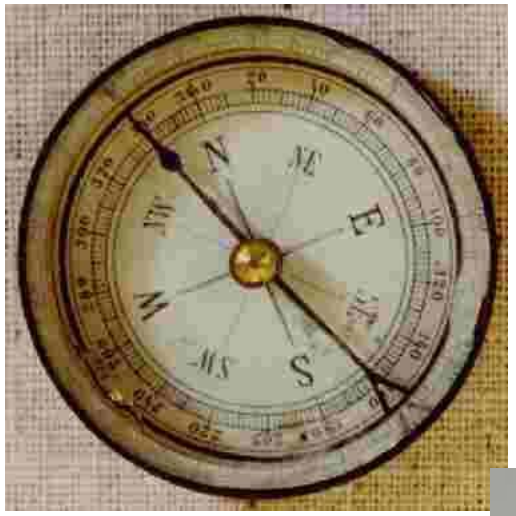
Challenges

- Incorporating information about health care work complexities into the design of new technology

- *"… the computer based [systems] that litter the cemetery of 'failed attempts' were bound to fail because the model of health care work inscribed in these tools clashed too much with the actual nature of health care work."* Berg (1997)

Postscript: Form vs. Function?

- Imagine yourself hiking on a remote mountain using a compass for a guide. A passerby takes your compass, and gives you a watch.
- “See, it has a dial, and a pointer, just like your compass - everything will be fine. You can even tell how long it takes you to climb!”



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