Human Computer Interaction in Health Informatics:

From Laboratory Usability Testing to “Televaluation” of Web-based Information Systems

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Motivation – HCI Issues in Health Informatics

- **Problems with information systems in health care**
  - Lack of acceptance of systems
  - Poor usability
  - Failure to support work practices
  - Introduction of errors

- **Issues related to human-computer interaction may be single-most important barrier to successful implementation of systems in health care**

From Laboratory to Real-world Analysis and Evaluation

(Kushniruk,2001)

A Continuum of Studies

LABORATORY

- Fixed usability lab
- Experimental tasks
  - "think aloud"
  - cognitive task analysis

- Simulations
- E.g. "simulated" doctor-patient interviews

NATURALISTIC

-"Virtual" usability lab
- Analysis of Web-based systems
- Data mining

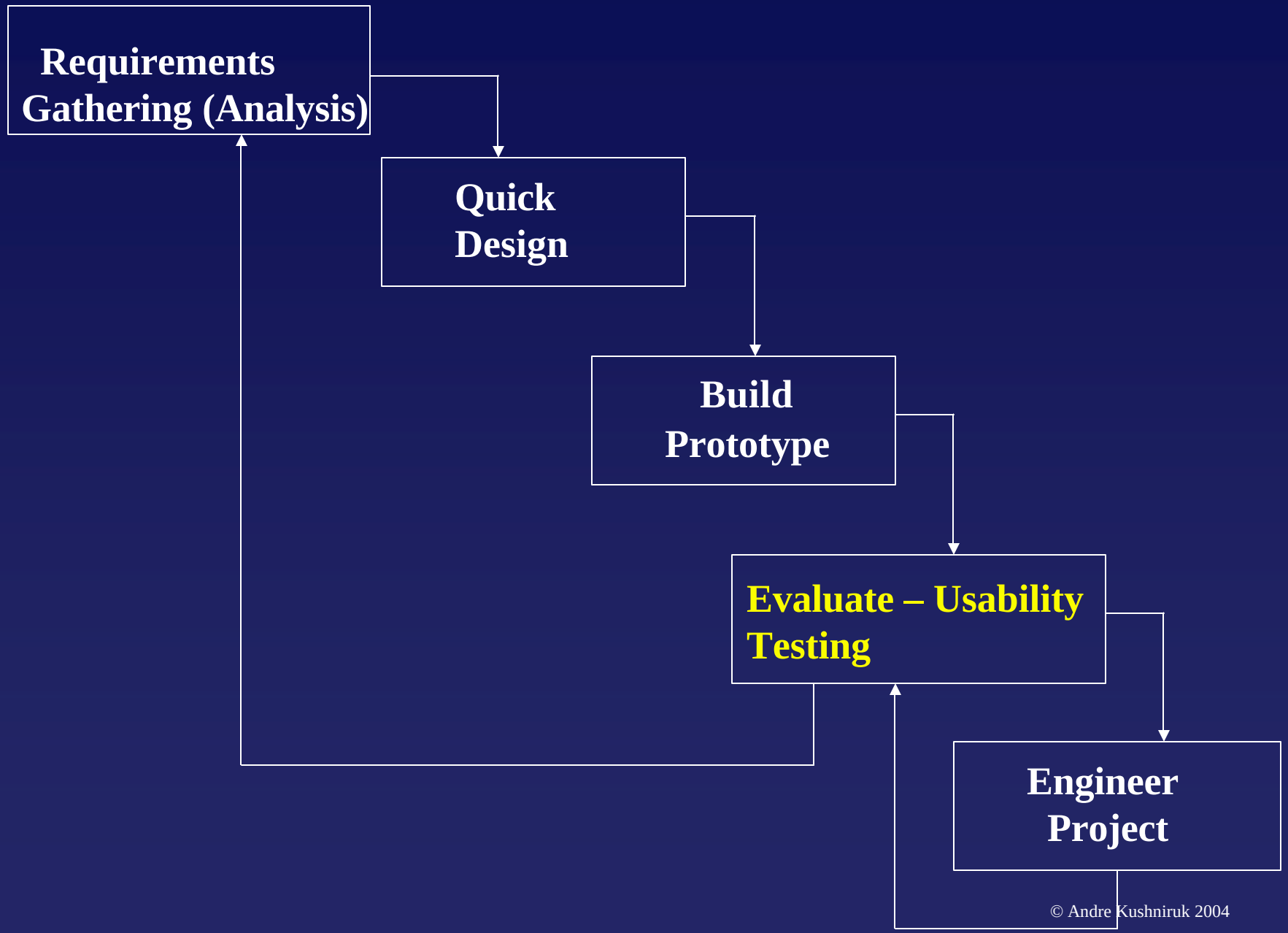
Evaluation in Health Informatics

- **Summative Evaluation - need for assessment of whether systems meet the needs of users, are safe and effective**

- **Formative Evaluation – need for assessment of systems throughout their development**

  - Traditional development approach – classic waterfall development cycle
  - Alternative approach – rapid prototyping involving continued user input and testing

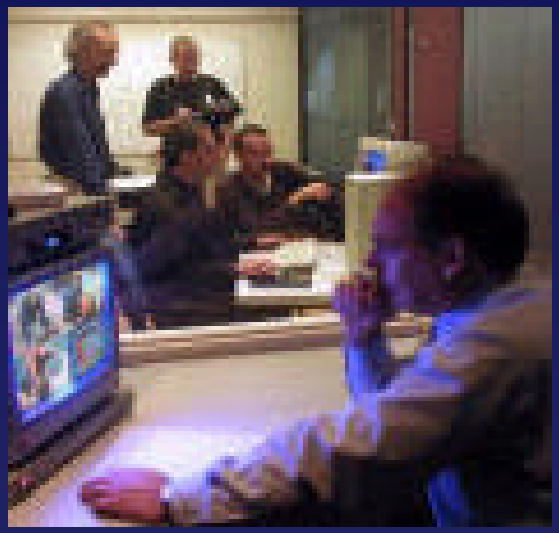
Usability Testing in Prototyping



Usability Engineering in Health Care

Usability - Measures of “ease of use” of a system

1. Learning
2. Effectiveness
3. Efficiency
4. Safety
5. Enjoyability



Importance of Usability Engineering in Health Care

- Problem of system acceptance
- Problems in deployment, errors
- Feedback into iterative design

Usability Engineering

- Usability Testing
  - Representative users and tasks
  - “Think Aloud” Protocols
  - Video Recording
- Usability Inspection
  - Usability “inspector” steps through system
  - Cognitive Walkthrough
- Cognitive Task Analysis
  - Process centered
  - Includes focus on mental operations

Emerging Applications in Health Care

- Patient record systems
- Decision support systems
- Educational systems
- Web-based information resources
- Patient clinical information systems
- Digital libraries
- On-line guidelines
- Data mining

Laboratory Testing of Decision Support and Development of Video Coding Schemes

- **How effective is the interface and content of a decision support tool? (Kushniruk et al., 1995)**

- **Data**
  - Video recording of doctors' and students' interaction with system
  - Audio recording of "think aloud"
  - Screen captures

Analysis

- **Computer-supported video coding**
  - Cvideo tool interfaces between computer and VCR
- **Develop coding scheme**
- **Code the data**
  - reasoning and decision making
  - problems/errors (content, conceptual and interface)

Example Coding Categories

1. User/System Problems

- Content
  - too much information
  - not enough information
  - innappropriate information
  - incorrect (out-of-date) information
  - relevance of information
- Comprehension
  - graphics
  - text
  - audio
  - synchronization

- Navigation
  - ability to go back or forward
  - ability to select/find wanted screen
- User Control/Pace
  - ability to pause
  - pace of material
- System Understandability
  - understandability of icons
  - consistency of operations
- System Help
  - accessibility
- System Robustness
  - crashes/failures

2. Reasoning

- Requests for information
- Hypothesis generation and testing
  - consider hypothesis
  - support hypothesis
  - eliminate hypothesis
  - confirm hypothesis

3. User Actions

- Menu selection
- Scrolling
- Entry of data

CVideo Log File - Subject #1

00:01:03 to 00:02:26 Introduction

"I've already had to loosen my tie"

Shifts in seat and studies screen

00:02:27 Risk Analysis Guidelines/Recommendations Screen

COMMENT: CRITIQUE-CONTENT

"My first comment is that 88 is a little old, I don't know if any of this has been updated since 88"

00:01:17 to 00:01:17 Checks out the sex factor

ACT: 00:01:44 Raises cholesterol levels by 1 to 6.3

ACT: 00:03:00 Goes to help screen

ACT: 00:03:12 surveys the powerbar choices (3) and selects the Introduction

GOAL:

"How do I fast forward?"

NAVIGATION PROBLEM

COMMENT:

"There is no way out of this?"

EXP:

"You can kill this"

COMMENT: STATE OF SYSTEM

"I can kill this, Sorry you told me that"

Stops the explanation

00:02:14 to 00:02:14 Surveys the icons

"OK, so, Risk Analysis"

ACT: 00:03:37 Selects risk analysis (help menu)

EVENT: 00:03:32 Crashes program

COMMENT: CRITIQUE -CONTENT

"When I said it was 88 recommendations, my first impressions was that it was kind of old. Was this made in 88? Things have changed a lot since 88. At that point I would probably turn it off (laughs), I need something newer. Things have changed a lot and I think the recommendations have been cleaned up a lot"

ACT: 00:04:49 Returns to risk analysis screen

00:05:29 Turns head sideways, and looks for options menu on powerbar

COMMENT: CRITIQUE-INTERFACE

"Options menu on the help, I don't know which one of these is the options menu. Which one of these is the options. It didn't come with instructions"

GOAL:

"I want to change the units because height is in centimeters"

00:05:44 Returns to Help and surveys the icons on the powerbar

"So now I have to get out the owner's manual!"

Questionnaire Response
(same subject)

I found the program easy to use

- Agree somewhat

It was fairly easy to learn

- Agree somewhat

The content of the program is presented clearly

- Agree completely

The interaction is properly paced

- Neutral

The narration is easy to follow

- Agree somewhat

Conclusion:

User's perceptions do not agree with actions captured on video

– multiple methods required

Impact of an Information System on Knowledge Organization and Reasoning

(Kushniruk, et al., 1996; Patel, Kushniruk, Yang, Yale, 2001)

- **Paper record to Computer-based patient record (CPR), back to Paper record**
- **Comparison of matched records**
  - Learner styles
  - Direct observation of process

- **Study 1: Experimental Study of Use**
  - Doctors asked to enter case data into the system
    - “think aloud”
  - Conduct patient interview using system
    - “simulated patient”
  - Video recordings of sessions
  - novice system users - tested over 4 sessions, from baseline and training
  - Analysis of contents of paper -> computer records

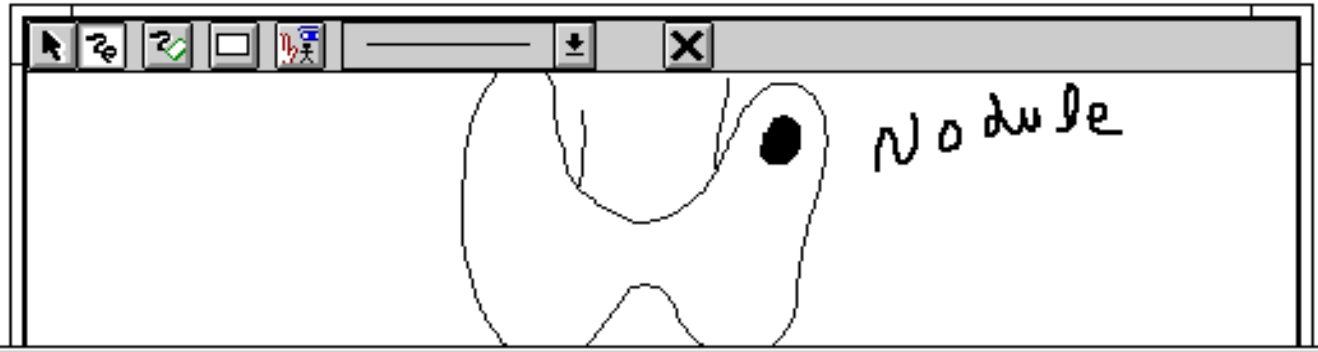
DCI - [Mr Levy, Henry, 56 years old]

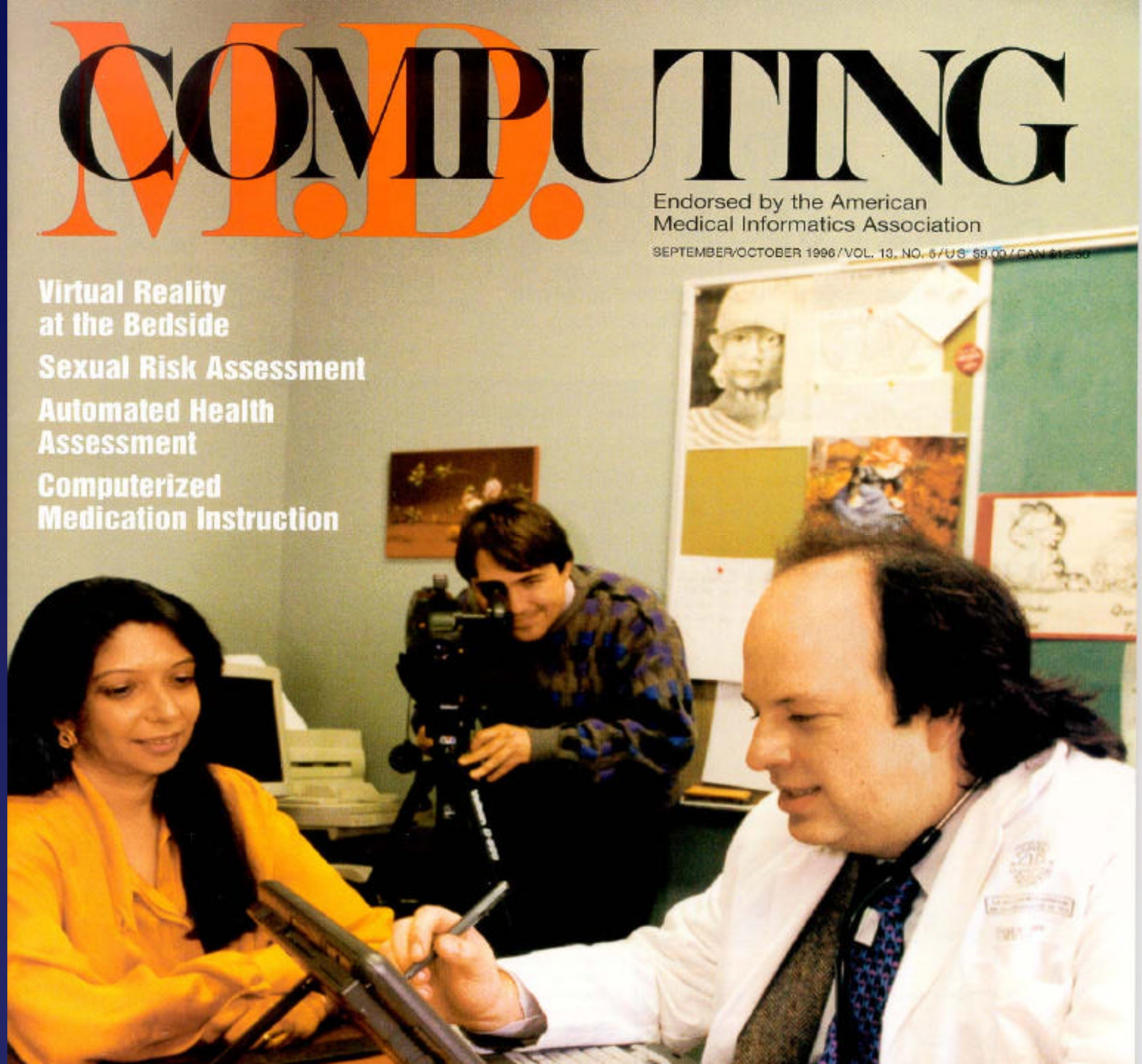
Record Edit Lists Options Purkinje Window Help

CC | PERS H | L STYLE | PROFILE | FAM H | HPI | RS | PE | DX | INV | TRMT | SIGN

PHYSICAL EXAMINATION: Normal examination

- GENERAL CONDITION: good
  - VS: N
    - BP: N 110 / 70 R: upper limb lower limb sitting up lying flat standing up L
    - pulse: 76 /min regular irregular
    - T°: N 37.5 °C buccal rectal axillary tympanic
    - RESP: N ____ /min regular irregular
- HEAD AND NECK: N
  - thyroid
    - nodule
      - location: isthmus lobe: upper lower R L
      - size: ___.___ cm² 1 cm X ___.___ cm
      - tenderness: 0 + ++ +++ ++++
      - skin overlying the mass: N edematous red retracted
        - tender: 0 + ++ +++ ++++ skin adherent to the mass




M.D. COMPUTING
Endorsed by the American Medical Informatics Association
SEPTEMBER/OCTOBER 1996 / VOL. 13, NO. 5 / US $9.00 / CAN $12.50
Virtual Reality at the Bedside
Sexual Risk Assessment
Automated Health Assessment
Computerized Medication Instruction

ık 2004

- **Study 2: Study of use in diabetes clinic over six month period – naturalistic approach**
  - Interviews (pre and post) – 16 clinic staff
  - Usability testing with subset of subjects
  - Training recorded as well
  - Logging of all system use
  - Study of contents of paper and computer records

- **Results:**
  - More irrelevant information in paper records
  - Overall less information recorded in computer based records
    - For corresponding records, CPR version contained 25% less information.
  - Fewer diagnoses recorded in CPR for matched records - typically only single primary diagnosis
  - Change in reasoning -- from “hypothesis driven” to “screen driven”

Changes in Reasoning

- Data-directed (paper records)

Problem-directed (CPR)

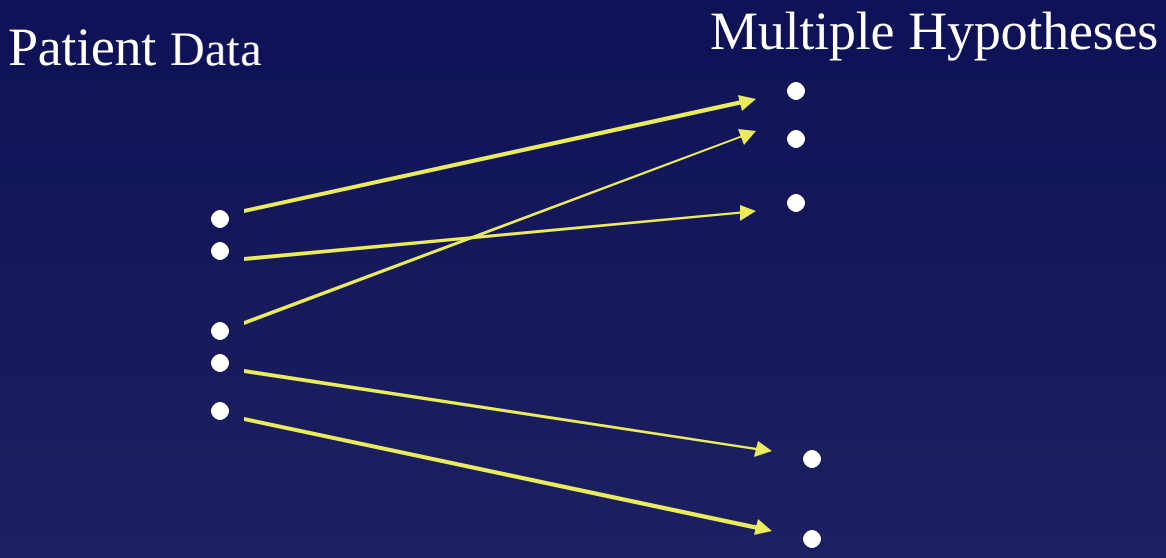
Problem-directed (paper records)

- Lasting change in reasoning patterns, even when CPR removed ("effects of" and "effects with")

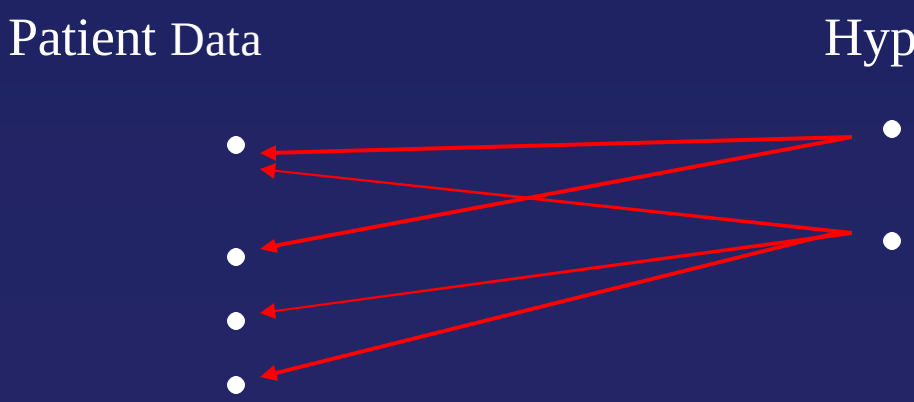
Information in CPR and Hand-Written Records

Category of Information	Hand-Written Patient Record	Computer-Based Patient Record
1. Chief Complaint	10	28
2. Past Medical History	13	13
3. Life Style	33	19
4. Psychological Profile	10	11
5. Family History	7	14
6. History of Present Illness	55	27
7. Review of Systems	52	8
8. Physical Examination	60	55
9. Diagnosis	14	9
10. Investigation	29	17
11. Treatment	21	24
TOTAL ENTRIES	304	225

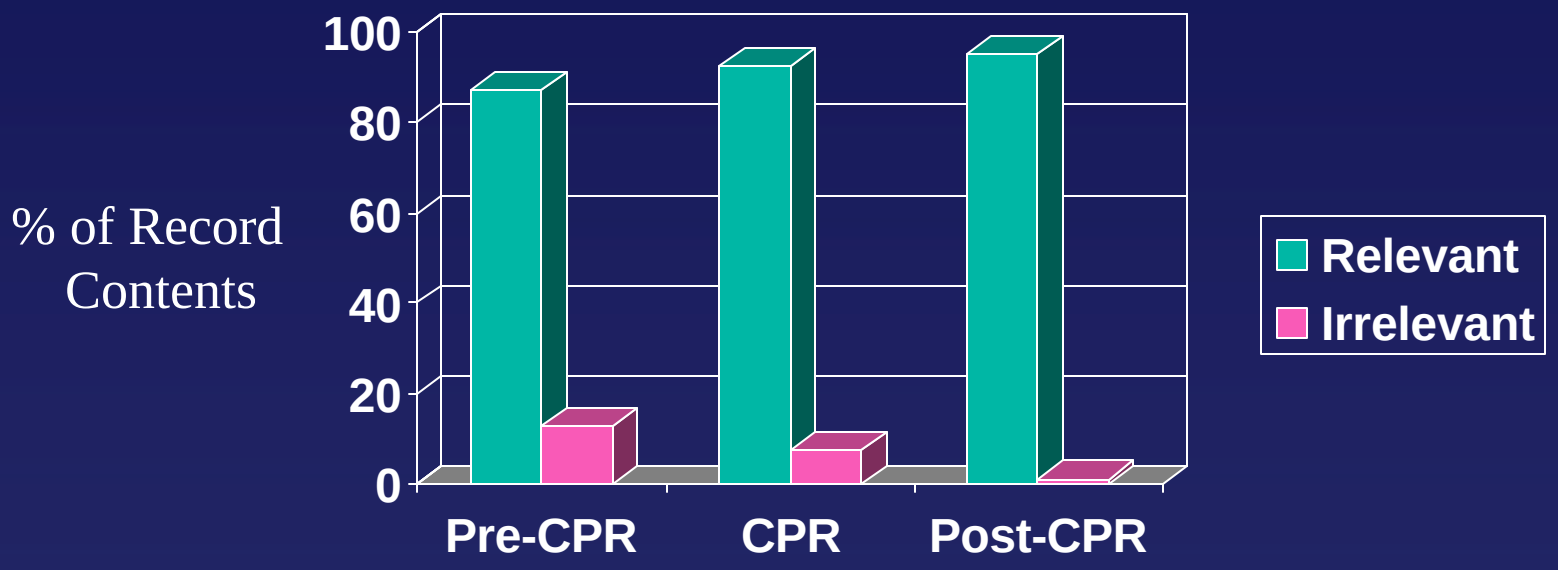
Diagnostic Reasoning Using Paper Record



Diagnostic Reasoning Using CPR



Residual Effects of CPR Use



Narrative of Doctor-Patient Interaction
(Involving Experienced User)

Time	Episode
00:00-02:30	- Creates a Patient Visit
02:47-03:26	- Reviews Presenting Complaint
	- Starts to Select a Filter but stops
03:55-04:39	- Gathers info without CPR (paper)
04:39-08:48	- History of Present Illness
	- Hypothesis: hyperthyroidism
09:21-09:49	- Chooses clinical note template
09:54-13:25	- Collects personal history, in order of categories on the screen
	("screen-driven behavior")

Experienced users become "screen-driven"

- affects reasoning and requests for information

Usability and the WWW
(Kushniruk et al., 2001)

- **Objective to adapt usability testing to the WWW**
  - how are people using health care sites?
  - Do they get information they want from particular sites?
  - what problems do they have?
  - How are Web-based guidelines used?

- **Remote tracking of Web users**
- **Remote video-based usability testing**

Evaluation of Usability of Web-Based Health Care Information Systems

- **Varied users who interact from various locations**
  - Less able to conduct controlled evaluative studies
- **Current state-of-the-art**
  - track user actions (e.g. clicks) - tells what they do, but not why
  - on-line questionnaires/feedback forms - often not filled in, limited questions
  - interviews - problem that users often do not know what they do

Questions in the Evaluation of e-Health Information Systems

- What type of information do e-Health consumers want?
- Is the information provided useful, helpful?
- How to collect useful data from large number of subjects remotely?
- How to integrate data from multiple sources?
- How to analyze such data from varied data sources to discover usage patterns?

Objectives

- **To collect psychologically rich and useful data on a large scale**
  - Methods for automatically collecting usability data at point of system use
    - identify patterns of usage of interest to automatically collect data about
  - Analysis tools and discovery tools
    - Automatically identify patterns of usage from merge of data collected
- **Integration of multi-method data collection and analysis**
  - To answer both specific and generic questions regarding use and usability of Web-based health systems

Evaluation Methods: An Integrative Approach

DATA SOURCES:

1. On-Line Questionnaires/Forms

- Baseline (presented on first login) Questions
  - Consumer Demographics
  - Prior Computer Experience
  - Type of Information of interest
    - disease categories
    - Expectations about use
- Questionnaires triggered to appear at point of use (triggered by browsing patterns):
  - Usability of the system
  - Problems/difficulties in using
  - Suggestions/Comments

2. Log Files of All User Interactions

- Automatically recorded
  - functions and buttons clicked
  - resources accessed
  - time spent in each function

3. Interviews

- Conduct with both patients and their providers
- Structured probes – experience, problems, suggestions
- Conduct over the phone or “electronically mediated conversation” (moving towards interviews using intelligent agents, leading to standardized data)

4. Usability Testing

- Conduct with subset of users at the usability laboratory
- Video recording of user interactions while “thinking aloud”
- Conduct remotely over the Web (virtual usability laboratory – record interactions to disc rather than VCR)
- Data sets containing screen recordings

Example: Evaluation of a Patient Clinical Information System (PatCIS)

- **Over the WWW patients can**
  - Review their own medical data (e.g. laboratory results
  - Enter their data (e.g. blood glucose levels)
  - Receive advice
  - Receive educational information
- **Subjects recruited from private practices in New York state**
- **Followed over one year**
- **Thousands of accesses**

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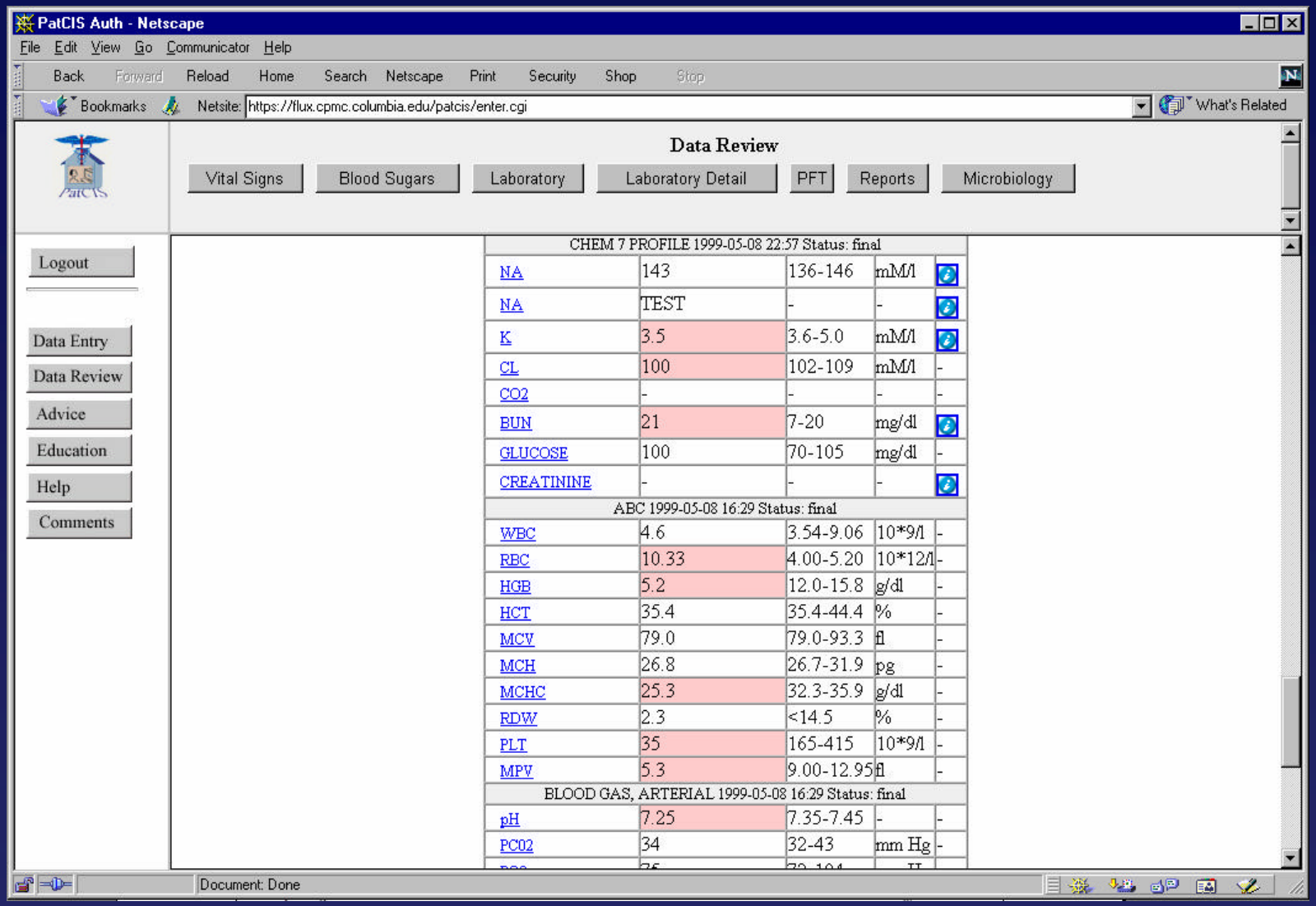

Screen of a patient clinical information system (PatCIS) showing data review function

Evaluation Questions

- What features of such systems are most used by patients, Why?
- What features are least used and why?
- Are there usability issues that need to be resolved?
- How does use of such systems affect the doctor-patient interaction?
- Can patients comprehend information presented?
- Does use of these types of systems affect decision making and disease management?

Results

- **Function Usage**
  - Most frequently accessed function was “Review of Laboratory Data”
    - Accessed by patients at least once in the majority of the sessions
  - “Review of Reports” was second most frequently accessed function
  - Other functions (advice, education and data entry) were used sparingly

Analysis of User-System Interactions

Function Usage (number and percentage of accesses)

ADVICE	DATA ENTRY	DATA REVIEW	EDUCATION	TOTAL
.3%	4%	93%	3%	100%

- **Majority of accesses by patients for Data Review**
  - Laboratory details
  - Reports – admit/discharge, cardiology, radiology
- **Discovery of patterns of usage related to both demographic and medical data**
  - **Most used and useful for patients with specific illnesses – chronic illness (e.g. diabetes)**
  - **Patients liked the system since they felt greater ownership**
  - **Physicians liked the system as it streamlined their limited face-to-face visits with patients (patients had often reviewed their data prior to the interview)**

Excerpts from interviews with Patients

" Communication is less in the way of getting information now, and more in the way of discussing treatment options and agreeing on a course of action, so to me its more efficient than the old way"

" I look for trends in my medical data and if I see something I can contact the doctor to see what's going on, what we can do, change meds or whatever"

Excerpts from Interviews with Physicians

" Right now most of the communication takes place during the ten or fifteen minute visit and if I throw a lot of information at the patient about their condition or what I want them to do, its very hard for them to absorb all that.

It (PatCIS) gives them a chance to go back and look at things about their health record that they can then ask better questions about in the limited time that we have during the visit. Its another channel of communication"

Current Work: The Virtual Usability Laboratory (VUL)

- **Objective to develop a software tool that would allow for**
  - Automated tracking and collection of multiple forms of data to be obtained remotely
    - e.g. log files, questionnaires, triggered on-line interviews
  - Automated storage of information in relational (and OO) databases to allow for ad-hoc querying
    - SQL queries about how users are interacting with a system being studied
  - Development of a user-friendly interface for *researchers* and *evaluators*
    - Allows them to interact with the system in setting up evaluations

Type of Analyses on Stored Data

- **Results displayed to evaluators on system usage**
  - E.g. graphs of functions accessed within a system etc.
  - Time spent in particular part of a system
  - Number of user problems etc.

- **Also allows for *ad-hoc* querying of data since data stored in relational db format**
  - E.g. Can ask what are the demographics (e.g. age, computer expertise, illness etc.) of subjects who access a particular patient health care site (or a specific subcomponent of that site)
    - What is the work context of physicians accessing a specific set of guidelines?

Ongoing Work

- **Analysis of use and usability of emerging Web-based applications**
  - clinical guidelines
  - Web-based EMRs
  - educational applications
- **Application with SSHRC funded Simulation and Gaming (SAGE) project**
- **Development of pattern discovery algorithms and data mining of stored usability/health data**