WATERLOO INSTITUTE FOR HEALTH INFORMATICS RESEARCH

Waterloo Smarter Health Seminar Series:

'why not'

Why Not a Cognitive Science Approach to Understanding Clinician-Computer Interaction?

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Why Not a Cognitive Science Approach to Understanding Clinician-Computer Interaction?

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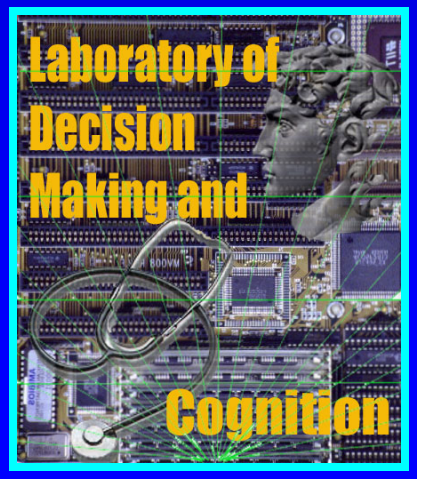
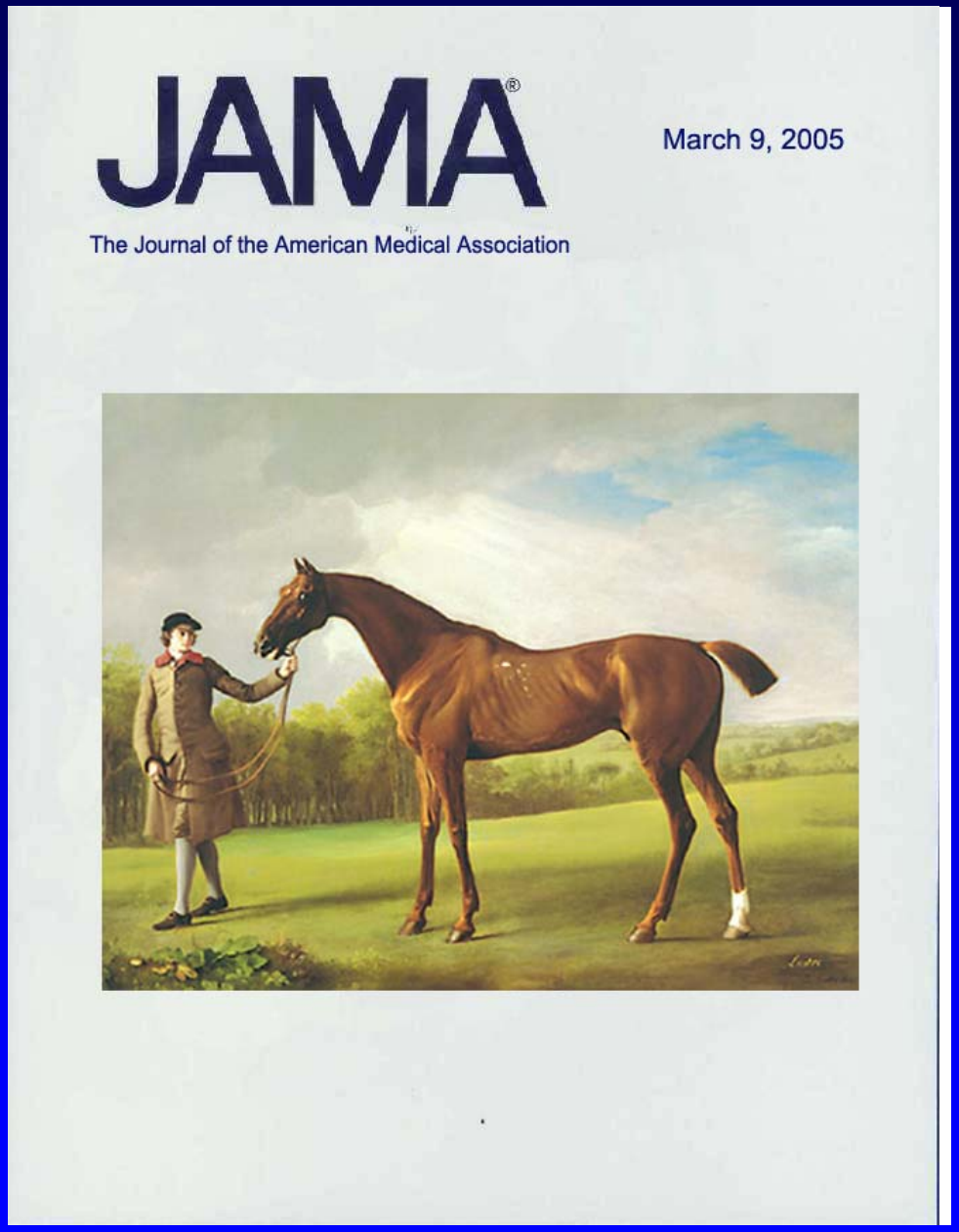


Koppel R, Metlay JP, Cohen A, Abaluck B, Localio AR, Kimmel SE, et al.

Role of Computerized Physician Order Entry Systems in Facilitating Medication Errors

JAMA 2005;293:1197-203.



Another Case

Potassium chloride (KCl) ordered as IV injection and as IV fluid additive using Eclipsys CPOE system:

- **85-year-old patient, admitted to the medical ICU with septic shock and respiratory failure**
- **Patient received 316 mEq KCl over 42 hrs in setting of acute and chronic kidney failure**
- **High dose delivered due to errors and misperceptions by several care providers**
- **Compounded errors propagated through the system over three days**

Horsky J, Kuperman GJ, Patel VL. Comprehensive analysis of a medication dosing error related to CPOE: A case report. J Am Med Inform Assoc 2005;12:377-382.

Analysis of Failure

- Misconceptions about the relation between IV volume (humans) and time duration (system)
- Misconception of latest and “dated” laboratory results
- Lack of Alerts when potassium value reached a dangerous level
- Inadequate clinical user training regarding safe and efficient ordering practices

Why are CPOE Systems Desirable?

- Orders are legible
- Transcription is eliminated (or reduced)
- Writer can be identified
- Orders are rapidly routed to destinations
- Orders are rechecked and clinical decision support is provided in real time

Computerized Provider Order Entry (CPOE)

NURSING

TESTS

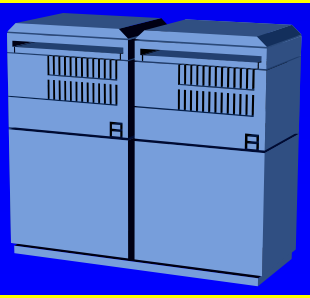
LABS

RADIOLOGY

Orders entered using a workstation or a wireless device

PHARMACY

Alerts, decision support



Hospital Information System

Patient Medical Records
Knowledge Bases

Designing for Safety

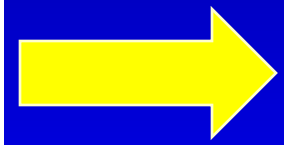
- Health information technology (HIT) has reduced the risk of serious injury for hospitalized patients.
- Paradoxically, some systems may give rise to hazards of their own
- Errors are the product of cognitive activity in human adaptation to complex physical, social and cultural environments
- How well the design of HIT complements its intended setting and purpose is critically important for safe and effective performance.

Horsky J, Zhang J, Patel VL. To err is not entirely human: Complex systems and user cognition. J Biomed Inform 2005;38 264-266.

Dimensions of Human Computer Interaction (HCI)

Technological

- Hardware and Software Advances



Cognitive

- Representation
- Knowledge Organization
- Reasoning and Strategies

What is Cognitive Science?

Multidisciplinary field incorporating theories and methods from psychology, linguistics, philosophy, anthropology, and computer science in the investigation of cognitive processes in humans and machines

From Cognitive Science to Medical Cognition

Cognitive Science Theory

- Memory
- Knowledge Organization
- Problem Solving
- Heuristics/Strategies
- Computational Theory of Mind

Medical Cognition Conceptual Frameworks

- Medical Problem Solving
- Organization of Clinical and Basic-Science Knowledge
- Diagnostic Reasoning Strategies
- Medical Decision Making

From Medical Cognition to Biomedical Informatics

Medical Cognition

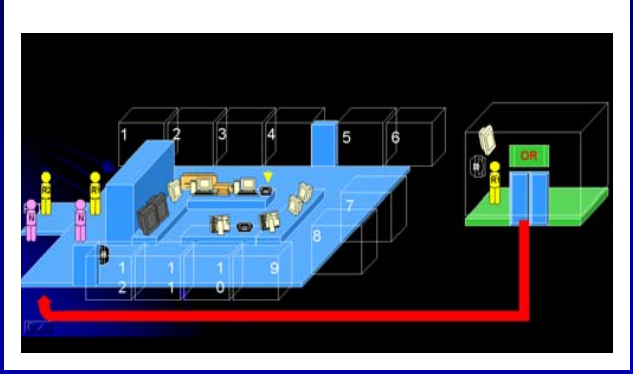
- Medical Problem Solving
- Organization of Knowledge
- Diagnostic Reasoning Strategies
- Medical Decision Making
- Text Comprehension and Problem Representation
- Development of Medical Expertise
- Medical Discourse

Biomedical Informatics

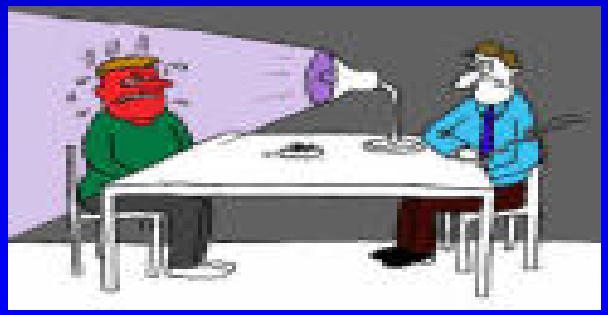
- Knowledge and Data Representation
- Management of Medical Information
- Human-Computer Interaction
- Cognitive Models for Enhancing Decision Support
- Cognitive Assessment of Usability and Interfaces
- Targeted Training

Specific Methods

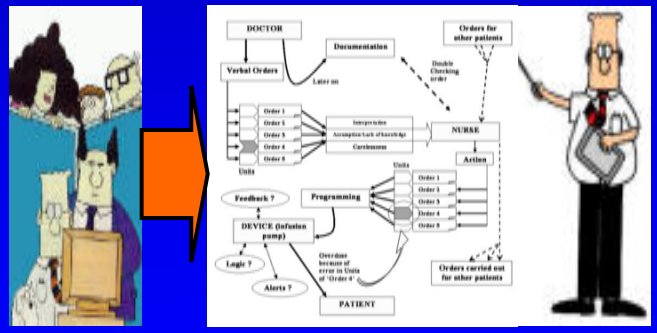
Shadowing of medical team personnel during ‘Crucial Periods’ pertinent to the individual



Mapping the activities to the ICU/ER layout and time-stamping each interaction or event

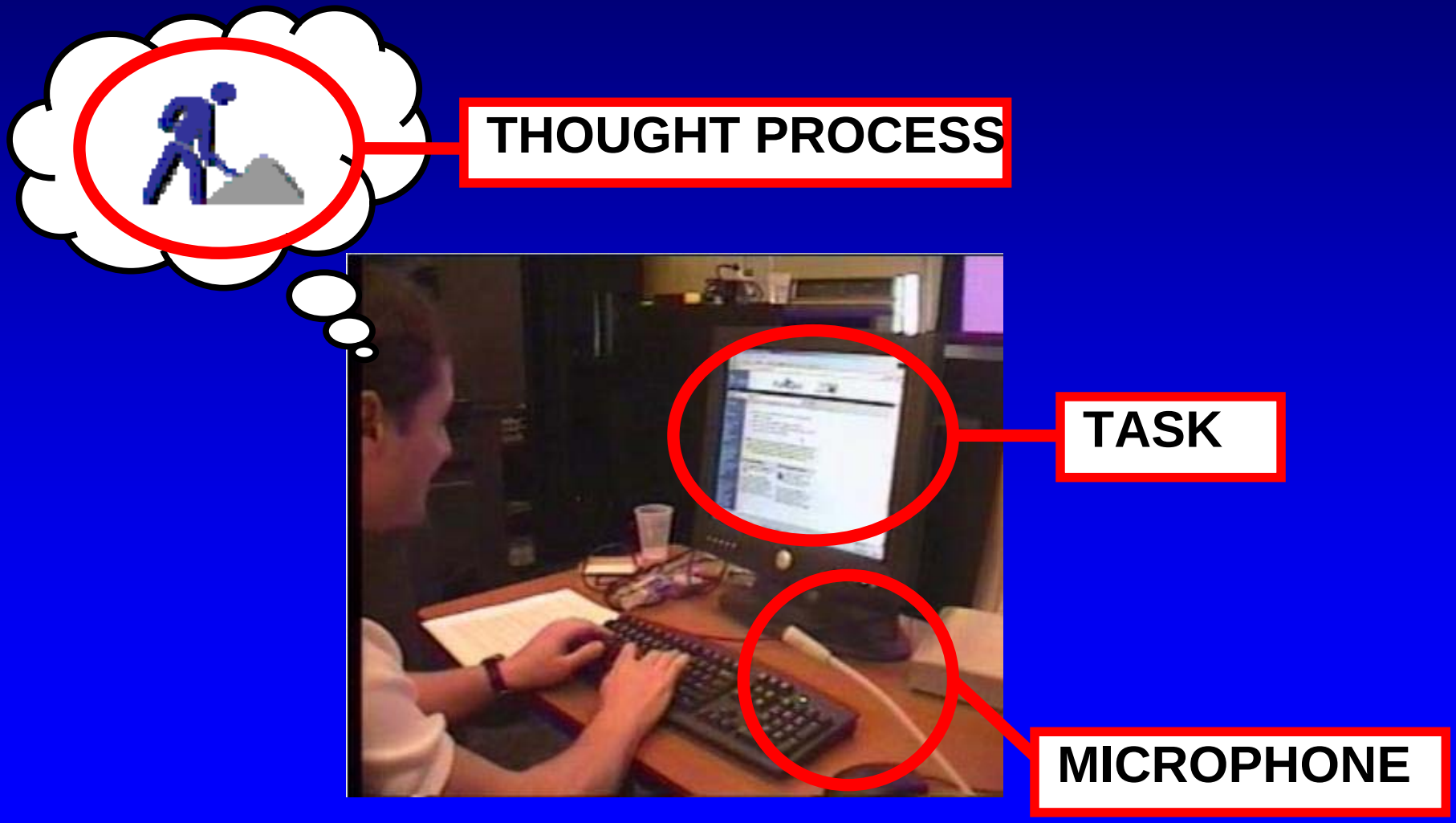


Conducting brief interviews to gain insight on infrastructure, roles, shifts, timings



Obtaining log files of the clinical information systems and attempting correlation with observational data.

Think-Aloud Protocol Reveals Underlying Thought Process



Clinical Applications and Cognition

- Effects of technology on human behavior
- Clinical workflow for triage decision making and technological support

Effect of an EMR System on Human Cognition

- Transition from paper records to EMR and back to paper record
- Impact on knowledge organization, reasoning
- Information and other technologies are not merely tools to expedite, facilitate and enable the execution of task

Patel V, Kushniruk A,Yang S,Yale J-F, Impact of a computer-based patient record system on data collection,knowledge organization and reasoning. *JAMIA*,7(6)569-85,2001

Information in EMR 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	

First section from paper-based record (Pre-EMR)

74 year old woman, whose diagnosis was made in February, as she complained of polyuria/nocturia and fatigue for a few years. She was told her sugar was very high and she was sent to Dr. K., who started her on Diabeta 5 mg/d and sent her to Dr. S. in ophthalmology who reported normal retina. She lost weight, her polyuria improved, her bladder urgency got better, and her glucose values improved dramatically. She does no monitoring at home. She had to be hospitalized for an ankle fracture after falling on ice, for 3 months. At follow-up, Dr. K. seemed pleased with the results.

First Section from Electronic Medical Record (EMR)

CHIEF COMPLAINT: Type II diabetes mellitus

PERSONAL HISTORY

SURGICAL: cholecystectomy: Age 60 years old

MEDICAL: hypothyroidism: asymptomatic since 25 years

LIFE STYLE

MEDICATION

DIABETA (Tab 2.5 MG)

Sig: 1 tab(s) Oral before breakfast

SYNTHROID (Tab 0.125 MG)

Sig: 1 tab(s) Oral before breakfast

HABITS: smoking: 0 alcohol: 0

First Section from Paper-Based Record (Post-EMR)

Diabetes type I X age 4

Currently on N54 - N28

	R6 - R2	Measure with OT II	
Glucose levels:	<130	130-180	>180
AM	IIIIIII	IIIIIIIIIIIIII	
Lunch			
Supper	IIIIIIIII		
Bedtime	IIIIIIII	IIIIIIIIIII	

Last HbA_{1C} since April 96: 7.4/7.2/6.7/6.6/8.9 - higher values in log book

Retinopathy: NIL March 97

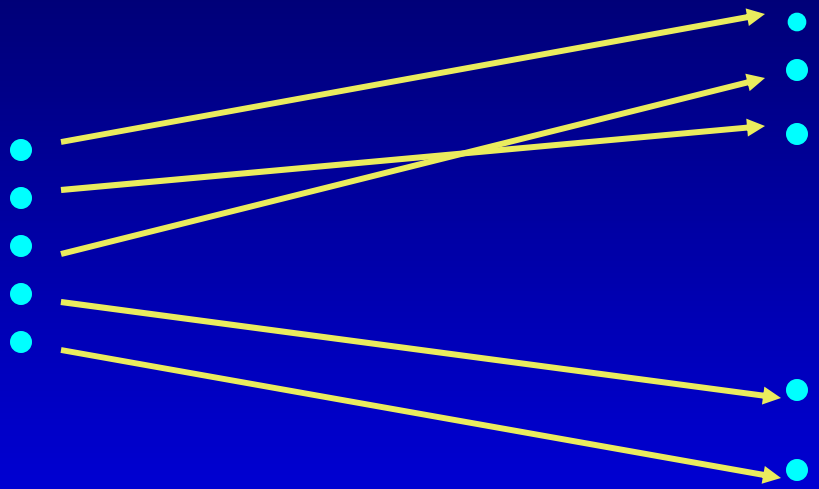
Nephropathy: NIL Oct. 96

Diagnostic Reasoning

Paper Record

Patient Data

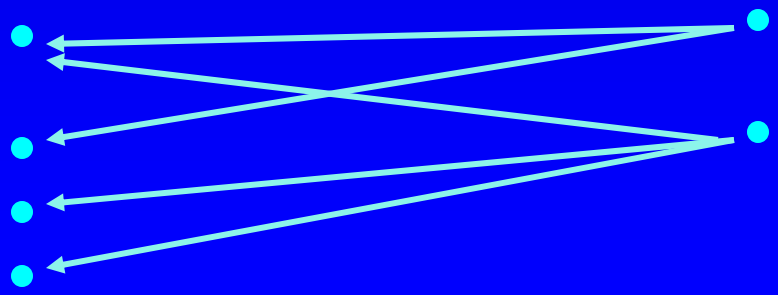
Multiple Hypotheses



Return to Paper Record

Patient Data

Hypotheses



Same as EMR!

Structure of Medical Knowledge in Problem Solving

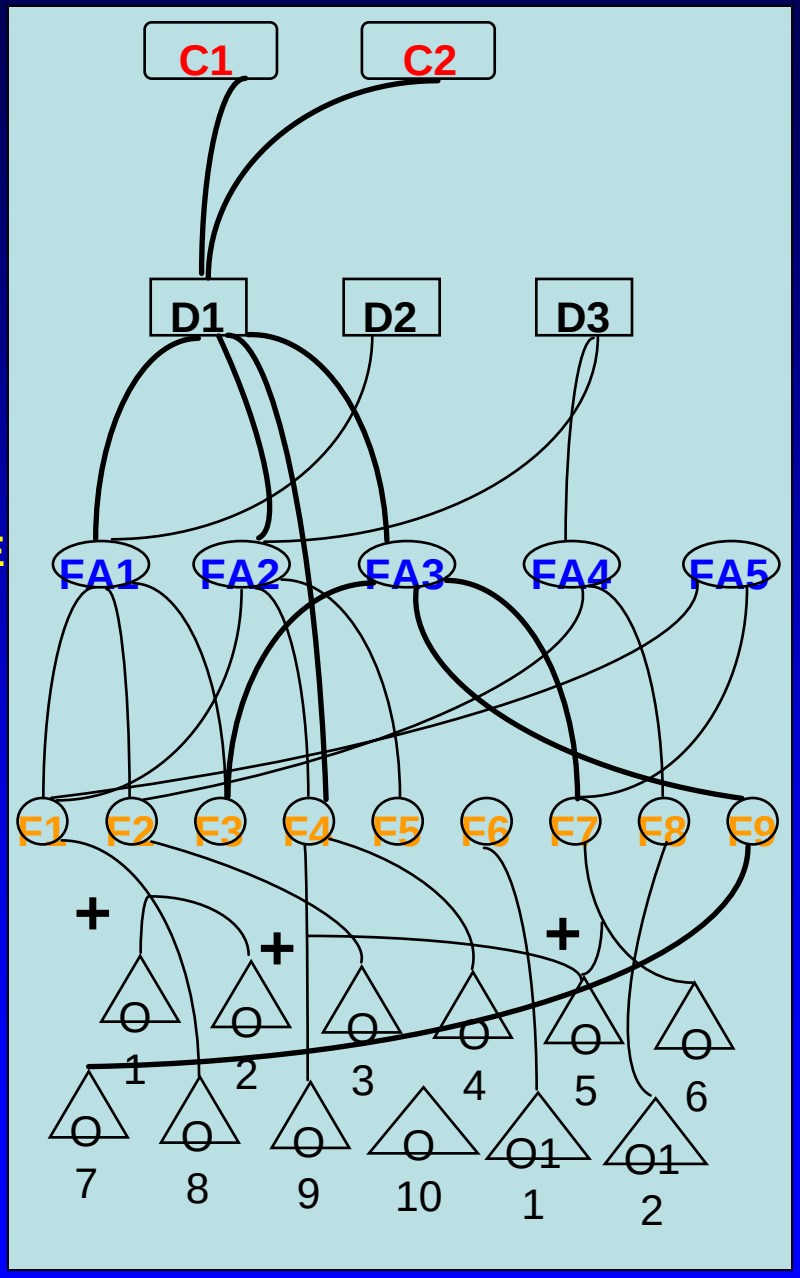
SYSTEMS LEVEL

DIAGNOSTIC LEVEL

INTERMEDIATE CONSTRUCT

FINDING LEVEL

OBSERVATION LEVEL



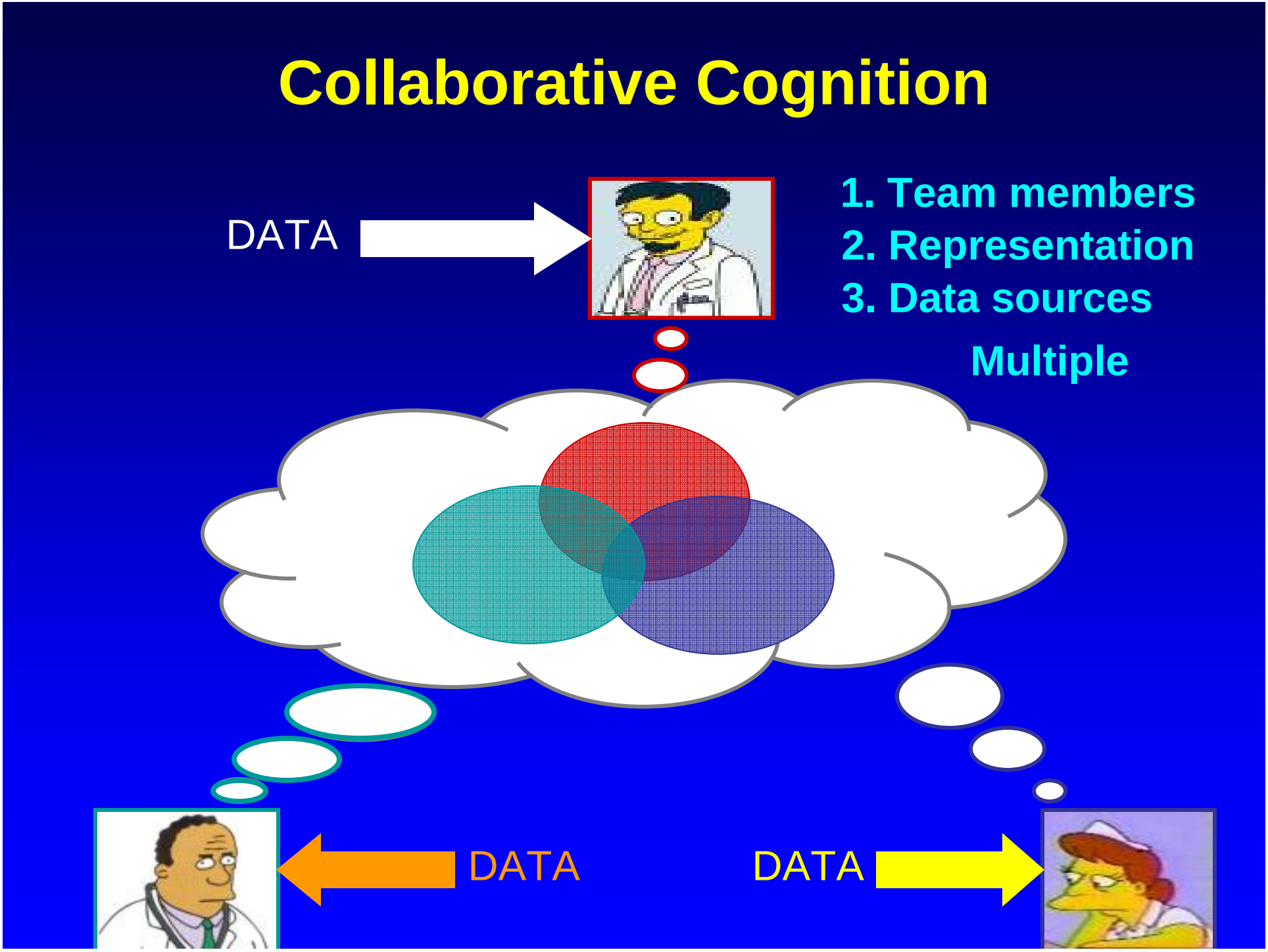
Influence of Technology on Human Cognition

- Information and other technologies are not merely tools to expedite, facilitate and enable the execution of tasks
  - They have profound and enduring consequences
- Optimal design requires sensitivity to internal organization of concepts by human beings
  - Utility and acceptance depend on designer's recognition that the system is a mediator of cognition (re-organizes cognition)

Clinical Applications and Cognition

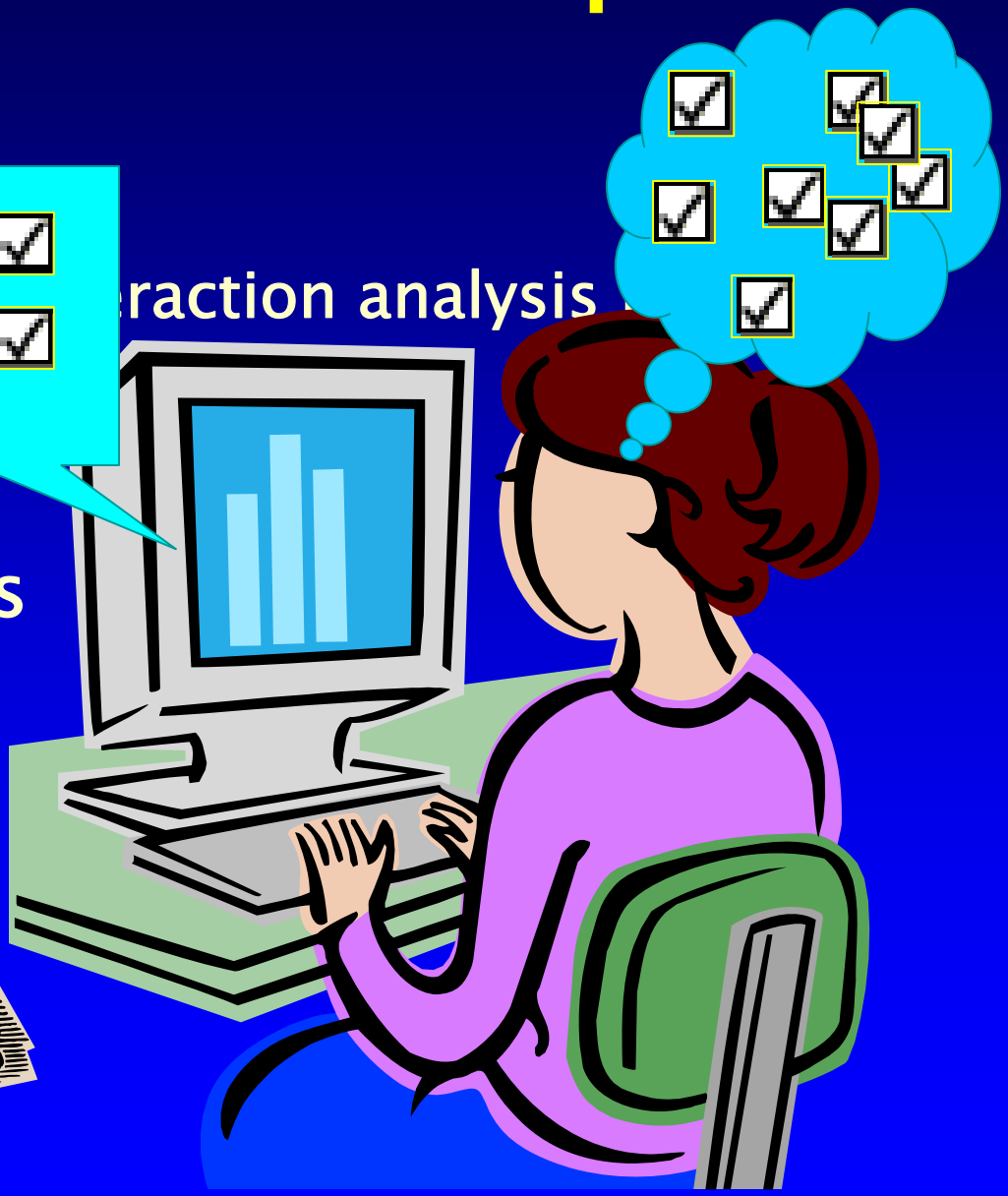
- Effects of technology on human behavior
- Clinical workflow for triage decision making and technological support

Collaborative Cognition



Intellectual Partnership

- Distributed
  - Human-co raction analysis
- Knowledge resides partly in the environment



Intellectual Partnership

- Coordinating internal (user's mind) and external (interface, environment) resources

References

Laxmisan A, Hakimzhada A, Sayan OR, Green RA, Zhang J, Patel VL. The multitasking clinician: Decision-making and cognitive demand during and after team handoffs in emergency care, *IJMI* (in press)

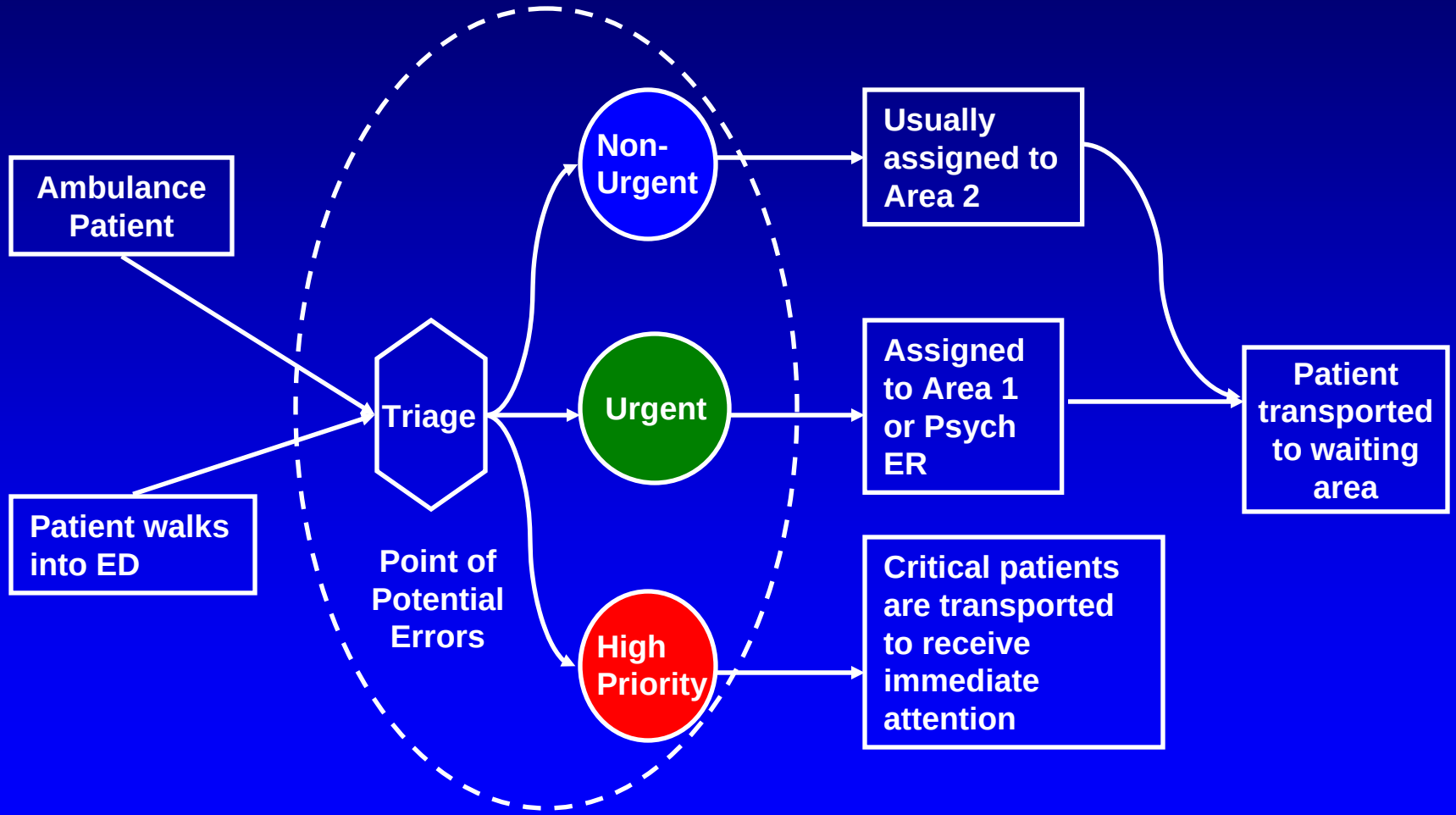
Maholtra, S., Jordan, D., Shortliffe, E.H., & Patel, V.L. (2006). Workflow in critical care: Piecing together your own puzzle. *Journal of Biomedical Informatics* [currently available online]

Cohen, T. Blatter, B. Almeida, C. Patel, VL. *Reevaluating recovery: Perceived violations and preemptive interventions on emergency psychiatry rounds*. JAMIA (in press)

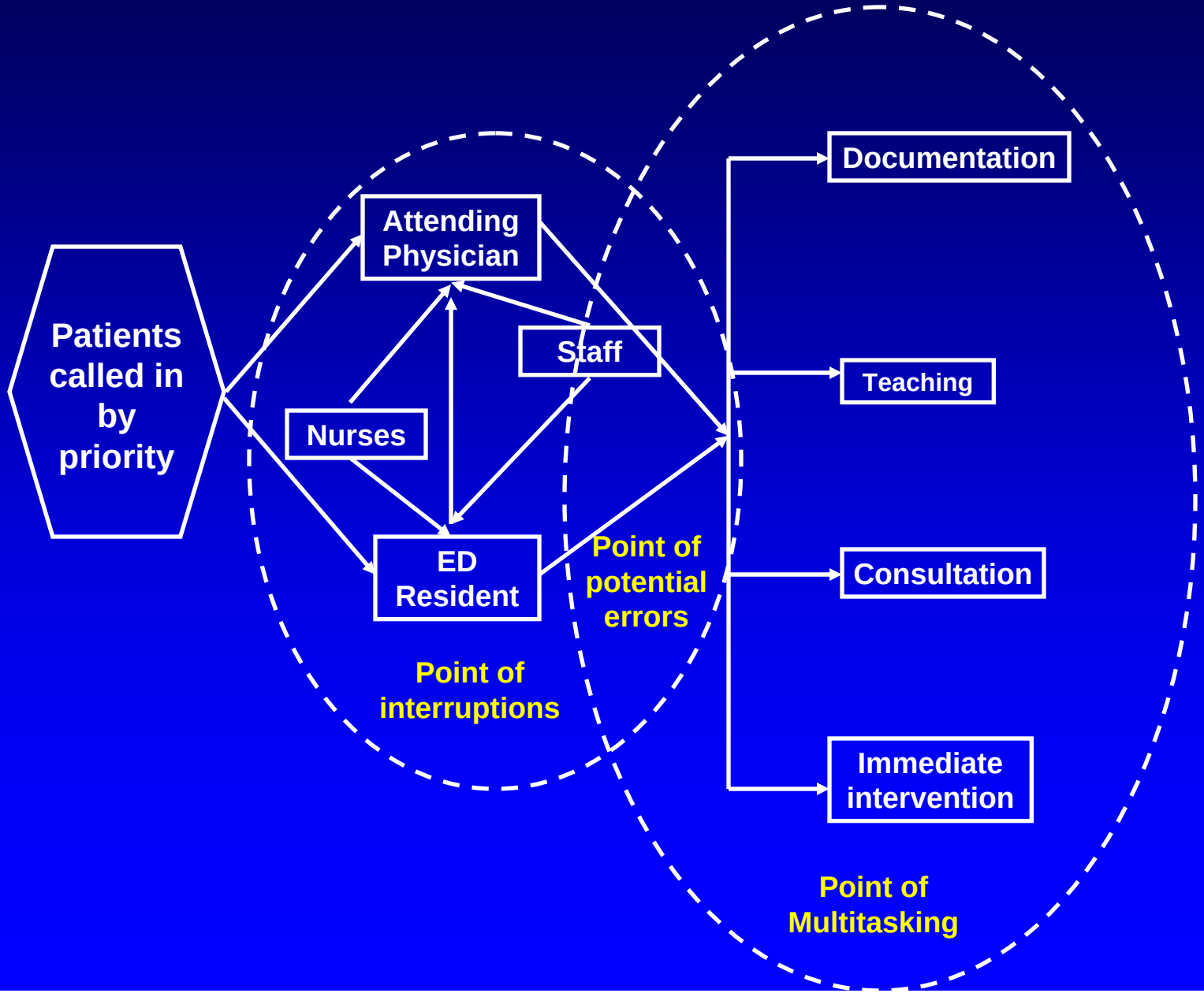
Cohen, T., Blatter, B., Almeida, C., Shortliffe, E., & Patel, V. (2006). Distributed cognition in the Psychiatric Emergency Department: A cognitive blueprint of a collaboration in context. *Artificial Intelligence in Medicine*, *37,* 73-83

Horsky J, Gutnik L, Patel VL. Technology for emergency care: Cognitive and workflow considerations, Proceedings of AMIA 2006 (in press)

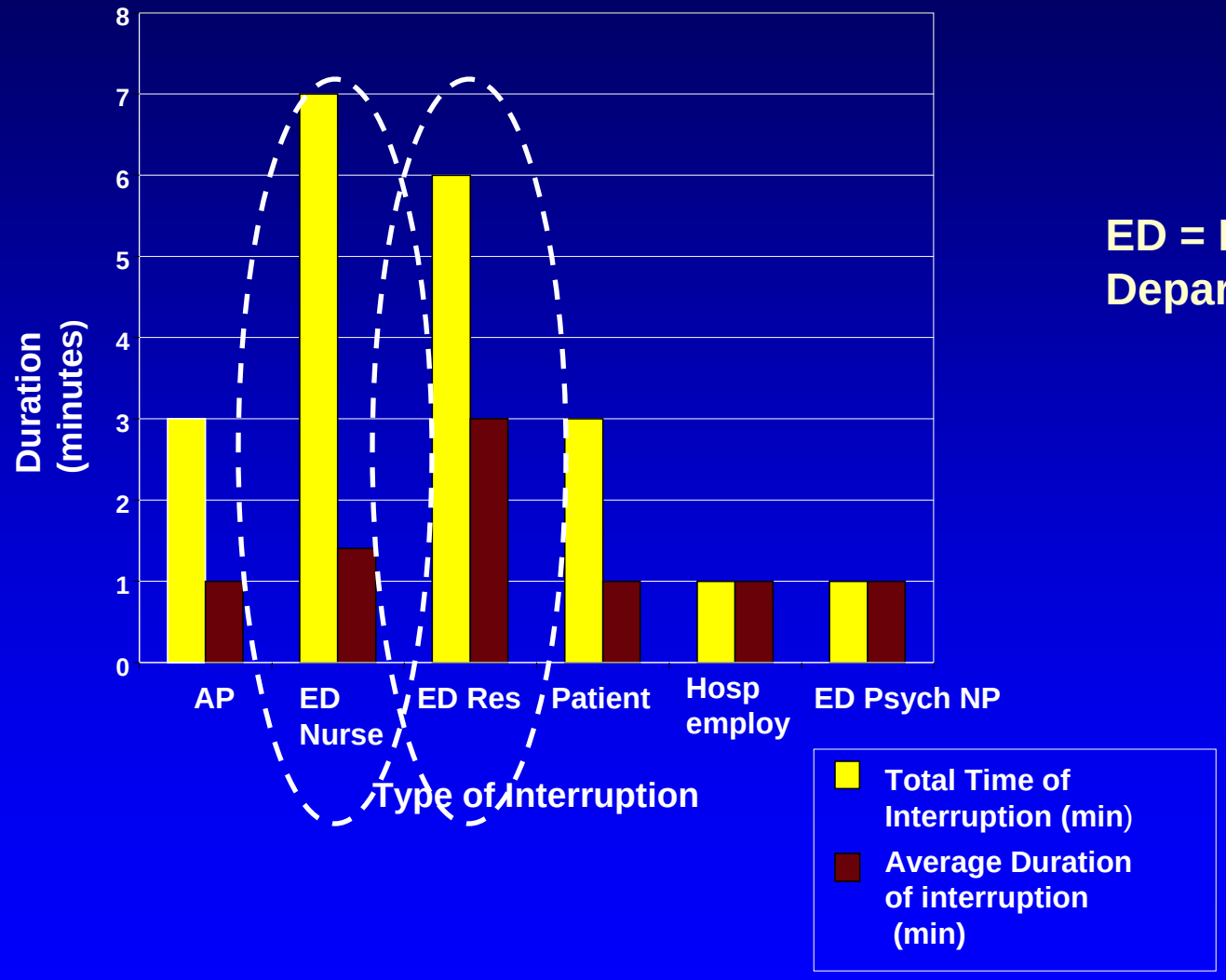
Overview of Clinical Workflow in the Emergency Department



Workflow (Continued)



Interruptions and Multitasking (over 3 hours)



ED = Emergency Department

Time and duration of interruptions for different types of individuals

Pre-Triage Issues in Emergency Dept

(duration 1-2 minutes)

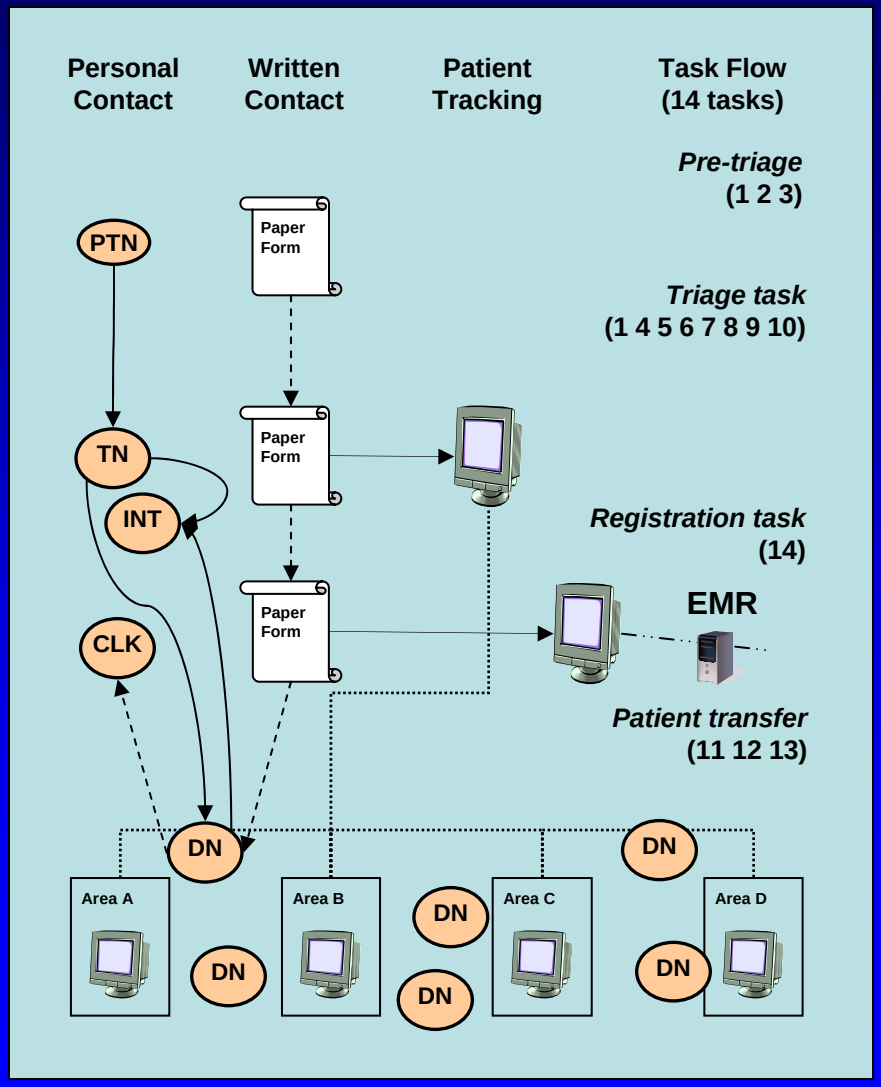
No	Task	Com	Findings - Problems	Recommendations
1	ID patient	Per	Privacy concerns; misspelled names may cause multiple entries in EMR	Separated from waiting room; electronic entry of pt. names
2	Urgency		No decision support; patient history and practice guidelines not accessible	Integrated tracking and EMR systems for immediate recall
3	Patient Destina-tion	Per	Waiting room activity not monitored; no direct communication with fast-track	Pts may be given bracelets; alerts to fast-track personnel
4	Paper form	Wrt	Legibility; single copy for all clinicians	Replace by electronic system

Triage Issues in Emergency Dept

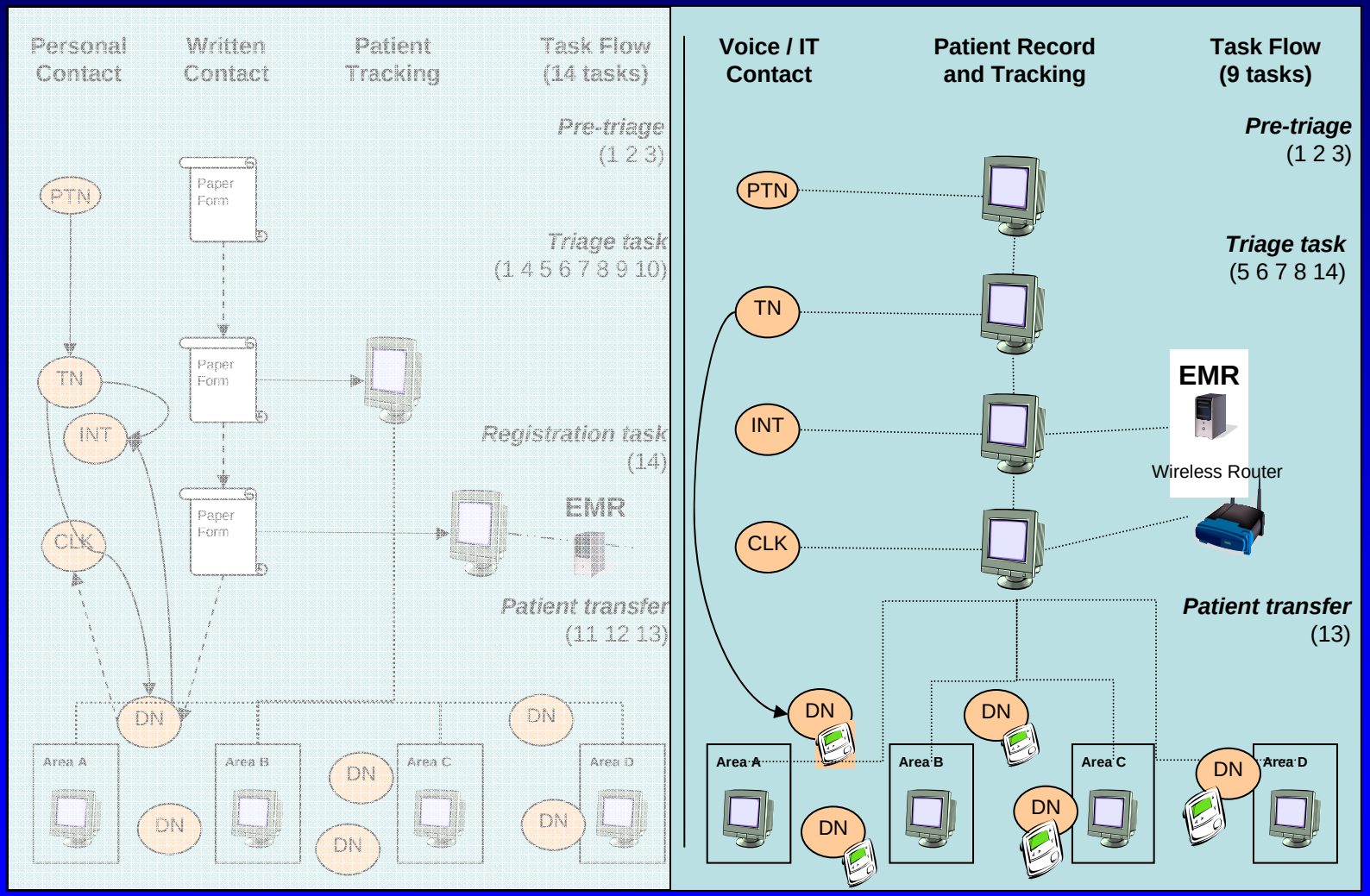
(duration: 12 minutes)

No	Task	Com	Findings - Problems	Recommendations
5	Assess-ment	Per Wrt	Interpreter inaccessible; EMR with visit history unavailable; no guideline access	Communication via PC or intercom; electronic guideline
6	Triage category	Wrt Per	No decision support available; patient longitudinal record/allergies unavailable	EMR may be ready from pre-triage stage for overview
7	Tracking	Elc	Duplication of data from paper; manual updates of state not always accurate	Integrated system with EMR; automatic updates via RFID
8	Workload estimate	Per Elc	Cognitively difficult; requires calls when tracking system is not updated	Tracking can auto-mate this with algo-rithms and updates
9	Patient Desti-nation	Per Elc	Awareness of current overall workload of district nurses required	Tracking system may allocate patients to appropriate area

Clinical Workflow in Emergency Room Triage



Proposed Clinical Workflow in Emergency Room Triage



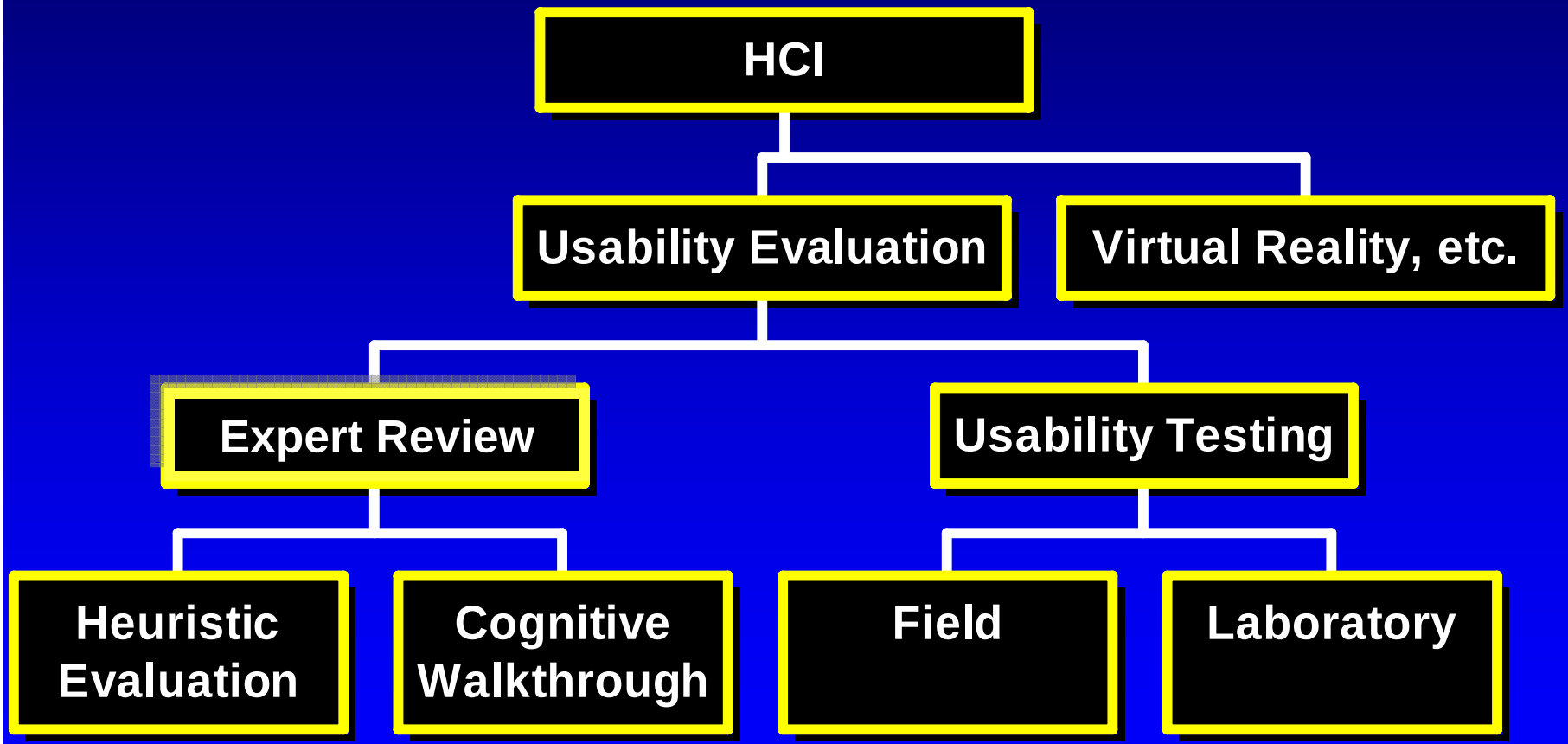
Summary

- Failure in interaction among human beings and system agents lead to delays, inefficiencies, and opportunities for error
- When information technology is not implemented or not well integrated into workflow, unnecessary tasks are performed and errors are generated
- Need to replace inadequate or non-existent technological support of clinicians by specific information and communication technologies that fit the cognitive and workflow demands of the task

Problems Using Things: Imperfect World of Design

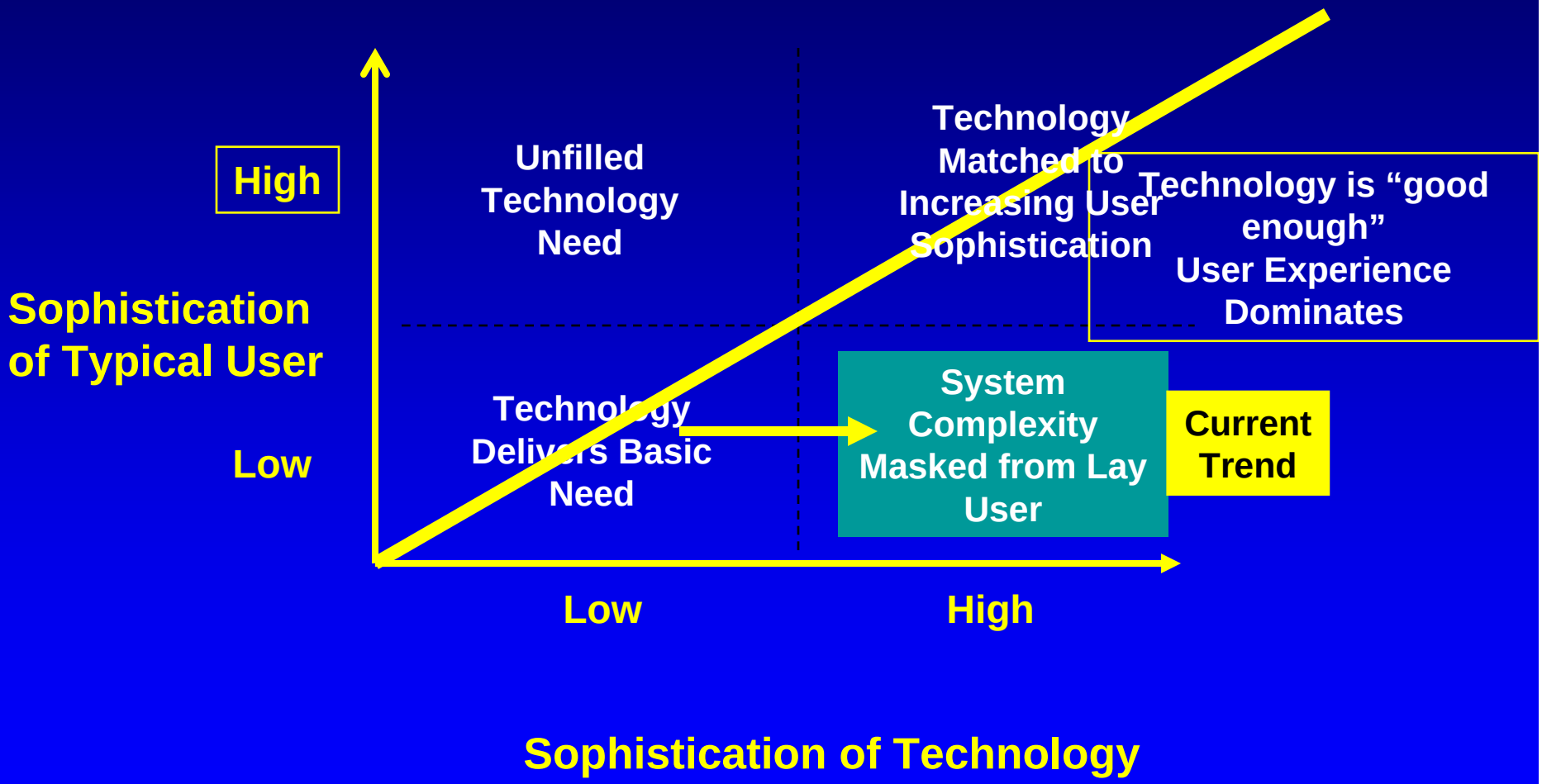
- Programmable Calculators.
- VCRs with or without Advanced Editing Features.
- Contemporary Office Telephones with Features such as Call Waiting& Call Forwarding.
- “State of the Art” Photocopying Machines.
- Home-Monitoring Devices for Patients
- Interactive Web Sites
- ATM Machines
- Computer-Mediated Learning Environments

HCI Landscape




KEEP
RIGHT

User-Technology Interaction: Role of Cognition



Some Lessons from Cognitive Studies

- Design of HIT must complement its intended setting and purpose to encourage safe and effective performance
- Technology can help to manage errors, but also introduce new opportunities for errors
  - Thus has to be carefully monitored for intended and unintended outcomes
- Technology must support (and be sensitive to) how we do our tasks in the clinical environment
  - Exception: when we are doing our task poorly without technology

Chapter 4:
Cognitive Science in Biomedical Informatics

—VL Patel and DR Kaufman—

Biomedical Informatics Textbook

(3rd edition)

Springer Verlag - 2006