



## Project 4: Cognitive Information Design and Visualization

Presented by

**Dr. Ben Shneiderman**

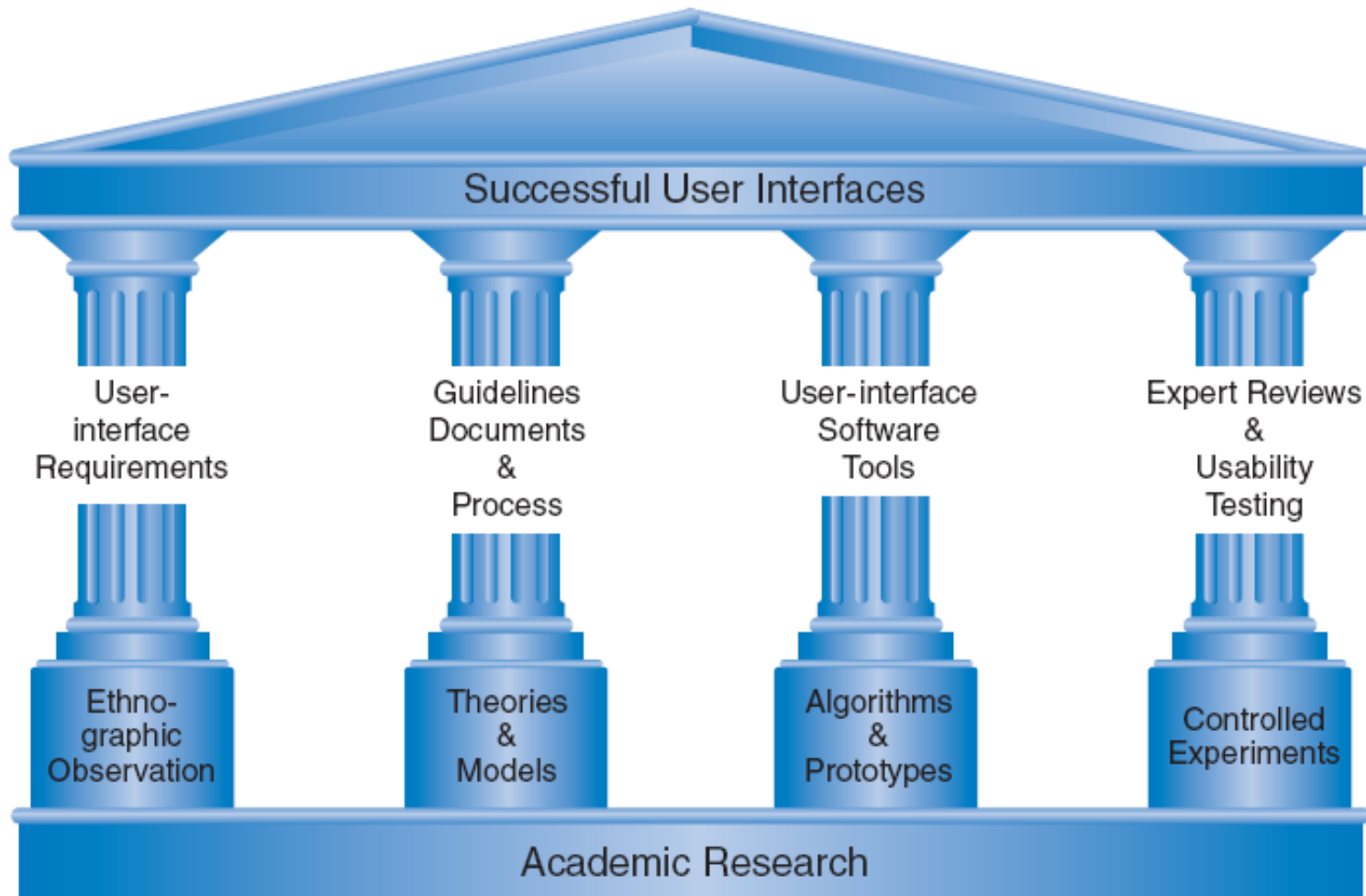
Catherine Plaisant  
Surreya Tarkan  
Tiffany Chao

Jorge Herskovic  
Elmer Bernstram  
Elis Markovitz  
Chitra Shriram

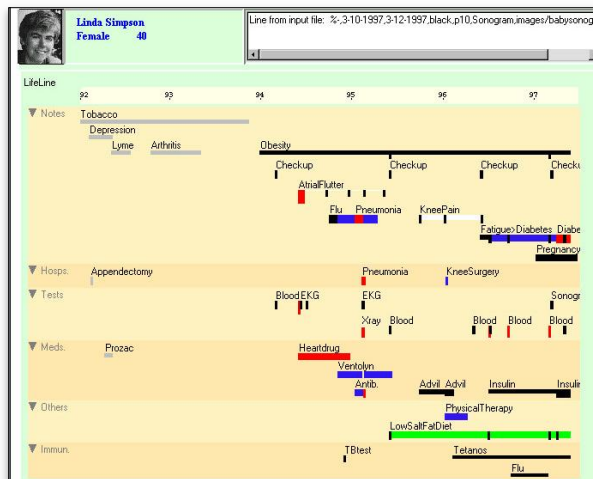
Todd Johnson



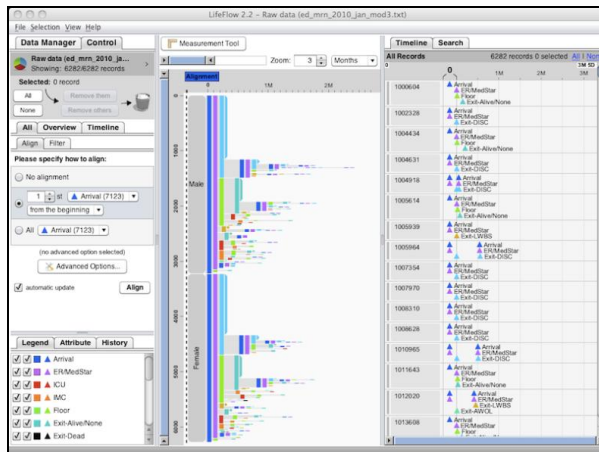
# Human-Computer Interaction has Strong Structures



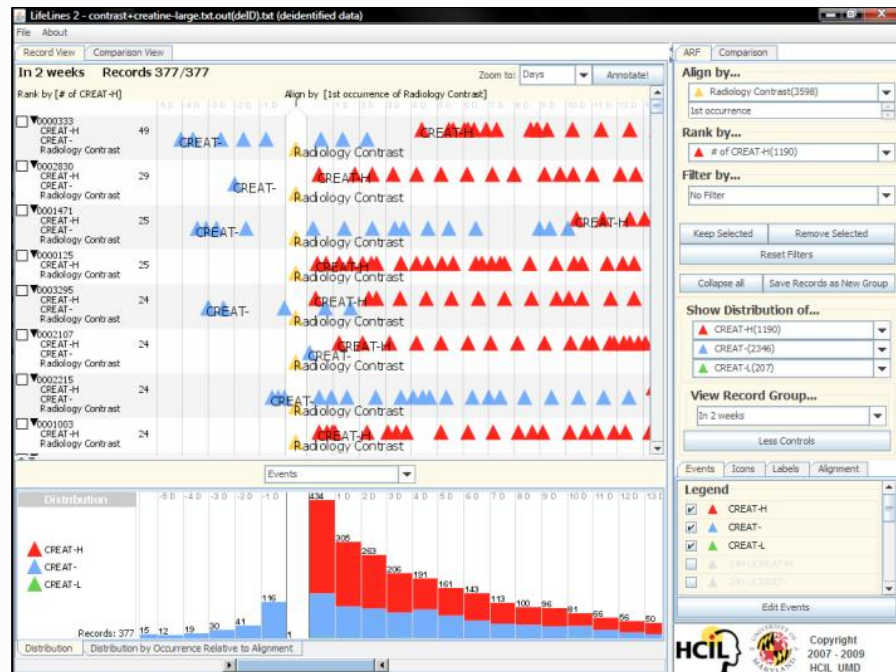
# History of EHR Interfaces & Tech Transfer



**Lifelines (AMIA 1998)**  
[cs.umd.edu/hcil/lifelines](http://cs.umd.edu/hcil/lifelines)



**LifeFlow** (CHI 2011, IHI 2011 with Mayo)  
[cs.umd.edu/hcil/lifeflow](http://cs.umd.edu/hcil/lifeflow)



**Lifelines2** (CHI 2009 - IHI 2010)  
[cs.umd.edu/hcil/lifelines2](http://cs.umd.edu/hcil/lifelines2)

Now Integrated with i2b2 & BTRIS

Lifelines & LifeFlow

# Overall Goals of Project 4

Create framework & guidelines for designing **interactive information visualizations** that provide **patient-centered cognitive support** by enhancing accessibility & understanding of patient data.

Short Term Goal: Focus on clinician-centered visualization tools that address **national priorities**.

- Lab & study tracking to ensure completion
- Medication Reconciliation

# Initial efforts

## 1. Survey EHR visualizations



## 2. Build relationships: Workshops with partners & vendors

## 3. Create national interest in EHR usability: ACM, UPA, HIMSS, InfoVis, The article by Steve Lohr in **The New York Times**

See: [cs.umd.edu/hcil/sharp](http://cs.umd.edu/hcil/sharp)

# Lab & study tracking to ensure completion

Sureyya Tarkan

The screenshot displays the MSTART Simulator interface. At the top, an XML editor shows a process definition for 'X-Ray' with a task 'Schedule an exam'. Below this, the 'Riverside Clinic' interface is shown with a 'Track' tab selected. It features a 'Filters' panel on the left with checkboxes for 'All Tests', 'Lateness', 'Abnormality', 'Patient', and 'Test'. The main area displays 'Arrived Results' and 'Pending Test Results' tables. The 'Arrived Results' table lists patients like Murphy, Sabrina and Evans, Anna, along with their tests and expected/elapsed times. The 'Pending Test Results' table lists patients like Collins, Emily and Edwards, Rachel. At the bottom, a 'Patient: Evans, Anna' form is visible with fields for 'Ask assistant to', 'Schedule Visit', 'Repeat Lipid Panel', 'Order Urinalysis', 'Order Cholesterol-lowering Drug', 'Consultation', and 'Referral'.

Define tracking processes  
Assign temporal responsibility  
Define possible actions  
Predict expected duration

Generate User Interface from processes  
Enhance situation awareness  
Integrate follow-up actions with results  
Simplify rapid operations  
Provide retrospective analysis



# Medication Reconciliation



A complex process:

- Develop a list of current medications
- Develop a list of medications to be prescribed
- Compare the medications on the two lists
- Make clinical decisions based on the comparison
- Communicate the new list to caregivers and the patient.

[ihs.gov/cio/ehr/index.cfm?module=medication\\_reconciliation](https://ihs.gov/cio/ehr/index.cfm?module=medication_reconciliation)

## Example of Medication Lists

## What is unique?

## What is identical?

## What is equivalent?

[illegible][illegible]



# Existing tools

**Patient Information**  
 Patient Name: Harry Heart  
 Patient ID: 23456789  
 Patient MRN: 1234

**Manage Medications**  
 Name: John Smith  
 Date: 05/15/08  
 Action: ☐ STOP ☐ Edit ☐ Continue

**HOME MEDICATION Entry Form**  
 Drug Name Search:   
 Dose:   
 Sig:   
 Status: ☐ Continue ☐ Change to ☐ Stop  
 Source: ☐ Patient ☐ Family ☐ EMS ☐ Transfer List ☐ Med Record ☐ Other

**Medication Reconciliation**  
 Medications (Manage Medications)  
 View (Current) (Medication History) Actions: (Status Selected) (Status All) (Status None) Check Interactions for Selected  
 Medication History: 100 mg 100 mg 100 mg 100 mg 100 mg 100 mg 100 mg 100 mg 100 mg 100 mg  
 Actions: (Status Selected) (Status All) (Status None) Check Interactions for Selected  
 Ceftriaxone (ceftriaxone axetil) Tablet 500 mg 1 tablet by mouth twice a day Disp 14 LAR (last 05/13/2010) by IEB started on 05/13/2010 stop on 05/20/2010  
 Actions: (Status Selected) (Status All) (Status None) Check Interactions for Selected  
 diabetes wonder drug No Quantity FR by IEB  
 Actions: (Status Selected) (Status All) (Status None) Check Interactions for Selected

**Maintain Active Meds List**  
 Indication: Diabetes

Instructions	Last Dose	Source	Last Updated	Charted By
PO 4 TIMES PER DAY	5/10/08 18:00	Patient	5/10/08 22:00	AMY OLSEN, MD
750 MG PO EVERY DAY	5/10/08 08:00	Family	5/10/08 20:29	LAUREN HOLT, RN
0.15 UNIT/LOGRAM SQ 3 TIMES PER DAY administer within 15 minutes before breakfast, lunch and supper or immediately following	5/10/08 18:00	Patient	5/10/08 20:00	MARY SMITH, RN
1 UNIT SQ ONE TIME ONLY	5/10/08 08:00	Patient	5/10/08 20:00	MARY SMITH, RN

## Limitations:

1. No or limited assistance
2. Increases workload for the clinician.
3. Usability problems

# Levels of Equivalence

Equivalence	Criteria	Example
Form Equivalence	Identical except for brand vs. generic	Advil = Ibuprofen Senormin = Atenolol
Functional Equivalence	Same therapeutic intent	Atenolol and Propanolol both betablockers
Partial Equivalence	Form or functional equivalence, but differ in dosage, frequency, or route	Advil 100 mg Acetaminophen 200mg
No equivalence	Unique in form and function	

# Levels of Equivalence

Equivalence	Criteria	Example
Form Equivalence	Identical except for brand vs. generic	Advil = Ibuprofen Senormin = Atenolol
Functional Equivalence	Same therapeutic intent	Atenolol and Propranolol both betablockers
Partial Equivalence	Form or functional equivalence, but differ in dosage, frequency, or route	Advil 100 mg Acetaminophen 200mg
No equivalence	Unique in form and function	

Bozzo Silva, P., Bernstam, E.,  
Markowitz, E., Johnson, T., Zhang, J.,  
Herskovic, J.

Automated medication reconciliation and complexity of care  
transitions

S87  
Wednesday, Oct. 26  
8:50 – 9:10 AM

Lincoln West

# Two Designs - Demos

Tabular layout  
Grouped rows = similarity

**MedRecon**

www.zdssoft.com  
jorgehskovic.net/medrec/MedRec.html

SHARPC NCCO

List 1 comes from:  List 2 comes from:

Consolidated Record

Origin	Medication	Dosage	Freq.	Start	End	Form	Relation
[DRAG]	Protonix	40 MG	Take 1 tablet daily: rx			Tablet delayed release	ingredients list
[DRAG]	Pantoprazole sodium	40 MG	Take 1 tablet daily: rx			Tablet	Unique
[DRAG]	Synthroid	100 MCG	Take 1 tablet daily: rx			Tablet	Unique

Reconciled Record

Origin	Medication	Dosage	Freq.	Start	End	Form	Alerts
[DRAG]	Coreg	25 MG	Take 1 tablet twice daily, with morning and evening meal: rpt			Tablet	
[DRAG]	Warfarin sodium	2.5 MG	Take as directed: rx			Tablet	
[DRAG]	Lipitor	10 MG	Take 1 tablet daily: rx			Tablet	
[DRAG]	Warfarin sodium	5 MG	Take 1 tablet daily as directed: rx			Tablet	
[DRAG]	Mirapex	0.5 MG	Take 1 tablet 3 times daily: rx			Tablet	
[DRAG]	Zoloft	50 MG	Take 1 tablet daily: rpt			Tablet	
[DRAG]	Lisinopril	5 MG	Take tablet twice daily: rx			Tablet	

Done

Spatial Layout  
Closeness = similarity

**TwinList**

twinlist (ver. 5 col) - Mozilla Firefox

twinlist (ver. 5 col)

twinlist

compare-lists confirm choices show help show options start over?

Intake unique	Intake similar	Identical	Hospital similar	Hospital unique
accept / reject remaining	accept / reject remaining	accept / reject remaining	accept / reject remaining	accept / reject remaining
Nexium PO daily 40 mg		Toprol XL PO daily 25 mg		Folic acid PO daily 1 mg
Plavix PO daily 75 mg		Enalapril PO BID 20 mg		
Tylenol PO PRN 325 mg		Amiodarone PO dieb. alt. 200 mg		
		Aspirin PO daily 325 mg		
		Isosorbide dinitrate PO TID 30 mg		
		Amiodipine PO BID 2.5 mg		
	Lipitor PO daily 40 mg		Lipitor PO HS 80 mg	
	Nitrostat SL PRN 0.4 mg		Nitroglycerin SL PRN 0.4 mg	
	Ferrous sulfate PO TID 325 mg		Ferrous sulfate PO BID or TID 325 mg	

Detail Nitroglycerin / SL / PRN / 0.4 mg / post-myocardial infarction

SHARPC NCCO

# MedRecon: semi automatic reconciliation

Eliz Markowitz, Elmer V. Bernstam, Jorge Herskovic, Jiajie Zhang, Todd R. Johnson

www.zdsoft.com prototype

jorgeherschovic.net/medrec/MedRec.html

test Google

**SHARPC**  
NCCO

List 1 comes from

List 2 comes from

### Consolidated Record

Origin	Medication	Dosage	Freq.	Start	End	Form	Relation
[DRAG]	<b>Protonix</b>	40 MG	Take 1 tablet daily; rx			Tablet delayed release	ingredients list
[DRAG]	<b>Pantoprazole sodium</b>						
[DRAG]	<b>Synthroid</b>	100 MCG	Take 1 tablet daily; rx			Tablet	Unique

### Reconciled Record

Origin	Medication	Dosage	Freq.	Start	End	Form	Alerts
[DRAG]	<b>Coreg</b>	25 MG	Take 1 tablet twice daily, with morning and evening meal; rpt			Tablet	
[DRAG]	<b>Warfarin sodium</b>	2.5 MG	Take as directed; rx			Tablet	
[DRAG]	<b>Lipitor</b>	10 MG	Take 1 tablet daily; rx			Tablet	
[DRAG]	<b>Warfarin sodium</b>	5 MG	Take 1 tablet daily as directed; rx			Tablet	
[DRAG]	<b>Mirapex</b>	0.5 MG	Take 1 tablet 3 times daily; rx			Tablet	
[DRAG]	<b>Zoloft</b>	50 MG	Take 1 tablet daily; rpt			Tablet	
[DRAG]	<b>Lisinopril</b>	5 MG	Take tablet twice daily; rx			Tablet	

Done

Un-reconciled medications require clinician's selection or rejection

Identical medications automatically reconciled

Markowitz, E., Bernstam, E., Herskovic, J., Zhang, J., Shneiderman, B., Plaisant, C., Johnson, T.

Medication Reconciliation: Work Domain Ontology, Prototype Development, and a Predictive Model

S87  
Wednesday, Oct. 26  
8:30 – 8:50 AM

Lincoln West

Paper

# MedRecon Demo

[Start demo](#)

(Or watch on [YouTube](#))

Stop demo

# Twinlist

Tiffany Chao, Catherine Plaisant, Ben Shneiderman

Based on class project of : Leo Claudino, Sameh Khamis, Ran Liu, Ben London, Jay Pujara (Students of CMSC734 Information Visualization class)

twinlist				
compare lists   confirm choices   show help   show options   start over?				
Intake unique accept / reject remaining	Intake similar accept / reject remaining	Identical accept / reject remaining	Hospital similar accept / reject remaining	Hospital unique accept / reject remaining
Nexium PO daily 40 mg		Toprol-XL PO daily 25 mg		Folic acid PO daily 1 mg
Plavix PO daily 75 mg		Enalapril PO BID 20 mg		
Tylenol PO PRN 325 mg		Amiodarone PO dieb. alt. 200 mg		
		Aspirin PO daily 325 mg		
		Isosorbide dinitrate PO TID 30 mg		
		Amlodipine PO BID 2.5 mg		
	Lipitor PO daily 40 mg		Lipitor PO HS 80 mg	
	Nitrostat SL PRN 0.4 mg		Nitroglycerin SL PRN 0.4 mg	
	Ferrous sulfate PO TID 35 mg		Ferrous sulfate PO BID or TID 325 mg	
Detail Nothing to display.				

Presentations:

HCIL symposium(200+attendees)

AMIA WISH tomorrow

***“Best reconciliation app I have ever seen”***

Dr. Shawn Murphy, PartnersHealthcare & Harvard Medical

# Twinlist Demo

**twinlist**

compare listsconfirm choicesshow helpshow optionsstart over?

Intake <small>accept / reject remaining</small>	Hospital <small>accept / reject remaining</small>
<b>Acetaminophen</b> PO q6h 32 mg	<b>Acetaminophen</b> PO q4h 325 mg
<b>Darbepoetin</b> SC qFriday 60 mg	<b>Darbepoetin</b> SC qFriday 60 mg
<b>Calcitrol</b> PO daily 0.25 mg	<b>Folic acid</b> PO daily 1 mg
<b>Ramipril</b> PO daily 5 mg	<b>Omeprazole</b> PO daily 40 mg
<b>Meloxicam</b> PO daily 7.5 mg	<b>Ciproflaxocin</b> PO daily 500 mg
<b>Folvite</b> PO daily 1 mg	<b>Ramipril</b> PO daily 5 mg
	<b>Calcitrol</b> PO daily 0.25 mg
	<b>Ferrous Gloconate</b> PO TID 300 mg

Detail

Nothing to display.

SHARPC  
NCCO

HCIL

SHARPC  
NCCO

[Play](#)

(Or watch on [YouTube](#))

Stop



# Systematic Yet Flexible HIT

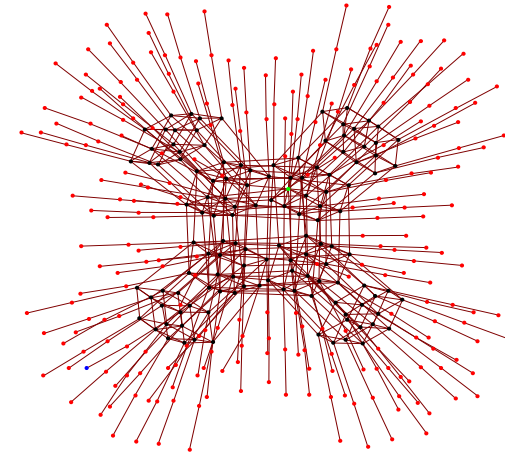
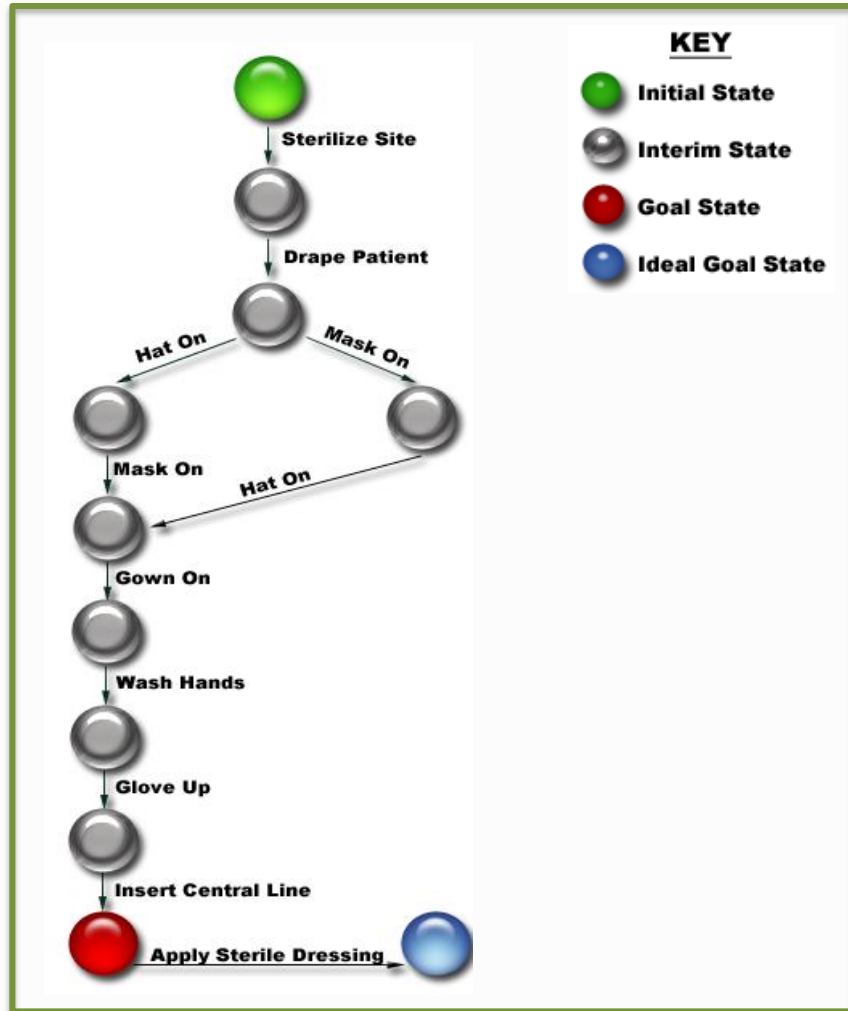
Ellis Markowitz

- Need balance between
  - *Systematicity* to ensure consistency, efficiency & safety
  - *Flexibility* to accommodate variability
- Hypothesis:  
Matching task & interface systematicity &  
flexibility improves efficiency & usability
- Goal: design guidelines

# Systematic Yet Flexible HIT

Ellis Markowitz

## Example: SYF & Catheter Insertion



- 384 total states
  - 286 goal states
- 13,004 paths to any state in which the central line is inserted
  - 1,680 paths to the “idealized” state
  - Only 2 paths contain the appropriate sequence of 9 actions

# Reducing Wrong Patient Errors


Meirav Taieb, Jyothi Vinjumur, Catherine Plaisant, Ben Shneiderman

With long lists, users may choose wrong item→

- Poor Visual Design
- Inadequate feedback
- Lack of error prevention

Wrong patients, medications, lab tests

Test: 100 subjects with 4 treatments  
Photos (Y/N) & Animation (Y/N)



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español

University Health Service

Provider: Smead, John

Your patient list:

	Sex	Age	MedRec	Birth Date	Admission Date	Attending Dr
Culbertson, George	M	77	9845722	EMM 3/4/1934	6/11/2011	Connors, Greg
Culbertson, Susan	F	24	9887333	JDC 5/22/1987	6/11/2011	Schneider, Ben
Donder, Bill	M	21	9823244	EMM 6/4/1990	6/10/2011	Tabibi, Mary
Harris, Emily	F	24	9828970	DRD 5/22/1987	6/12/2011	Tabibi, Mary
Isaacson, Thomas	M	53	9845722	EMM 7/11/1958	6/11/2011	Connors, Greg
Burchard, Susan	F	24	9887333	JDC 5/22/1987	6/12/2011	Schneider, Ben
Culbertson, George	M	77	9823244	EMM 3/4/1934	6/11/2011	Connors, Greg
Culbertson, Susan	F	24	9828970	DRD 5/22/1987	6/12/2011	Franks, George
Albertson, George	M	77	9845722	EMM 3/4/1934	6/11/2011	Schneider, Ben
Burchard, Susan	F	24	9887333	JDC 5/22/1987	6/12/2011	Schneider, Ben
Albertson, George	M	77	9823244	EMM 3/4/1934	6/11/2011	Tabibi, Mary
Burchard, Susan	F	24	9828970	DRD 5/22/1987	6/12/2011	Schneider, Ben



# University Health Service

## Patient: Culbertson, George

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### Rounds Report

PT#: 0897709870987

Sex: M

Birth date: 3/4/1934

Rm/Bed: EMM

MR#: **9845722**

Admit: 6/11/2011

Attending: **Connors, Greg**

[Blood Test](#)[Electrocardiogram](#)[MRI](#)[CT Scan](#)



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### Rounds Report

PT#: 0897709870987

Sex: M

Birth date: 3/4/1934

Rm/Bed: EMM

MR#: **9845722**

Admit: 6/11/2011

Attending: **Connors, Greg**

[Blood Test](#)[Electrocardiogram](#)[MRI](#)[CT Scan](#)

**Blood Test Confirmed: Due back in 6 hours**



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### Rounds Report

PT#: 0897709870987

Sex: M

Birth date: 3/4/1934

Rm/Bed: EMM

MR#: **9845722**

Admit: 6/11/2011

Attending: **Connors, Greg**

[Blood Test](#)[Electrocardiogram](#)[MRI](#)[CT Scan](#)



# University Health Service

## Patient: Culbertson, Susan

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### Rounds Report

PT#: 0897709870987

Sex: F

Birth date:

Rm/Bed: EMM

MR#: **9845758**

Admit: 6/11/2011

Attending: **Connors, Greg**

[Blood Test](#)[Electrocardiogram](#)[MRI](#)[CT Scan](#)





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## Provider: Smead, John

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Your patient list:	Sex	Age	MedRec	Birth Date	Admission Date	Attending Dr
Culbertson, George	M	77	9845722	EMM 3/4/1934	6/11/2011	Connors, Greg
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Culbertson, Susan	F	24	9828970	DRD 5/22/1987	6/12/2011	Franks, George
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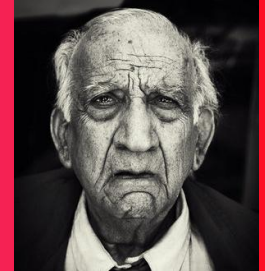
español

Your patient list:      Sex Age MedRec Birth Date Admission Date Attending Dr

Culbertson, George	M	77	9823244	EMM	3/4/1934	6/11/2011	Connors, Greg
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# Culbertson, George



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# University Health Service

## Patient: Culbertson, George

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PT#: 0897709870987

Sex: M

Birth date: 3/4/1934

Rm/Bed: EMM

MR#: **9845722**

Admit: 6/11/2011

Attending: **Connors, Greg**

[Blood Test](#)[Electrocardiogram](#)[MRI](#)[CT Scan](#)

# Student spinoff projects

### IdentifyRX

Usage:  Color:  Form:  Shape:  View:

Select a color:

Lipitor Lipitor Niaspan Niaspan

Lipitor Niaspan Niaspan Niaspan

Lipitor Niaspan Niaspan Niaspan

← abcdefghijklmnopqrstuvwxyz →

Save and print

### MyPrescription




Patient Name:   
Doctor's Name:   
Doctor's Phone #:   
Doctor's Address:   
Street Address:   
City:  State:  Zip Code:   
Medication Name:   
Dosage:   
Generic: ☐ Yes ☐ No  
Shipping Address:   
Patient's Address:   
Default Address:   
Street Address:   
City:  State:  Zip Code:

### MedSocial

Find Patients

Home Logout

#### Messages

 **George Sovechkin** October 4, 2011

Prescription: Altace  
Status: Did not take  
Comment: It makes my heart hurt.

Suggestion: Stop taking it immediately.  
That's a rare and dangerous side effect.

Write a suggestion...

#### Prescription

Edit Prescriptions

##### Altace

Directions: Take 200ml once every 12 hours for 1 week  
Notify Me If: Patient misses 1 dosage by 3 hours

##### Warfarin

Directions: Take 1 pill once per day for 1 month  
Notify Me If: Do not notify

### Mood Tracker

graph mood for

past # of days

duration of

aspirin 300mg

create graph

Rate your Mood

Choose your Emotion

Add a note Medications

# Next?

- Two PhD theses emerging
  - Lab tracking & Systematic Yet Flexible Framework
- Nov/Dec special section of ACM Interactions
  - Includes paper by Siemens/Allscripts
- Presentations to corporate designers
- Users studies & clinician reviews
- Comparative analyses & guidelines



## Project 4: Cognitive Information Design and Visualization

Thanks for support (#10510592) from:

**Office of the National Coordinator  
Strategic Health IT Advanced Research Projects**

Pre-doctoral training fellowship:  
Agency for Healthcare Research and Quality

