



# Twinlist: Novel User Interface Designs for Medication Reconciliation

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**SHARPC**  
NCCD





# Medication Reconciliation (illustrated)



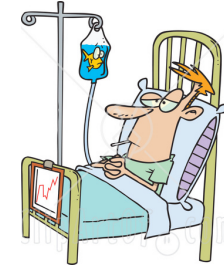
Pharmacy

# Hospital Discharge Scenario (used in rest of talk)



Home Meds reported  
during Intake Interview

Compare



Meds administered  
while at hospital

Keep or not?  
Change?

Reconciled list  
Meds to take at home



A stylized, handwritten signature in black ink.

## Intake

keep rest | reject rest [ clear ]

### Acetaminophen

325 mg PO q6h

### Calcitrol

0.25 mg PO daily

### Darbepoetin

60 mg SC qFriday

### Folvite

1 mg PO daily

### Meloxicam

7.5 mg PO daily

### Ramipril

5 mg PO daily

## Hospital

keep rest | reject rest [ clear ]

### Acetaminophen

325 mg PO q4h

### Calcitrol

0.25 mg PO daily

### Ciprofloxacin

500 mg PO daily

### Darbepoetin

60 mg SC qFriday

### Ferrous Gluconate

300 mg PO TID

### Folic acid

1 mg PO daily

### Omeprazole

40 mg PO daily

### Ramipril

5 mg PO daily



## Intake

keep rest | reject rest [ clear ]

### Acetaminophen

325 mg PO q6h

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0.25 mg PO daily

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60 mg SC qFriday

### Ferrous Gluconate

300 mg PO TID

### Folic acid

1 mg PO daily

### Omeprazole

40 mg PO daily

### Ramipril

5 mg PO daily

unique

unique

unique

unique

# Twinlist

**spatial layout**

to reveals similarities and differences

**multi-step animation**

to help 1<sup>st</sup> time users

**carefully designed interaction**

to facilitate task of reconciliation

# VIDEO

Search for “Twinlist demo” on YouTube  
OR go to [www.cs.umd.edu/hcil/sharp/twinlist](http://www.cs.umd.edu/hcil/sharp/twinlist)



## Intake

[keep rest](#) | [reject rest](#) [ [clear](#) ]**acetaminophen**

650 mg PO q4h prn

**Aldactone**

100 mg PO daily

**Amaryl**

4 mg PO daily

**Ambien**

10 mg PO qHS prn

**Aricept**

10 mg PO daily

**aspirin**

81 mg PO daily

**cimetidine**

800 mg PO BID

**Colace**

100 mg PO BID

**Coreg**

6.25 mg PO BID

**Crestor**

20 mg PO daily

**Hyzaar**

100 / 25 mg PO daily

## Hospital

[keep rest](#) | [reject rest](#) [ [clear](#) ]**acetaminophen**

650 mg PO q4h prn he...

**aspirin**

81 mg PO daily

**cimetidine**

800 mg PO q12h

**Coreg**

6.25 mg PO BID

**donepezil**

10 mg PO qAM

**furosemide**

40 mg PO BID

**glimepiride**

4 mg PO qAM

**lorazepam**

1 mg PO qHS prn inso...

**losartan**

50 mg PO qAM

**magnesium hydroxi...**

30 ml PO daily prn con...

**rosuvastatin**

20 mg PO qAM

**spironolactone**

100 mg PO qAM

[add](#)[edit](#)

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off  
23  
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Jones,](#)[Detail](#)

Nothing to display.

[back](#)

Intake keep rest   reject rest [ clear ]	Identical keep rest   reject rest [ clear ]	Hospital keep rest   reject rest [ clear ]
---	--	---

<b>acetaminophen</b> 650 mg PO q4h prn		<b>acetaminophen</b> 650 mg PO q4h prn he...
<b>Aldactone</b> 100 mg PO daily		
<b>Amaryl</b> 4 mg PO daily		<b>cimetidine</b> 800 mg PO q12h
<b>Ambien</b> 10 mg PO qHS prn		
<b>Aricept</b> 10 mg PO daily		<b>donepezil</b> 10 mg PO qAM
	<b>aspirin</b> 81 mg PO daily	<b>furosemide</b> 40 mg PO BID
<b>cimetidine</b> 800 mg PO BID		<b>glimepiride</b> 4 mg PO qAM
<b>Colace</b> 100 mg PO BID		<b>lorazepam</b> 1 mg PO qHS prn inso...
	<b>Coreg</b> 6.25 mg PO BID	<b>losartan</b> 50 mg PO qAM
<b>Crestor</b> 20 mg PO daily		<b>magnesium hydroxi...</b> 30 ml PO daily prn con...
<b>Hyzaar</b> 100 / 25 mg PO daily		<b>rosuvastatin</b> 20 mg PO qAM
		<b>spironolactone</b> 100 mg PO qAM

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sign off  
21  
left Jones,

back

Detail Nothing to display.

Intake unique <small>keep rest   reject rest [ clear ]</small>	Intake <small>keep rest   reject rest [ clear ]</small>	Identical <small>keep rest   reject rest [ clear ]</small>	Hospital <small>keep rest   reject rest [ clear ]</small>	Hospital unique <small>keep rest   reject rest [ clear ]</small>
	<b>acetaminophen</b> 650 mg PO q4h prn		<b>acetaminophen</b> 650 mg PO q4h prn he...	
	<b>Aldactone</b> 100 mg PO daily			
	<b>Amaryl</b> 4 mg PO daily		<b>cimetidine</b> 800 mg PO q12h	
<b>Ambien</b> 10 mg PO qHS prn				
	<b>Aricept</b> 10 mg PO daily		<b>donepezil</b> 10 mg PO qAM	
		<b>aspirin</b> 81 mg PO daily		
	<b>cimetidine</b> 800 mg PO BID		<b>glimepiride</b> 4 mg PO qAM	
<b>Colace</b> 100 mg PO BID				
		<b>Coreg</b> 6.25 mg PO BID	<b>losartan</b> 50 mg PO qAM	
	<b>Crestor</b> 20 mg PO daily			
	<b>Hyzaar</b> 100 / 25 mg PO daily		<b>rosuvastatin</b> 20 mg PO qAM	<b>furosemide</b> 40 mg PO BID
			<b>spironolactone</b> 100 mg PO qAM	



add  
edit

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21  
left Jones,

back

Detail Nothing to display.

Intake unique

keep rest | reject rest [ clear ]

Intake similar

keep rest | reject rest [ clear ]

Identical

keep rest | reject rest [ clear ]

Hospital similar

keep rest | reject rest [ clear ]

Hospital unique

keep rest | reject rest [ clear ]

acetaminophen

650 mg PO q4h prn

acetaminophen

650 mg PO q4h prn he...

Aldactone

100 mg PO daily

spironolactone

100 mg PO qAM

Amaryl

4 mg PO daily

glimepiride

4 mg PO qAM

Ambien

10 mg PO qHS prn

Aricept

10 mg PO daily

donepezil

10 mg PO qAM

aspirin

81 mg PO daily

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800 mg PO BID

cimetidine

800 mg PO q12h

Colace

100 mg PO BID

Coreg

6.25 mg PO BID

Crestor

20 mg PO daily

rosuvastatin

20 mg PO qAM

furosemide

40 mg PO BID

Hyzaar

100 / 25 mg PO daily

losartan

50 mg PO qAM

Detail

Nothing to display.

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Intake unique <small>keep rest   reject rest [ clear ]</small>	Intake similar <small>keep rest   reject rest [ clear ]</small>	Identical <small>keep rest   reject rest [ clear ]</small>	Hospital similar <small>keep rest   reject rest [ clear ]</small>	Hospital unique <small>keep rest   reject rest [ clear ]</small>
<p><b>Ambien</b> 10 mg PO qHS prn</p> <p><b>Colace</b> 100 mg PO BID</p>		<p><b>aspirin</b> 81 mg PO daily</p> <p><b>Coreg</b> 6.25 mg PO BID</p>		<p><b>furosemide</b> 40 mg PO BID</p> <p><b>lorazepam</b> 1 mg PO qHS prn inso...</p> <p><b>magnesium hydroxi...</b> 30 ml PO daily prn con...</p>
<p><b>acetaminophen</b> 650 mg PO q4h prn</p>		<p><b>acetaminophen</b> 650 mg PO q4h prn he...</p>		
<p><b>Aldactone</b> 100 mg PO daily</p>		<p><b>spironolactone</b> 100 mg PO qAM</p>		
<p><b>Amaryl</b> 4 mg PO daily</p>		<p><b>glimepiride</b> 4 mg PO qAM</p>		
<p><b>Aricept</b> 10 mg PO daily</p>		<p><b>donepezil</b> 10 mg PO qAM</p>		
<p><b>cimetidine</b> 800 mg PO BID</p>		<p><b>cimetidine</b> 800 mg PO q12h</p>		
<p><b>Crestor</b> 20 mg PO daily</p>		<p><b>rosuvastatin</b> 20 mg PO qAM</p>		
<p><b>Hyzaar</b> 100 / 25 mg PO daily</p>		<p><b>losartan</b> 50 mg PO qAM</p>		

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Jones,

**Detail** Nothing to display.

back

Intake unique <small>keep rest   reject rest [ clear ]</small>	Intake similar <small>keep rest   reject rest [ clear ]</small>	Identical <small>keep rest   reject rest [ clear ]</small>	Hospital similar <small>keep rest   reject rest [ clear ]</small>	Hospital unique <small>keep rest   reject rest [ clear ]</small>
<p><b>Ambien</b> 10 mg PO qHS prn</p> <p><b>Colace</b> 100 mg PO BID</p>		<p><b>aspirin</b> 81 mg PO daily</p> <p><b>Coreg</b> 6.25 mg PO BID</p>		<p><b>furosemide</b> 40 mg PO BID</p> <p><b>lorazepam</b> 1 mg PO qHS prn inso...</p> <p><b>magnesium hydroxi...</b> 30 ml PO daily prn con...</p>
	<p><b>acetaminophen</b> 650 mg PO q4h prn</p>		<p><b>acetaminophen</b> 650 mg PO q4h prn he...</p>	
	<p><b>Aldactone</b> 100 mg PO daily</p>		<p><b>spironolactone</b> 100 mg PO qAM</p>	
	<p><b>Amaryl</b> 4 mg PO daily</p>		<p><b>glimepiride</b> 4 mg PO qAM</p>	
	<p><b>Aricept</b> 10 mg PO daily</p>		<p><b>donepezil</b> 10 mg PO qAM</p>	
	<p><b>cimetidine</b> 800 mg PO BID</p>		<p><b>cimetidine</b> 800 mg PO q12h</p>	
	<p><b>Crestor</b> 20 mg PO daily</p>		<p><b>rosuvastatin</b> 20-mg PO qAM</p>	
	<p><b>Hyzaar</b> 100 / 25 mg PO daily</p>		<p><b>losartan</b> 50 mg PO qAM</p>	

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**Detail** Nothing to display.

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# Evaluation

- **1- Role of animation**  
with students
  - > **Animation helped users learn the layout**
    - Fewer clarification questions
    - Animated version preferred
  - > Most said they would eventually turn off animation
- **2- Performance (just completed)**  
20 physicians  
4 complex cases to reconcile
  - 2 with Baseline
  - 2 with Twinlist

# Participants read narrative about case

e.g.

Jim Jones is a 74 year old, married businessman, now retired. He's being treated for Coronary Artery Disease (stent placed at age 70) Constipation, chronic Diabetes Mellitus, Type II Elevated Cholesterol GERD Hypertension Mild Dementia

His family internist sent him to the hospital Monday morning after his wife insisted he go to the clinic because he was having trouble breathing, and was rubbing his chest. He had been doing fine until sometime during the night. She said he had seemed quite well Sunday afternoon watching the game-- two of their sons came over to watch the game with him. They made it "a little tailgate party-- hot dogs with saukraut and everything."

On examination his internist found moderate pulmonary congestion, but no EKG changes. Troponin was negative. Because of his past history and strong family history of MI, patient was admitted, treated, and now on Wednesday afternoon, wants to be discharged. His internist is away for a professional meeting. One of the medical house officers is handling the discharge orders, etc.



then use either  
Baseline or Twinlist

Contact [plaisant@cs.umd.edu](mailto:plaisant@cs.umd.edu) for  
copy of demonstration + code

**DEMO**

**Unpublished so not  
included in online slides**

**Results preview**

**Please contact [plaisant@cs.umd.edu](mailto:plaisant@cs.umd.edu)**

# Alternative layouts

- Further grouping of drugs (still 5 columns)
  - Grouping by class
  - Grouping by diagnosis
  - Multiple groups per drug
- No horizontal spreading
  - 1 column/list + similarity info on mouse-over
  - 1 column/list + extra column for groups
- Vertical grouping by similarity (U. Texas Prototype)

See PAPER

Intake unique keep rest   reject rest [ clear ]	Intake similar keep rest   reject rest [ clear ]	Identical keep rest   reject rest [ clear ]	Hospital similar keep rest   reject rest [ clear ]	Hospital unique keep rest   reject rest [ clear ]
--	---	--	---	--

<i>analgesic</i>	<b>acetaminophen</b> 650 mg PO q4h prn		<b>acetaminophen</b> 650 mg PO q4h prn he...	
<i>antidiabetic</i>	<b>Amaryl</b> 4 mg PO daily		<b>glimepiride</b> 4 mg PO qAM	
<i>sedative</i> <b>Ambien</b> 10 mg PO qHS prn				<b>lorazepam</b> 1 mg PO qHS prn inso...
<i>diuretic</i>				<b>furosemide</b> 40 mg PO BID
<i>antihypertensive</i>	<b>Aldactone</b> 100 mg PO daily	<b>Coreg</b> 6.25 mg PO BID	<b>spironolactone</b> 100 mg PO qAM	
	<b>Hyzaar</b> 100 / 25 mg PO daily		<b>losartan</b> 50 mg PO qAM	
<i>non-steroidal anti-inflammatory drug</i>		<b>aspirin</b> 81 mg PO daily		
<i>antacid</i>	<b>cimetidine</b> 800 mg PO BID		<b>cimetidine</b> 800 mg PO q12h	
<i>acetylcholinesterase inhibitor</i>	<b>Aricept</b> 10 mg PO daily		<b>donepezil</b> 10 mg PO qAM	
<i>anticholesterol</i>	<b>Crestor</b> 20 ma PO daily		<b>rosuvastatin</b> 20 ma PO qAM	

e.g. Group by class,  
or by diagnosis

**Detail** Nothing to display.

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21  
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Jones,  
back

Intake unique	Intake similar	Identical	Hospital similar	Hospital unique
<i>analgesic</i>	<b>acetaminophen</b> 650 mg PO q4h prn		<b>acetaminophen</b> 650 mg PO q4h prn he...	
<i>antidiabetic</i>	<b>Amaryl</b> 4 mg PO daily		<b>glimepiride</b> 4 mg PO qAM	
<i>sedative</i>	<b>Ambien</b> 10 mg PO qHS prn			<b>lorazepam</b> 1 mg PO qHS prn inso...
<i>diuretic</i>				<b>furosemide</b> 40 mg PO BID
<i>antihypertensive</i>	<b>Aldactone</b> 100 mg PO daily	<b>Coreg</b> 6.25 mg PO BID	<b>spironolactone</b> 100 mg PO qAM	
	<b>Hyzaar</b> 100 / 25 mg PO daily		<b>losartan</b> 50 mg PO qAM	
<i>nonsteroidal anti-inflammatory drug</i>		<b>aspirin</b> 81 mg PO daily		
<i>antacid</i>	<b>cimetidine</b> 800 mg PO BID		<b>cimetidine</b> 800 mg PO q12h	
<i>acetylcholinesterase inhibitor</i>	<b>Aricept</b> 10 mg PO daily		<b>donepezil</b> 10 mg PO qAM	
<i>anticholesterol</i>	<b>Crestor</b> 20 mg PO daily		<b>rosuvastatin</b> 20 mg PO qAM	

**Detail** Nothing to display.

add  
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back

# Computing Similarity

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	

**Available** at [https:// github.com/jherskovic/MedRec](https://github.com/jherskovic/MedRec) (contact [Jorge.R.Herskovic@uth.tmc.edu](mailto:Jorge.R.Herskovic@uth.tmc.edu))

REF: “Automated medication reconciliation and complexity of care transitions” AMIA 2011

**See also AMIA 2013 papers** re: mining associations between medications & problems (D. Sittig – A.Wright etc.)  
SHARPC P3 website points to knowledge bases

**See also Pan-SHARP project** for a **SMART app** combining NLP to extract drug names + similarity computation + Twinlist

# Other Uses

- Reconciling problems
  - Reconciling allergies
  - Reconciling immunizations
  - etc.
- 
- Several vendors using/adapting design

~ SharpC at Maryland ~  
**User Interface and Visualization for Medication Reconciliation**

**MARYLAND PARTICIPANTS**

- Catherine Plaisant, (Co-PI) - Research Scientist, UMIACS, Associate Director of Research at HCIL
- Ben Shneiderman, (Co-PI) - Professor, Computer Science, Researcher (and Founding Director) at HCIL
- (past) Tiffany Chao, Graduate Student in the Department of Computer Science, University of Maryland
- Johnny Wu, MS Graduate Student in the Department of Computer Science, University of Maryland

**TEXAS AND KENTUCKY PARTNERS**

- University of Texas, Houston: Jorge Herskovic, Elmer V Bernstam, Eliz Markovitz (and many more providing feedback)
- University of Kentucky: Todd Johnson
- Yale University: Seth Powsner
- Medstar Institute: Zach Hettinger

**Medication Reconciliation**

Two initial prototypes were completed to present two completely different user interface and ways for clinicians to address medication reconciliation (i.e. reconciling two lists of medications into a single reconciled list) in two different use-case scenarios. These interfaces (Twinlist and Medrec) were built on the substratum of a novel medication reconciliation algorithm that removes the tediousness of a fully manual reconciliation without diminishing the decision making power of the clinician.

Later on additional prototypes were developed with more complex cases, and alternative screen layout and grouping of the drugs. Current effort focus on evaluation with 2 controlled studies with physicians .

**Papers**

- **Latest description of Twinlist and several of its variations:**  
Plaisant, C., Chao, T., Wu, J., Hettinger, A., Herskovic, J., Johnson, T., Bernstam, E., Markovitz, E., Powsner, S., Shneiderman, B., Twinlist: Novel User Interface Designs for Medication Reconciliation, to appear in *AMIA 2013 (Tech report version)*
- **Discussion of the role of animation in Twinlist and other similar interfaces:**  
Plaisant, C., Chao, T., Liu, R., Norman, K., Shneiderman, B. [Multi-Step Animation to Facilitate the Understanding of Spatial Groupings: the Case of List Comparisons](#)
- **Early prototype description (Infovis class project):**  
Claudio, L., Khamis, S., Liu, R., London, B., Pujara, J., Plaisant, C., Shneiderman, B., [Facilitating Medication Reconciliation with Animation and Spatial layout](#) *Proceedings of the Workshop on Interactive Healthcare Systems (WISH2011)*
- **Early work:**  
Markovitz, E., Bernstam, E., Herskovic, J., Zhang, J., Shneiderman, B., Plaisant, C., Johnson, T., [Medication Reconciliation: Work Domain Ontology, Prototype Development, and a Predictive Model](#) (AMIA Fall 2011)

**Early papers:**

- **Description of Twinlist - for potential implementers - January 2012 (newer version will follow soon):**  
Chao, T., Plaisant, C., Shneiderman, B., [Twinlist: Overview and general implementation description](#)
- **Early Description of Twinlist:**  
Chao, T., [Visual techniques for medication reconciliation: spatial metaphor, animated explanation, and flexible decision-making](#) (Undergrad Honor Project report - Dec 2011)

**Videos**

- **TWINLIST INTERFACE** (visual layout and animation can help users see similarities in the lists):  
[Download the video of the latest version of Twinlist \(22.6 MB, 1024 x 768 resolution\)](#)



[www.cs.umd.edu/hcil/sharp/twinlist](http://www.cs.umd.edu/hcil/sharp/twinlist) (papers/videos)

**Acknowledgements**

Strategic Health IT Advanced Research Projects Program (SHARP)  
Office of the National Coordinator for Health Information Technology (Grant Number 10510592)





# Thank You

UI design can have strong impact on patient safety

Numerous ways to reveal similarity

Multi-step animations can help 1<sup>st</sup> time users

Consider grouping

Twinlist open source (email me)

*plaisant@cs.umd.edu*

[www.cs.umd.edu/hcil/sharp/twinlist](http://www.cs.umd.edu/hcil/sharp/twinlist) (papers/videos)



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