Relational Agents in Nursing

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Northeastern University
Computer Science

- Founded 1982
- 26 FT faculty, 21 other staff
- 500 undergrads, 220 MS, 75 PhD
- Degree programs
  - 15 undergraduate programs in CS, IS
  - Ph.D., MS in CS
  - MS Information Assurance
  - MS Health Informatics

Relational Agents Group
relationalagents.com

Dialogue Systems for Longitudinal Health Counseling

Timothy Bickmore
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Northeastern University, Boston
Motivation: Rapid Acceptance
• Natural, intuitive modality provides rapid acceptance
• Emulate human face-to-face conversation
• Focus on nonverbal communicative behavior
  – gaze, posture, gesture, etc.

Motivation: Patients with Low Health Literacy
• Face-to-face communication, in conjunction with written instructions, is best
• However, most health professionals have extremely limited time to spend with a patient

Motivation: Therapeutic Alliance
• Maintaining engagement is a pre-requisite for longitudinal interventions.
• Agents can emulate human relationship-building behavior to build and maintain trusting, therapeutic alliance.

Pre-Inpatient
• Anesthesia education

Inpatient
• Discharge education

Preventive
• Exercise promotion
• Diet promotion
• Cancer prevention

Post-Inpatient
• Medication adherence
• Medication event screening

Outpatient
• Preconception care
• Geriatric exercise & cognitive stimulation

Technology Overview

Agent Architecture
Dialogue Representation
• Hierarchical Transition Networks
Agent Architecture
Dialogue Representation

- Hierarchical Task Decomposition Planner
  - Based on ANSI/CEA 2018

DoConversation
  DoGreeting
  DoCounseling
  DoFarewell


DoGreeting
  DoConversation

U: “Hello.”

<UTTERANCE>It is for your
<br><HEADNOD/><BEAT>blood
<br>pressure.</BEAT></UTTERANCE>

BEAT

- Speech
- Intonation
- Hand Gesture
- Gaze
- Posture
- Eyebrow
- etc.

Input Text → BEAT → Animation

XML Trees Passed Among Modules

- Discourse Model
- Knowledge Base
- Word Timing
- Behavior Generation
- Language Tagging
- Behavior Selection
- Generator Set
- Filter Set
- Translator

Agent Architecture
Development Pipeline

- Custom, Eclipse-based IDE
- Integrated debug and test
- BEAT
Run Time Architecture

Platforms

Systems & Studies

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- Discharge education

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Exercise Promotion for Older Adults

Boston Medical Center
Geriatrics Ambulatory Practice
2004-2005

Participants

- Randomized 10 to RELATIONAL
  11 to CONTROL
- 2 men, 19 women
- Age 63-85 (mean 74)
- 76% African American
- 77% Overweight or Obese
- 86% Low Reading Literacy
- 38% Never Used a Computer (50% in REL)
- 29% Used Computer a “Few Times”
Results: Ease of Use

“That is so easy. That is so good. Regular computers I don’t do. But, that was so easy, even a baby could do that.”

Results: Satisfaction

Satisfaction with Overall System

Desire to Continue

Satisfaction with Laura

Results: Relationship with Laura

Trust in Laura

Liking of Laura

Results: Impressions of Laura

Friendly

Repetitive

Liking of Laura

Trust in Laura

Results: Walking

Difference in slopes p=.004

Steps Walked

Week

RELATIONAL

CONTROL

5/25/2010

Qualitative Results

Overall Impressions

“It was the best thing that happened to me, to have something that pushed me out and get me walking.”

“She’s nice. She’s really good. Really good. She asks you the right questions. She tells if you if you’re not doing up to par, you know, and all that. And if you’re doing good, she’ll tell you. If you’re not she’ll tell you. And it’s honest. And it works. It really does. I like it. I like talking to her.”
Relational/Social Interaction

“She says ‘Good Morning Camille’ [laughs]. Yeah, it’s nice. I liked that. You know a lot of more people would like that because they’re lonely.”

“I told you I like to talk, so that was, you know, good chit-chat’n. I found it very good, you know, chit-chat’n with her.”

“I wanted to have more conversation with her.”

NIA Steps to Health

Additional Exercise Interventions Partners Healthcare

<table>
<thead>
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<th>Quarter</th>
<th>C, n=30</th>
<th>L, n=27</th>
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<td>Q1</td>
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<tr>
<td>Q1-Q2</td>
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<td></td>
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<tr>
<td>Q1-Q3</td>
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<tr>
<td>Q1-Q4</td>
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</table>

COMPASS Computerized Physical Activity Advice for Seniors

- Exercise promotion for older, bilingual Latino adults.
- 4 month x 2 contact/wk
- N=40, 2 group
- Intervention group did more exercise than wait-list control

NCI Relational Agent Intervention for Sun & Exercise

- Home computer-based intervention for exercise & sun
- Year-long, daily contact
- With U. Rhode Island Cancer Prevention Research Center

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Hospital Discharge

- 40M per year
- 8 minutes
- No standards
- 42% know diagnosis
- 37% know medications
- 20% readmits

RED Checklist

1. Medication reconciliation
2. Reconcile discharge plan with national guidelines
3. Follow-up appointments
4. Outstanding tests
5. Post-discharge services
6. Written discharge plan
7. What to do if problem arises
8. Patient education
9. Assess patient understanding
10. Discharge summary to PCP
11. Telephone Reinforcement

RED Checklist

**Being this Plan to ALL Appointments**

After Hospital Care Plan for:

John Smith

Discharge Date: September 19, 2008

Question or Problem about this Packet? Call your Discharge Advocate: (978) 414-6622

Serious health problem? Call Brain Inc (317) 414-2020

EACH DAY follow this schedule:

MEDICINES

<table>
<thead>
<tr>
<th>Time of Day</th>
<th>Despite Drug</th>
<th>Dosage</th>
<th>How Much Do I Take?</th>
<th>How Do I Take This Medicine?</th>
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<tbody>
<tr>
<td>Morning</td>
<td>Stomach</td>
<td>PROTON PANTOPRAZOLE</td>
<td>40 mg</td>
<td>1 pill</td>
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<tr>
<td></td>
<td>Blood Pressure</td>
<td>Atenolol</td>
<td>50 mg</td>
<td>1 tablet</td>
</tr>
<tr>
<td></td>
<td>Stomach</td>
<td>PROTON PANTOPRAZOLE</td>
<td>40 mg</td>
<td>1 pill</td>
</tr>
</tbody>
</table>
Primary Outcome:
Hospital Utilization within 30d after discharge

Dissemination

Interdisciplinary Collaboration
- Doctors, Nurses, Pharmacologists, Animators
- 3 Year Development
- 2,254 medications
- 48 diagnoses
- 32,000 lines of dialogue script
Resulting model of Gesture Stroke

<table>
<thead>
<tr>
<th>New Topic Level</th>
<th>Gesture</th>
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<td>POINT</td>
<td>REGION</td>
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<tr>
<td>ITEM</td>
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<td>65.9%</td>
<td>2.9%</td>
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Designing for Patients with Low Health Literacy

- Simple language
- Pictographs
- Face-to-face explanation by provider
- Scaffold
- Teach back & Comprehension checks

After Hospital Care Plan for:

John Smith

Discharge Date: September 19, 2008

Questions or Problems about this Packet? Call your Discharge Advocate: (617) 414-8822

Serious health problem? Call Nurse John: (617) 414-3202
Evaluation

• HCI Lab Studies
• Pilot studies with non-patients
• Pilot studies with patients
• Clinical trial

Pilot Hospital Study

• 19 patients, age 25-75, 45% low health literacy
• All completed the interaction without any problems.
• Sessions lasted 7 to 79 minutes.
• Average of 2.4 (range 0 to 7) nurse issues.
• 94% indicated the system was easy to use.
• 60% chose to hear additional details.

Pilot: Bedside Manner

• Randomized use of relational behavior
• Patients interacting with the relational nurse
  – Felt the agent cared more about them, p=.07.
  – Felt the information provided was more useful, p<.05.

“She treated me like a real person! She’s not like a computer. This is awesome work! This is really excellent.”
Pilot: Time for Caring

- Most appreciated the amount of information and time given to them by the agent.
  - "I prefer Louise, she’s better than a doctor, she explains more, and doctors are always in a hurry."
  - "It was just like a nurse, actually better, because sometimes a nurse just gives you the paper and says 'Here you go.' Elizabeth explains everything."

Pilot: "Who would you rather receive discharge instructions from?"

- Agent, 74%
- Doctor or Nurse, 10%
- Either, 16%

Clinical Trial

- Started October 14, 2008.
- 750 pts, randomized to RED vs. usual care
  - 400 enrolled to date (45% low health literacy)
  - 171 completed agent conversations

Sub-studies
- Racial concordance
- Relational behavior
- Number of contacts

Overall Usability

- Overall Satisfaction
- Ease of Use

Overall Attitudes

- Relationship with Agent
- Trust in Agent

1=stranger, 4=neutral, 7=close friend

How much do you feel that Elizabeth cares about you?

1=not at all, 7=very much

How much do you feel that you and Elizabeth understand each other?
Preference over Doc or Nurse

<table>
<thead>
<tr>
<th>Preference</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Definitely prefer doc</td>
<td>36%</td>
</tr>
<tr>
<td>Neutral</td>
<td>48%</td>
</tr>
<tr>
<td>Definitely prefer agent</td>
<td>16%</td>
</tr>
</tbody>
</table>

Hospital Rating

- Low Comp Literacy
  - Task-Oriented Agent
  - High Comp Literacy
  - Relational Agent

- F(1,104) = 4.78, p < .05

Hospital Consumer Assessment of Healthcare Providers and Systems

Current Trials

- NIH/National Cancer Institute
  - R01 Exercise & UV for Cancer Prevention (JU)
  - R21 Exercise Promotion for Older Bilingual Latino Adults (Stanford)
  - P50 Exercise Promotion for Bilingual Puerto Rican Adults (NU)
- NIH/National Institute on Aging
  - R01 Clinic-based Walking Promotion for Older Adults (BMC)
- NIH/National Heart, Lung, and Blood Institute
  - R01 Hospital Discharge Patient Education (BMC)
- NIH/National Library of Medicine
  - R21 Ontology-based Health Behavior Change (NU)
- AHRQ
  - Web-based post-discharge medication adherence/screening (BMC)
  - Preconception care for young African American Women (BMC)
- NSF
  - CAREER: Long-term exercise promotion for older adults (NU)

AHRQ Ambulatory Safety & Quality

- Promote medication adherence
- Screen for medication adverse events
- Mediate communication with clinicians

The Future

AHRQ Ambulatory Safety & Quality
Towards the Personal Health Advocate

- Anytime, Anywhere access to health information

Conclusions

- Simulated face-to-face conversation provides the greatest reach for health messages.
- Therapeutic alliance leads to improved satisfaction, adherence, and health outcomes.
- Relational agents can provide a persistent, long-term health communication channel.

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