



Relational Agents in Nursing

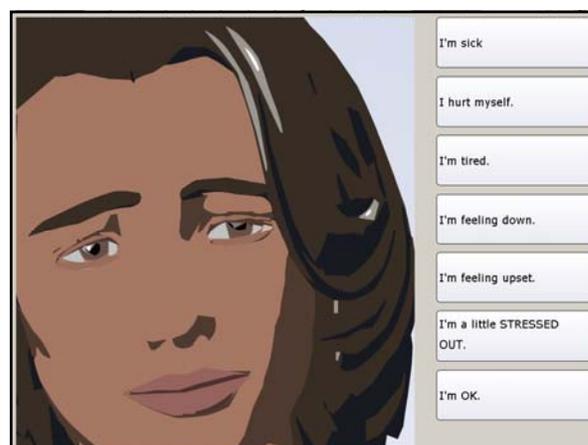
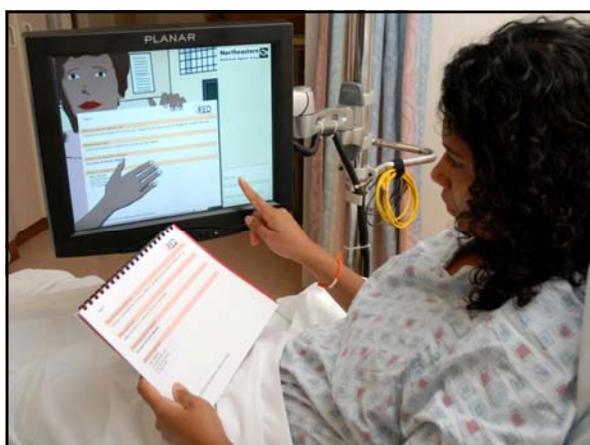
Timothy Bickmore
Northeastern University
Boston, MA, USA

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



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

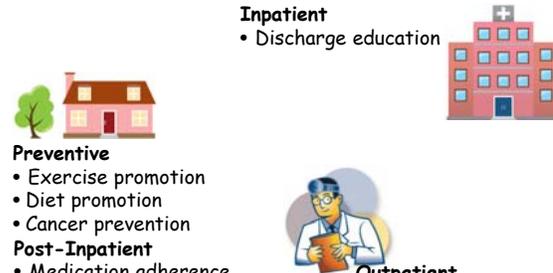


Motivation: Therapeutic Alliance

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



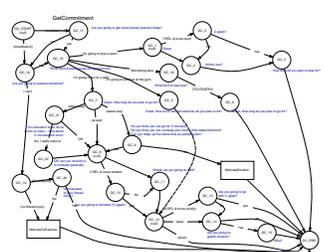
- Pre-Inpatient**
 - Anesthesia education
- Inpatient**
 - Discharge education
- Preventive**
 - Exercise promotion
 - Diet promotion
 - Cancer prevention
- Post-Inpatient**
 - Medication adherence
 - Medication event screening
- Outpatient**
 - Preconception care
 - Geriatric exercise & cognitive stimulation



Technology Overview

Agent Architecture Dialogue Representation

- Hierarchical Transition Networks



Agent Architecture Dialogue Representation

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

```

graph TD
    DoConversation --> DoGreeting
    DoConversation --> DoCounseling
    DoConversation --> DoFarewell
    DoGreeting --> A["A: 'Hello.' U: 'Hello.'"]
        
```

| |
|----------------|
| U: "Hello." |
| DoGreeting |
| DoConversation |

Agent Architecture Dialogue Representation

- Agent utterances represented by words plus XML annotations for synchronized nonverbal behavior

```

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

BEAT

BEAT

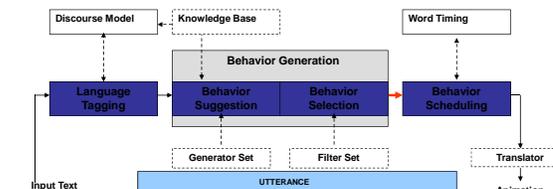
- Speech
- Intonation
- Hand Gesture
- Gaze
- Posture
- Eyebrow
- etc.



Animation

Input Text → BEAT → [Speech, Intonation, Hand Gesture, Gaze, Posture, Eyebrow, etc.] → Animation

XML Trees Passed Among Modules

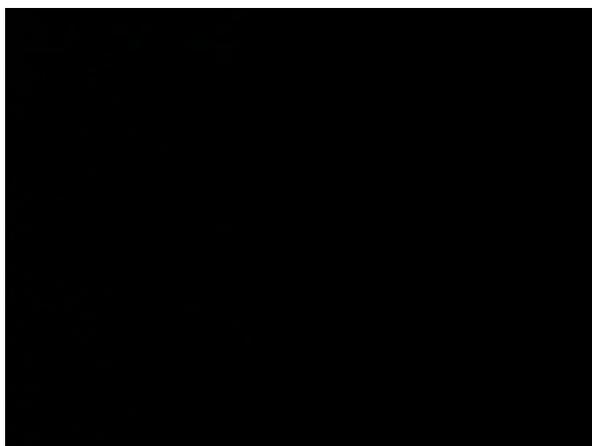


UTTERANCE

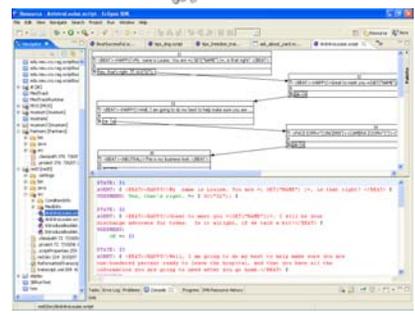
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graph TD
    U[UTTERANCE] --> SP1[SPEECH PAUSE]
    U --> SP2[SPEECH PAUSE]
    SP1 --> GA1[GAZE AWAY TONE=L-H%]
    SP1 --> GT[GAZE TOWARDS TONE=L-L%]
    SP2 --> GA2[GAZE AWAY TONE=L-H%]
    GA1 --> GE[GESTURE ICONIC EYEBROWS]
    GT --> GE
    GA2 --> EB[GESTURE BEAT EYEBROWS]
    EB --> ACCT[ACCT=H+]
    
```

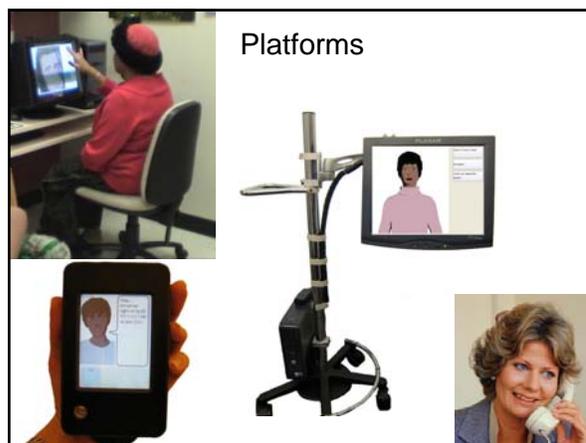
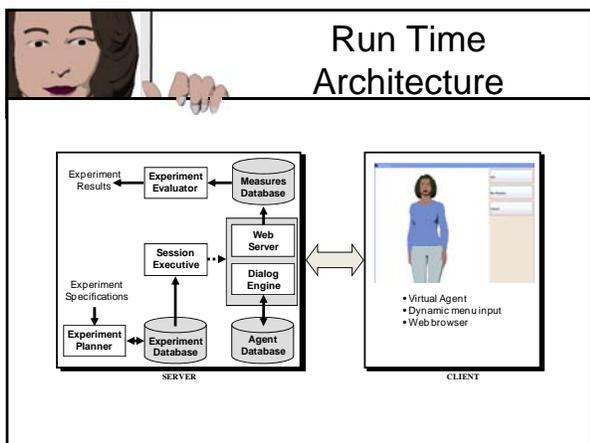
You just have to type in some text and the actor ...



Agent Architecture Development Pipeline



- Custom, Eclipse-based IDE
- Integrated debug and test
- BEAT



Systems & Studies

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



Systems & Studies

Pre-Inpatient

- Anesthesia education

Inpatient

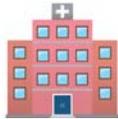
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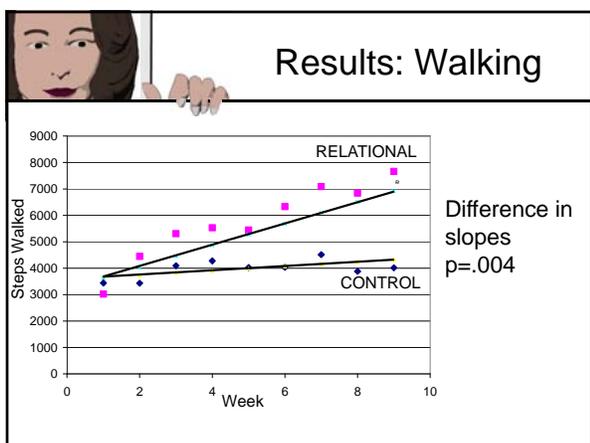
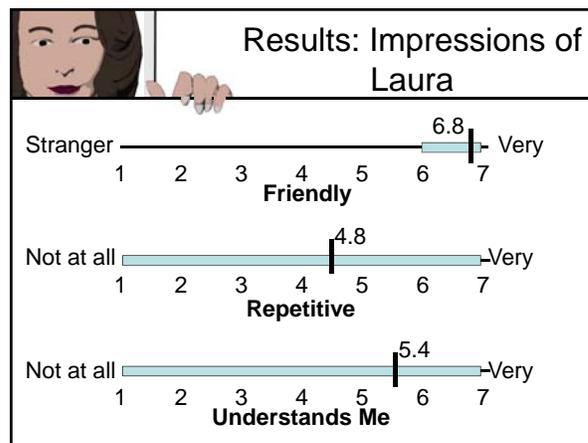
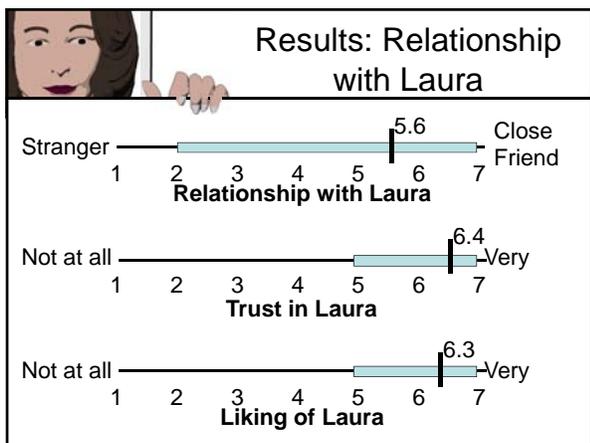
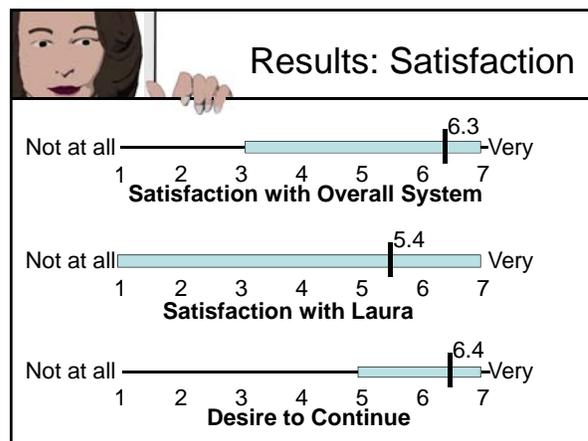
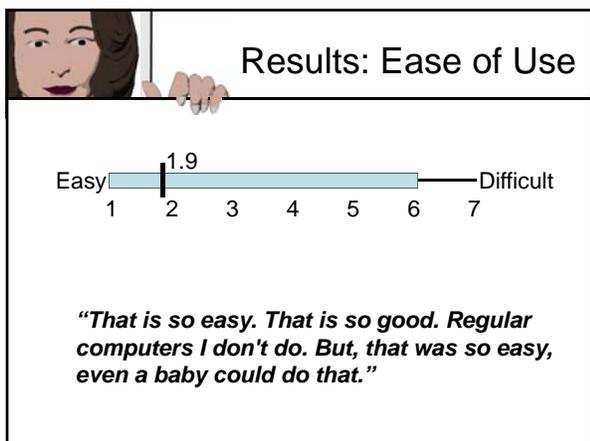
Outpatient

- Preconception care
- Geriatric exercise & cognitive stimulation





- ### 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"



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."

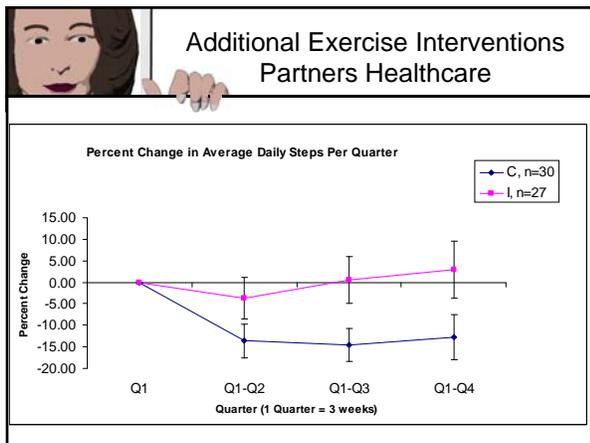
Relational/Social Interaction

"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



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

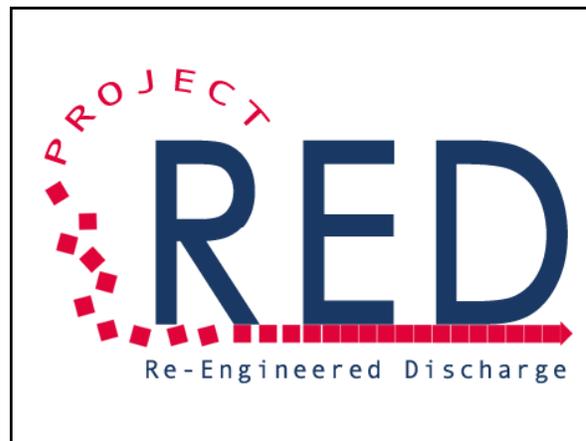
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Hospital Discharge

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



PROJECT RED
Re-Engineered Discharge

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**

Page 1



**** Bring 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: (617) 414-6822




Serious health problem? Call Brian Jack (617)-414-2080

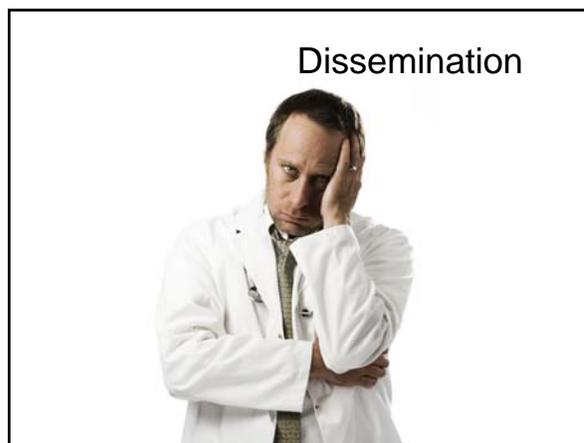
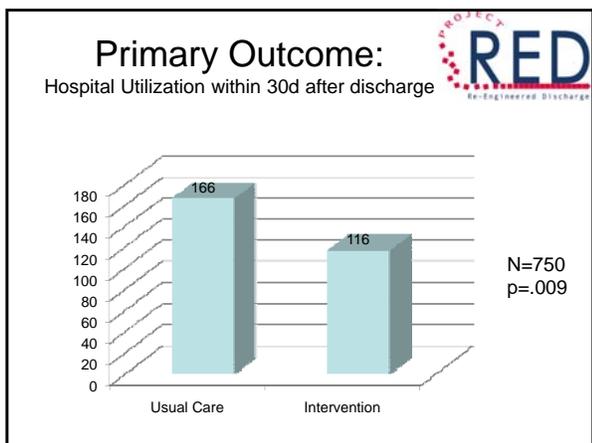
Page 2



EACH DAY follow this schedule:
MEDICINES

| What time of day do I take this medicine? | Why am I taking this medicine? | Medication Name Amount | How much do I take? | How do I take this medicine? |
|--|--------------------------------|-----------------------------------|---------------------|------------------------------|
|  Morning | Stomach | PROTONIX PANTOPRAZOLE 40 mg | 1 pill(s) | by mouth |
| | Blood Pressure | ATENOLOL 50 mg | 1 tablet(s) | by mouth |
|  Bedtime | Stomach | PROTONIX PANTOPRAZOLE 40 mg | 1 pill(s) | by mouth |





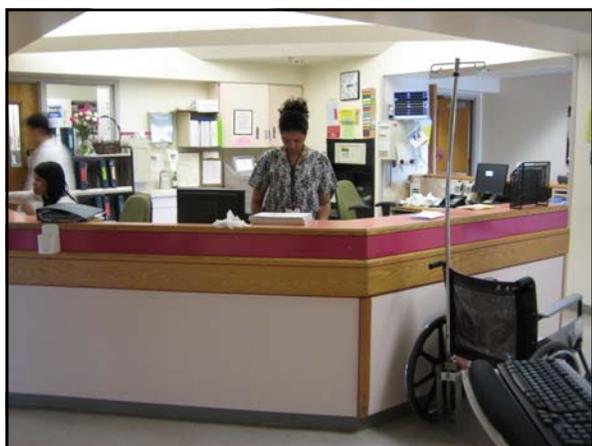
Page 2

EACH DAY follow this schedule.

| What time of day do I take the medication? | Why am I taking this medication? | Medication name (brand) | How much do I take? | How do I take the medication? |
|--|----------------------------------|--|---------------------|-------------------------------|
| | Blood pressure | PROCAREM XL NIFEDIPINE 60 mg | 1 pill | By mouth |
| | Blood pressure | HYDROCHLOROTHAZIDE 25 mg | 1 pill | By mouth |
| | Blood pressure | CLONIDINE HCl 0.1 mg | 3 pills | By mouth |
| | cholesterol | LIPITOR ATORVASTATIN CALCIUM 20 mg | 1 pill | By mouth |
| | stomach | PROTONIX PANTOPRAZOLE SODIUM 40 mg | 1 pill | By mouth |

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

| New Topic Level | Gesture | | |
|-----------------|---------|-------|--------|
| | NONE | POINT | REGION |
| No Change | 80.8% | 13.1% | 6.1% |
| PAGE | 63.6% | 13.6% | 22.7% |
| SECTION | 48.3% | 32.8% | 19.0% |
| ITEM | 31.2% | 65.9% | 2.9% |

Designing for Patients with Low Health Literacy

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




Page 1 

**** Bring this Plan to ALL Appointments****



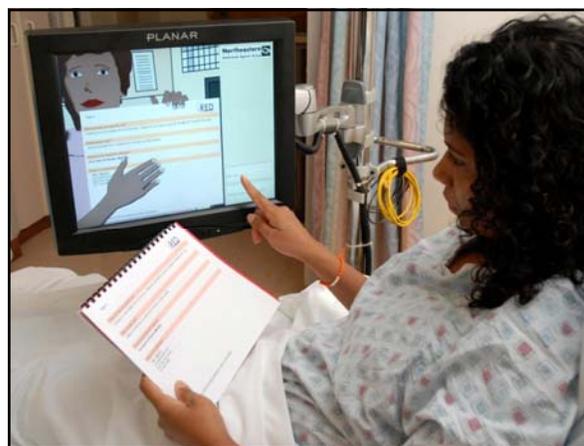

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Evaluation

- 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, $p<.05$.

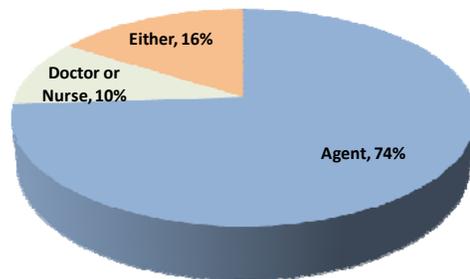
“She treated me like a real person! She’s not like a computer. This is awesome work! This is really excellent.”



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."*

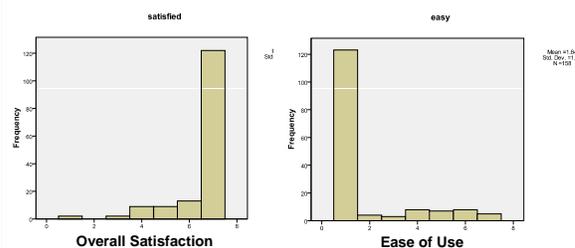
Pilot: "Who would you rather receive discharge instructions from?"



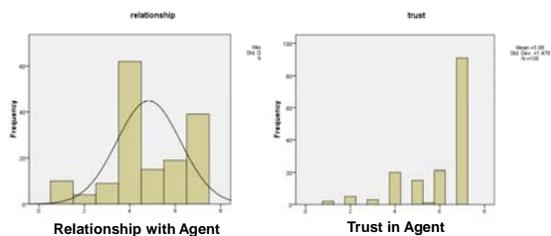
Clinical Trial

- 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

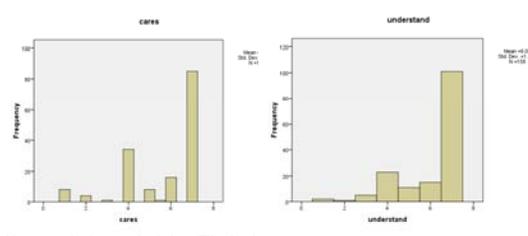


Overall Attitudes

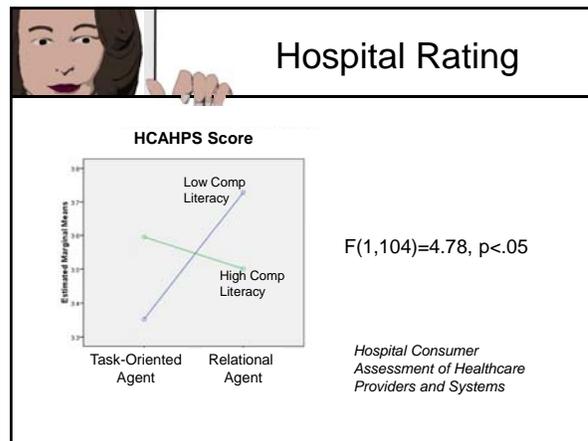
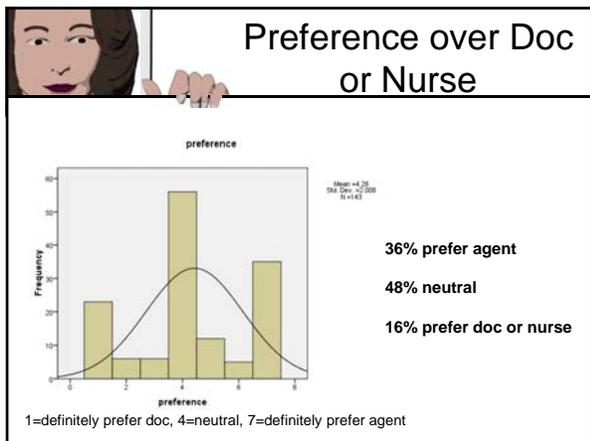


1=stranger, 4=neutral, 7=close friend

Overall Attitudes



1=not at all, 7= very much

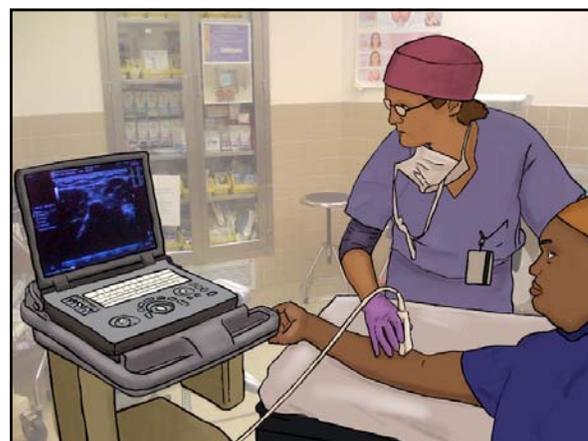


The Future

- ### Current Trials
- **NIH/National Cancer Institute**
 - R01 Exercise & UV for Cancer Prevention (URI)
 - 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



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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