



# Machines that Care

## Building Empathy into Assistive Devices

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Assistant Professor

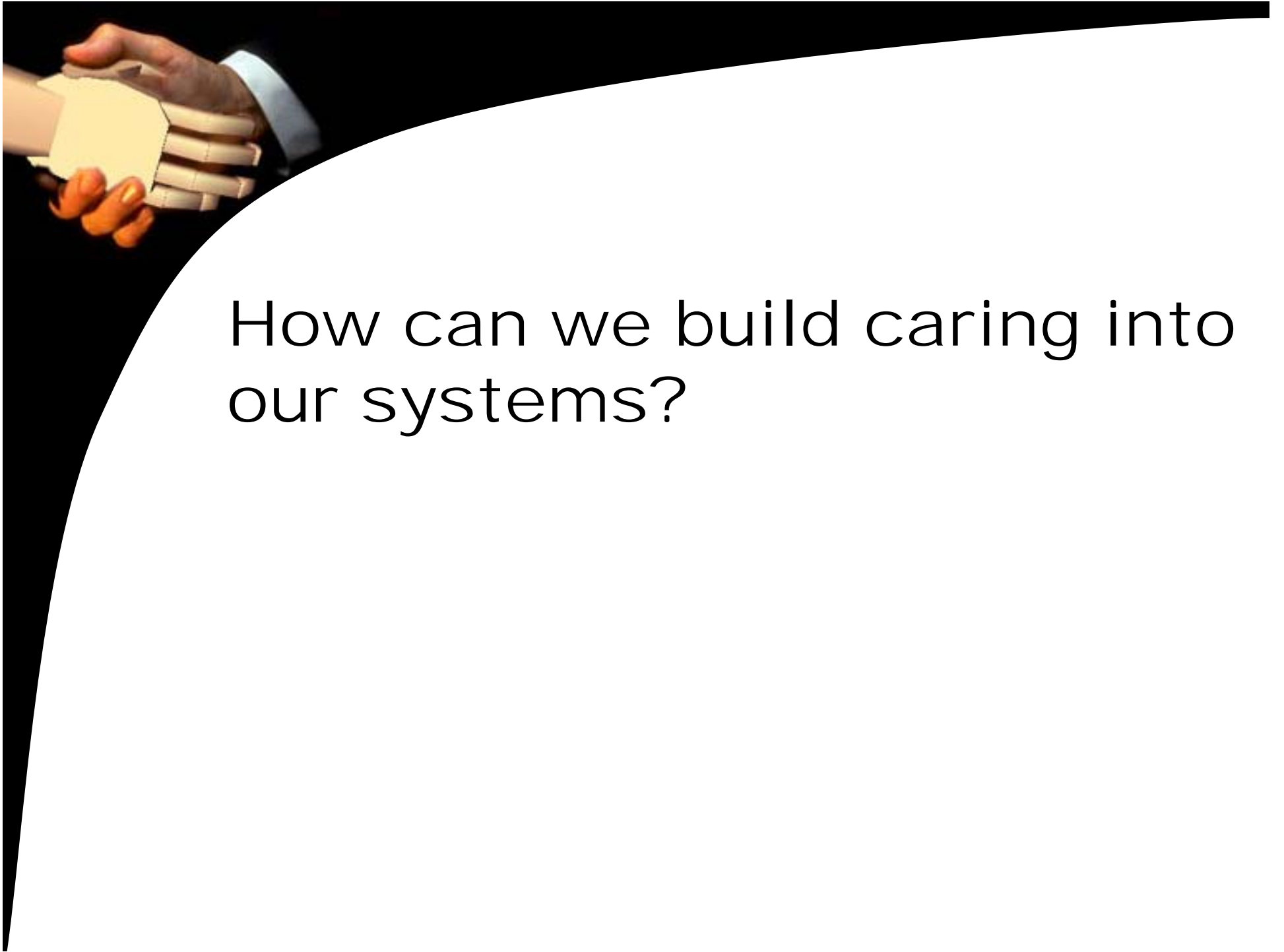
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How can we build caring into our systems?



# Theories of Caring

- **Psychotherapy**
  - Unconditional positive regard
  - Empathetic listening
- **Social Psychology**
  - Social penetration theory / self-disclosure
  - Meta-relational communication
  - Continuity behaviors
- **Sociolinguistics**
  - Politeness theory
- **Linguistics / Conversation Analysis**
  - Structure & function of social dialogue
- **Communication**
  - Comforting behavior
  - Nonverbal immediacy behavior



I'm sick

I hurt myself.

I'm tired.

I'm feeling down.

I'm feeling upset.

I'm a little **STRESSED**  
**OUT.**

I'm OK.



# Technology Overview

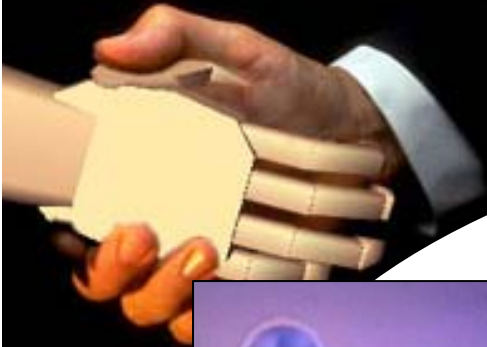


## Embodied Conversational Agents

- Emulate human face-to-face conversation
- Focus on nonverbal communicative behavior
  - gaze, posture, gesture, etc.
- Multi-modal interfaces are better for accessibility



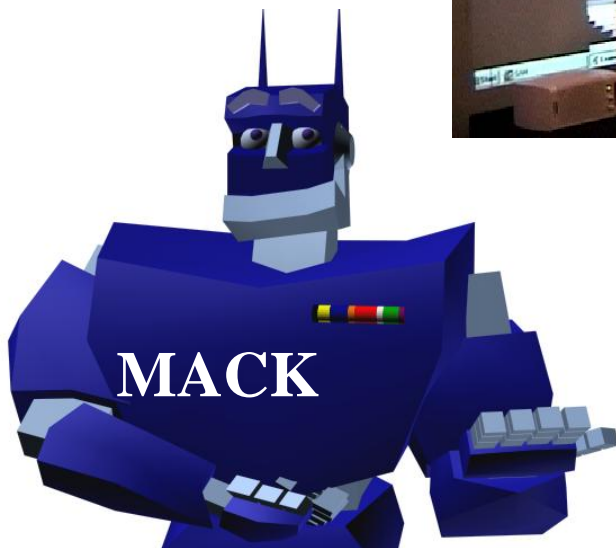
# Embodied Conversational Agents



REA



SAM



MACK

MIT FitTrack  
Exercise Advisor

MIT FitTrack

Log your activity for Tuesday, April 30

Went to bed at: 1 | 1:00am

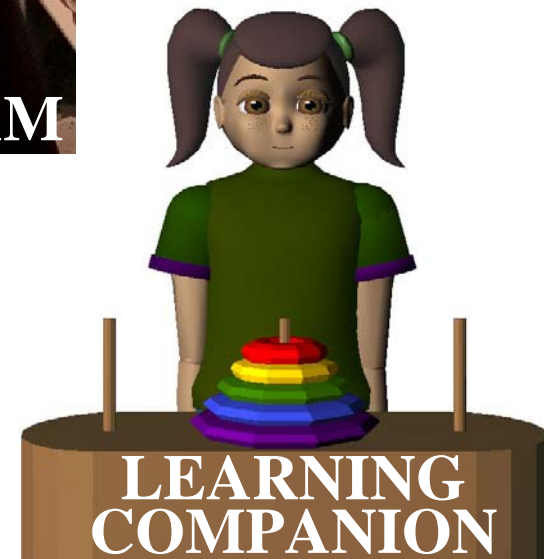
Got out of bed at: 1 | 1:00am

Morning Activity

Moderate	Hours	Minutes
	0	00
Hard	Hours	Minutes
	0	00
Very Hard	Hours	Minutes
	0	00

No. no problems this week.  
Yes, I had a few problems exercising this week.  
Yes, I had some significant problems exercising this week.

LAURA

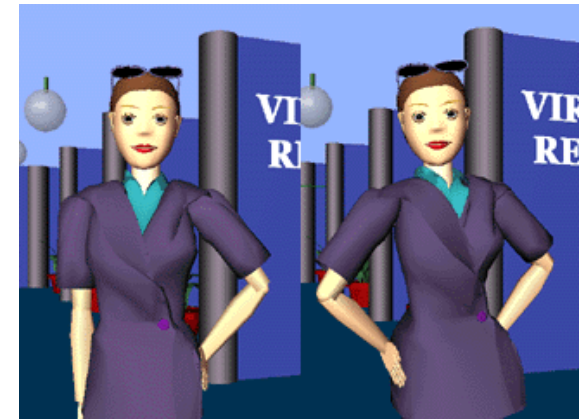
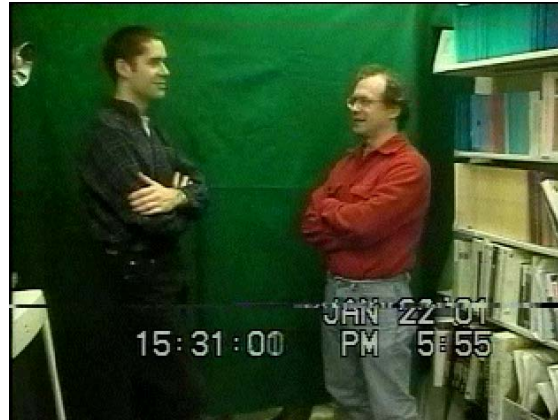
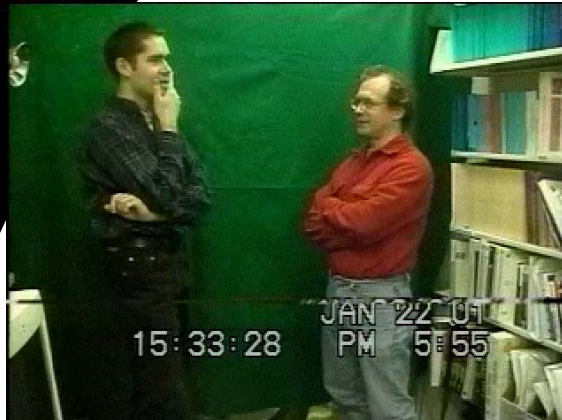


LEARNING COMPANION



# Posture Shifts

**Cassell,  
Nakano,  
Bickmore  
ACL '01**



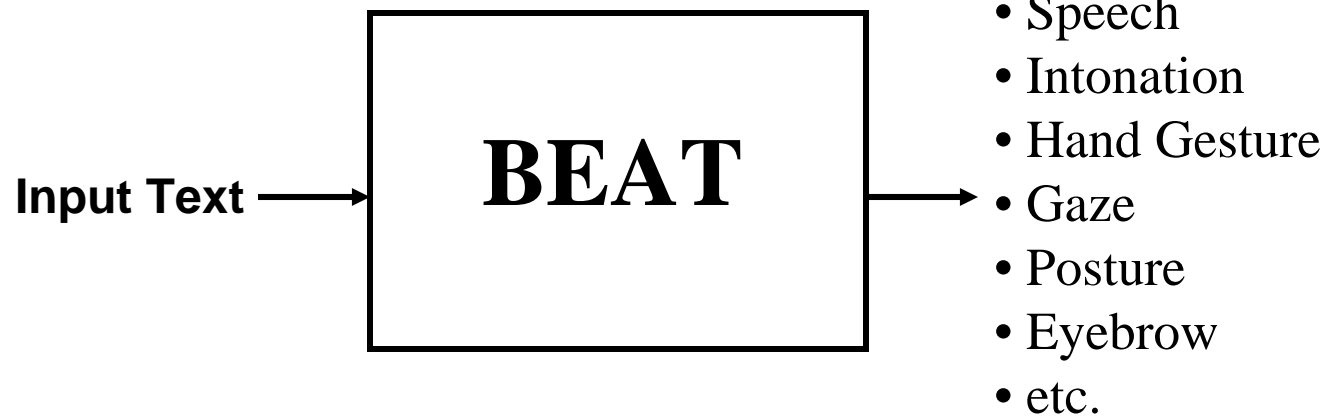
## Posture shifts with respect to discourse segment

	Monologues (0.06/s)			Dialogues (0.07/s)		
	ps/s	ps/int	energy	ps/s	ps/int	energy
Inter-dseg	<u>0.340</u>	0.837	0.832	<u>0.332</u>	0.533	0.844
intra-dseg	<u>0.039</u>		0.701	<u>0.053</u>		0.723

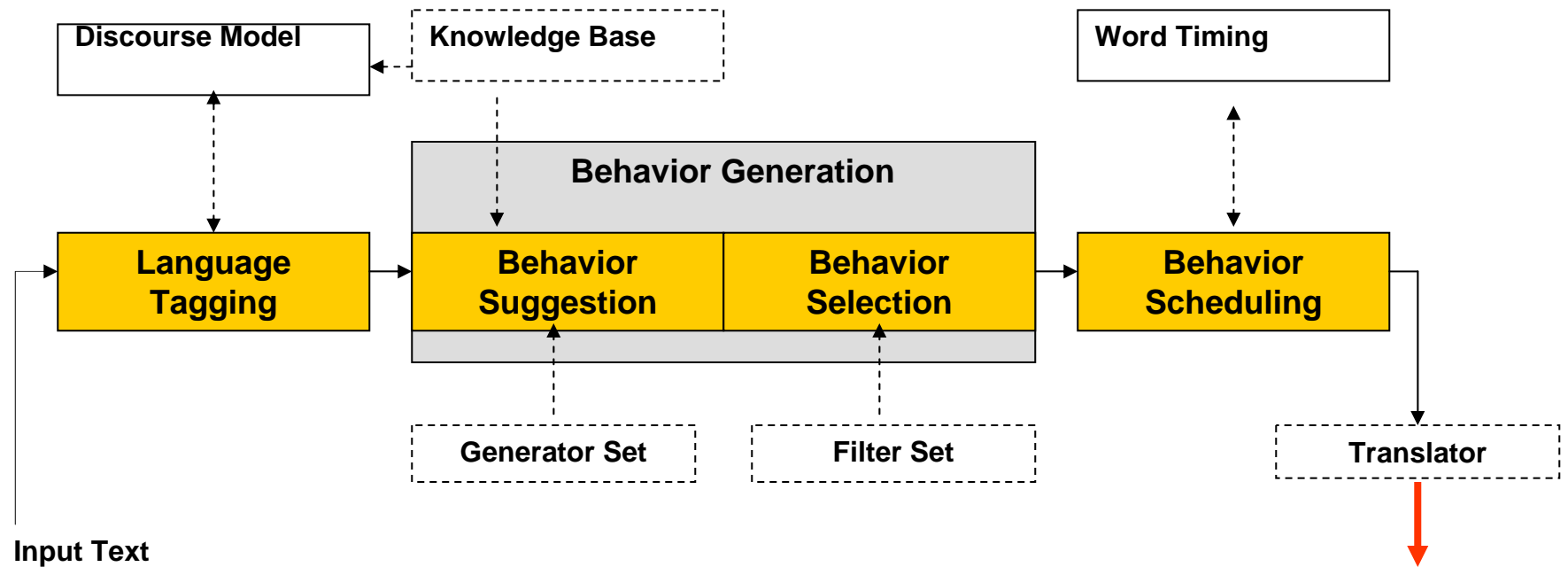


BEAT

**Cassell,  
Vilhjálms  
Bickmore  
SIGGRAPH '01**



# BEAT Architecture



“You just type in some text, and the actor talks and gestures by itself!”





***Bickmore,  
Cassell  
CHI '01***

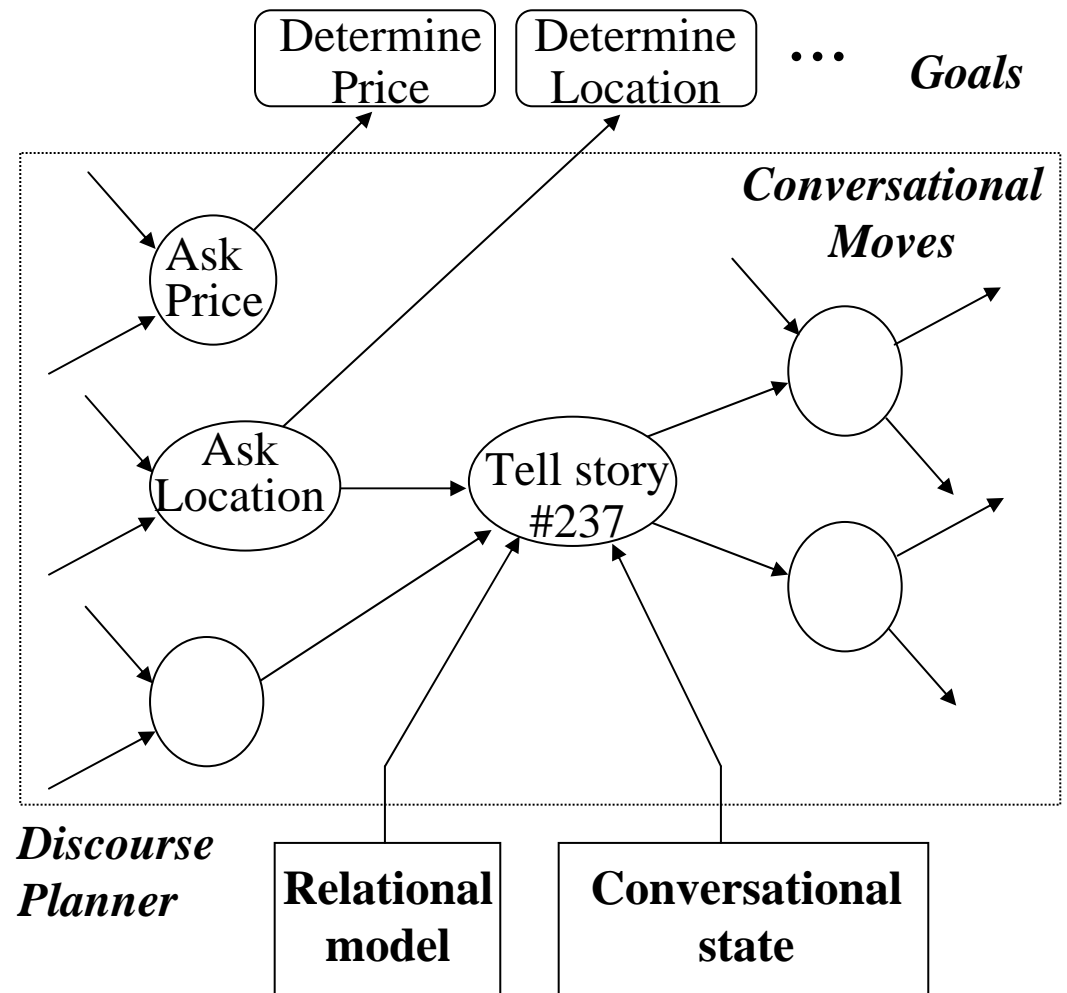
# Social Dialog Planning

- How do we plan when to do social dialogue within a task interaction?
- Problem:
  - Dynamically sequence agent dialogue moves to achieve (prioritized) task goals.
    - Assumes agent-initiated dialogue
    - Moves can be task or social
    - Minimal text generation
  - Constraints:
    - Minimize face threat (social penetration)
    - Maximize sequential topic coherence
    - Maximize user topic coherence



# Relational Dialogue: Discourse Planner

- Activation nets (Maes '89)
- Criteria for selecting next action:
  - Classical planning
  - Relational constraints (minimize face threat due to social penetration and topic management violations)





A photograph showing a human hand holding a prosthetic hand. The prosthetic is white and has a yellow square on its palm. The background is black.

# Dialogue Models to Support Long-Term Health Interventions

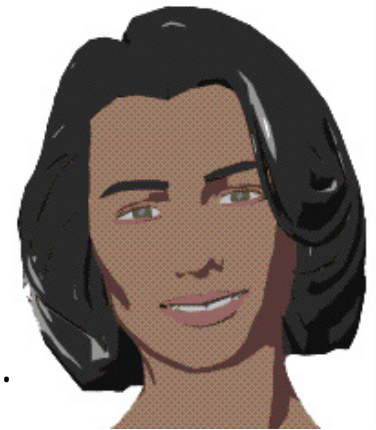
- Long-term interactions
  - Health behavior change: months or years
  - Chronic disease mgt or disability: lifetime
- Requirements
  - Persistent Memory
  - Rich Dialog & Variability
  - Relational Behaviors



# Applications & Studies

## MIT FitTrack Evaluation Study Objective

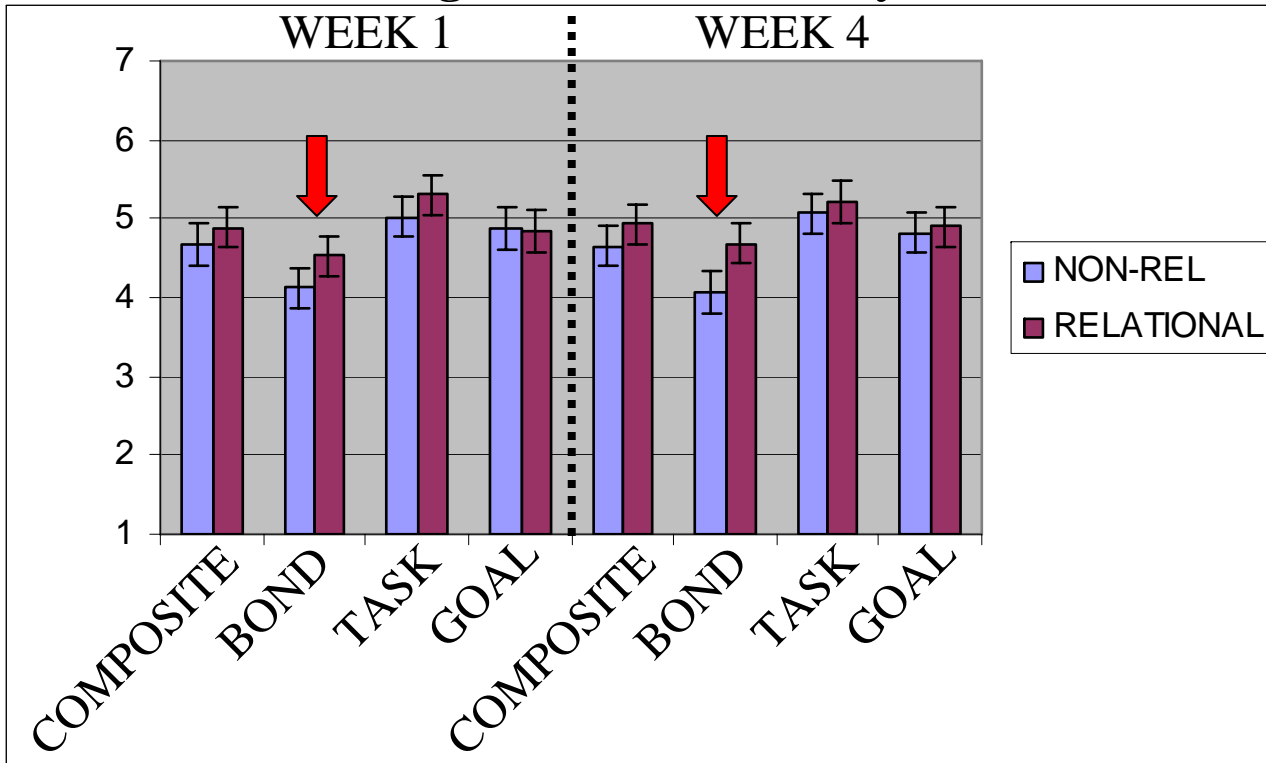
- Determine if
  - Agent can build a working alliance.
  - This translates into gains in behavior change.
- Behavior change objective
  - “30 minutes or more of moderate or better activity on most, if not all, days of the week” (recommend walking)
  - Secondary goal: 10,000 steps a day
- Between Subjects Design:
  - RELATIONAL – relational agent
  - NON-RELATIONAL – relational behaviors ablated
  - CONTROL – no agent





# Relational Results

### Working Alliance Inventory



Differences in BOND subscales significant:  
WK1  $p < .05$   
WK4  $p = .007$

A photograph in the top left corner shows a human hand holding a prosthetic hand. The prosthetic is white and has a yellow square on its palm. The background is black.

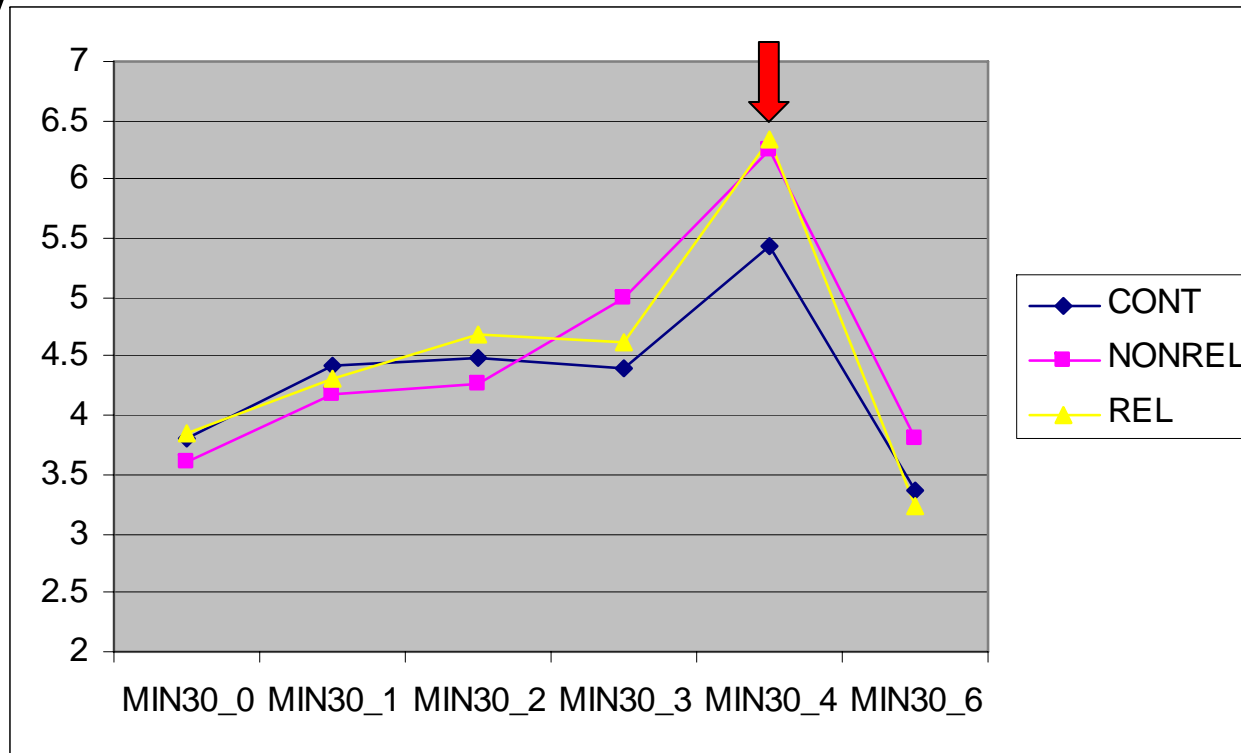
## Relational Results

- Single items:
  - “How much do you like Laura?”  $p < .05$
  - “How would you characterize your relationship with Laura?”  $p < .05$
  - “Would you like to continue working with Laura?” (at end of WK4)  $p < .05$
- Behavioral measure:
  - Sentimental farewell (70% REL vs. 32% NON-REL;  $p < .001$ )



# Behavioral Results (Representative)

**Days per week over 30 minute goal**

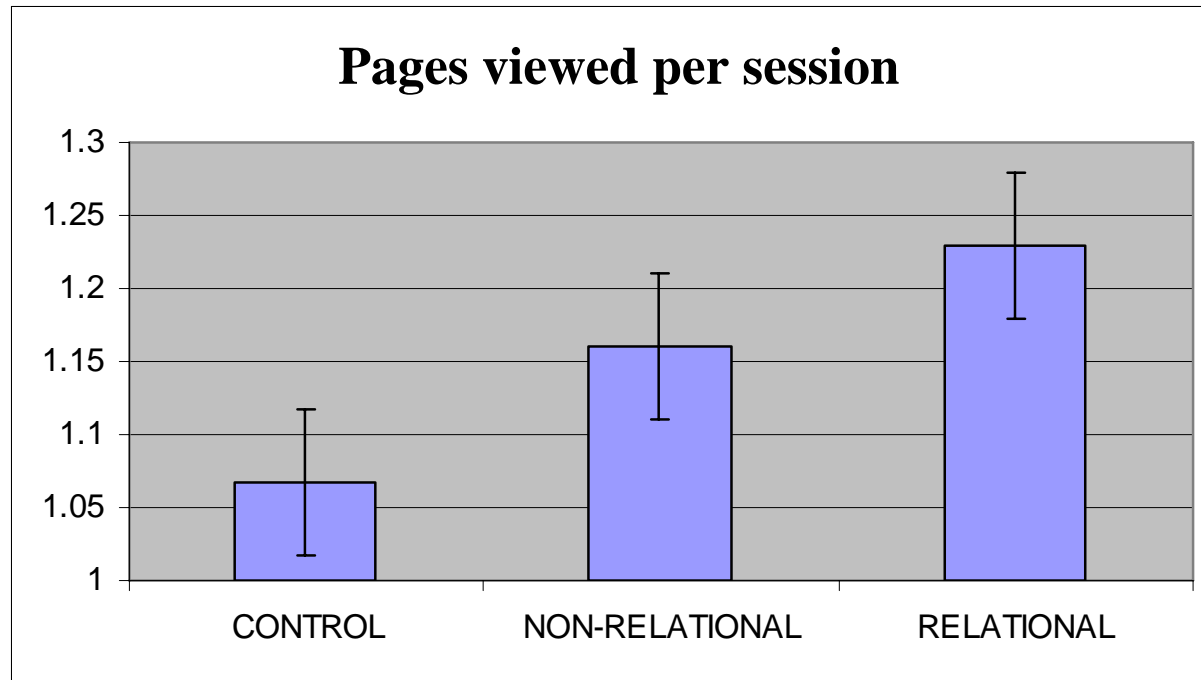


Only difference  
between groups is  
WK4,  
CONTROL < AGENT  
 $p=.06$

Significant increase  
WK0-WK4  $p<.001$   
Significant decrease  
WK4-WK6  $p<.001$



# Participation Results All Subjects



Significant difference  
in educational pages  
viewed:  
**CONTROL < AGENT**  
 $p < .05$



## MIT Study Conclusions

- Demonstrated ability of relational agents to build caring, trusting relationships with users
  - "Laura and I trust one another." ( $p < .001$ )
  - "I believe Laura is genuinely concerned about my welfare." ( $p < .001$ )
  - "My relationship with Laura is very important to me." ( $p < .05$ )
  - "I feel Laura cares about me..." ( $p < .001$ )
  - "Laura and I respect each other." ( $p < .001$ )
  - "I feel Laura appreciates me." ( $p = .009$ )
  - "I believe Laura likes me." ( $p < .001$ )
  - Reported liking of Laura. ( $p = .007$ )
  - Reported desire to continue working with Laura. ( $p = .001$ )
- Demonstrated the efficacy of having an animated exercise advisor who set and followed up on goals.

## Geriatric FitTrack Study

- **H1** – Older adults will accept, use and enjoy the relational agent system.
- **H2** – Users will perform more physical activity compared to a control group.





# Study Protocol

- BMC – South Boston Safety Net Hospital
- Two month daily contact intervention
- Subjects referred from geriatric clinic
- Stand-alone computer & table provided
- Control: standard-of-care (brochure)
- Measures
  - Pedometer readings (steps)
  - Likert scale questions about system & Laura
  - Computer logs
  - Demographics & SF-12
  - Semi-structured interviews

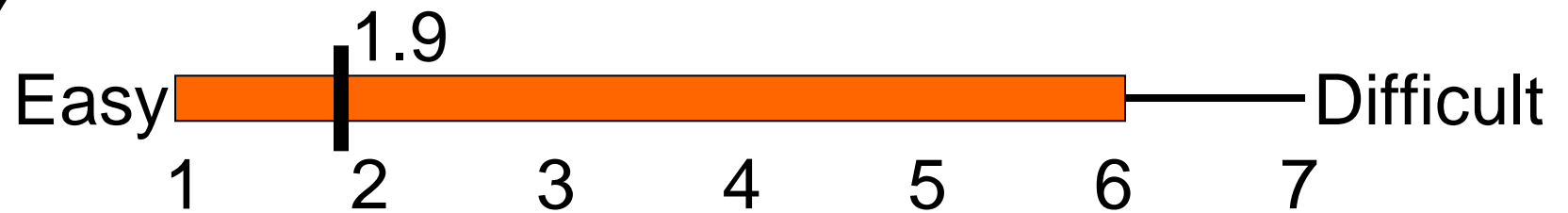


## Subjects

- 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"



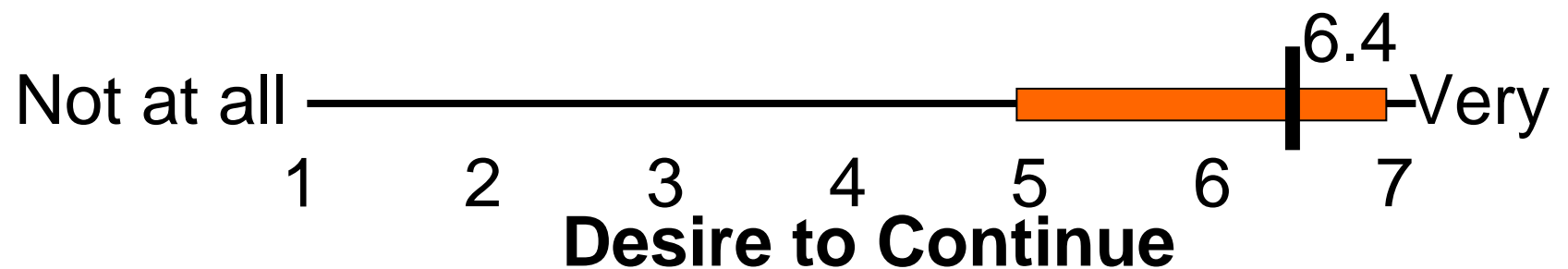
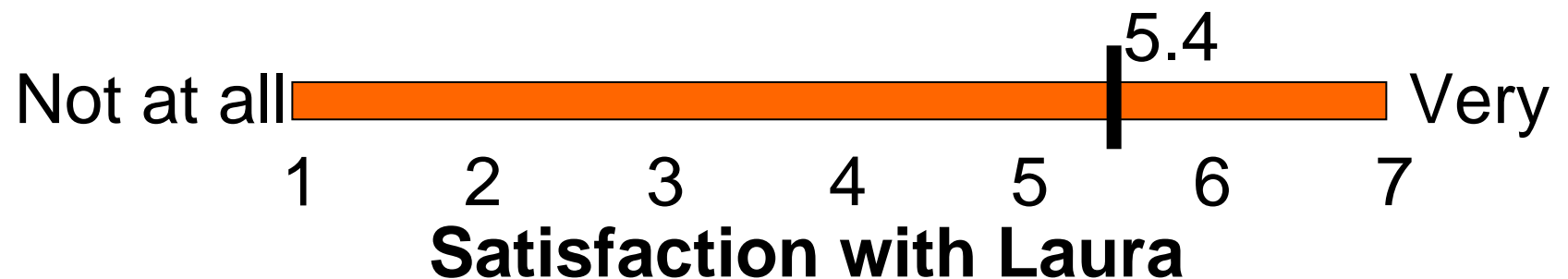
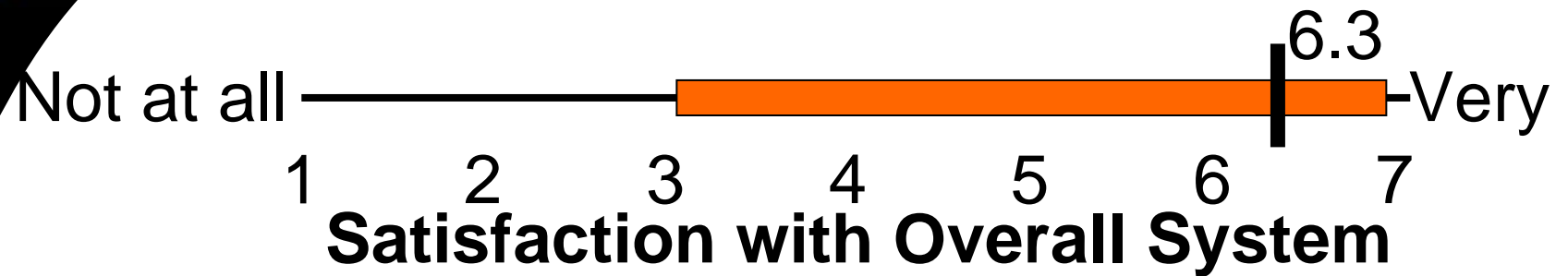
## Results: Ease of Use



***“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.”***

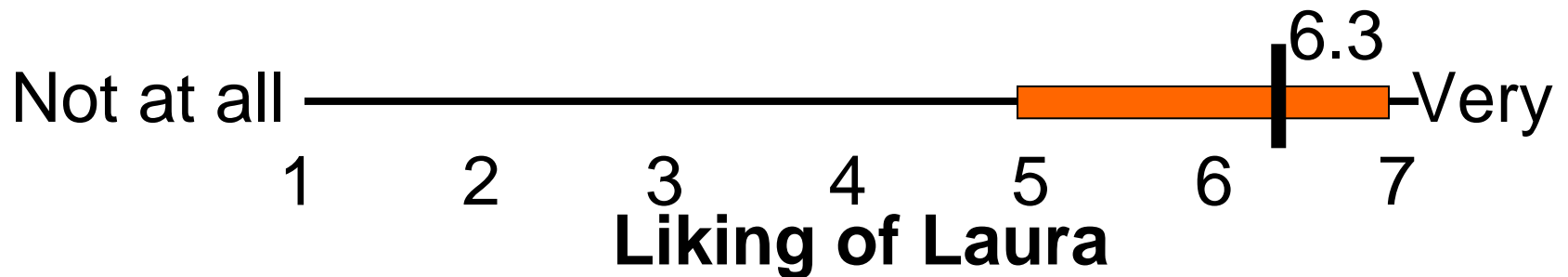
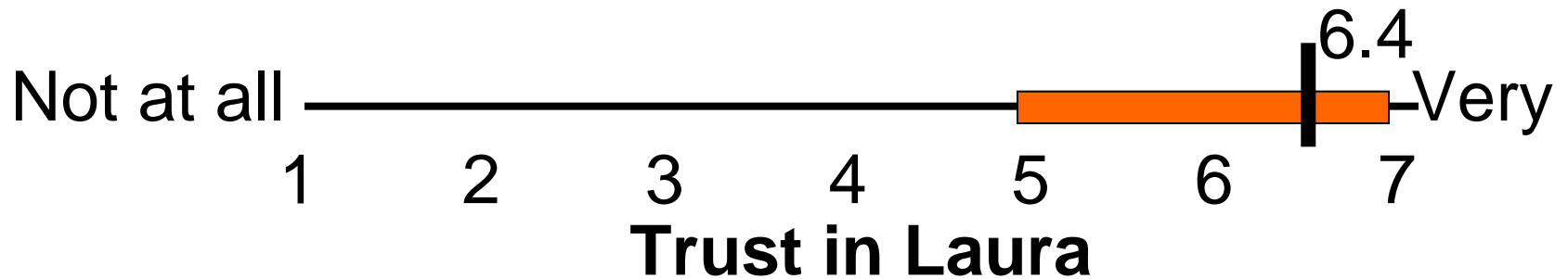


# Results: Satisfaction



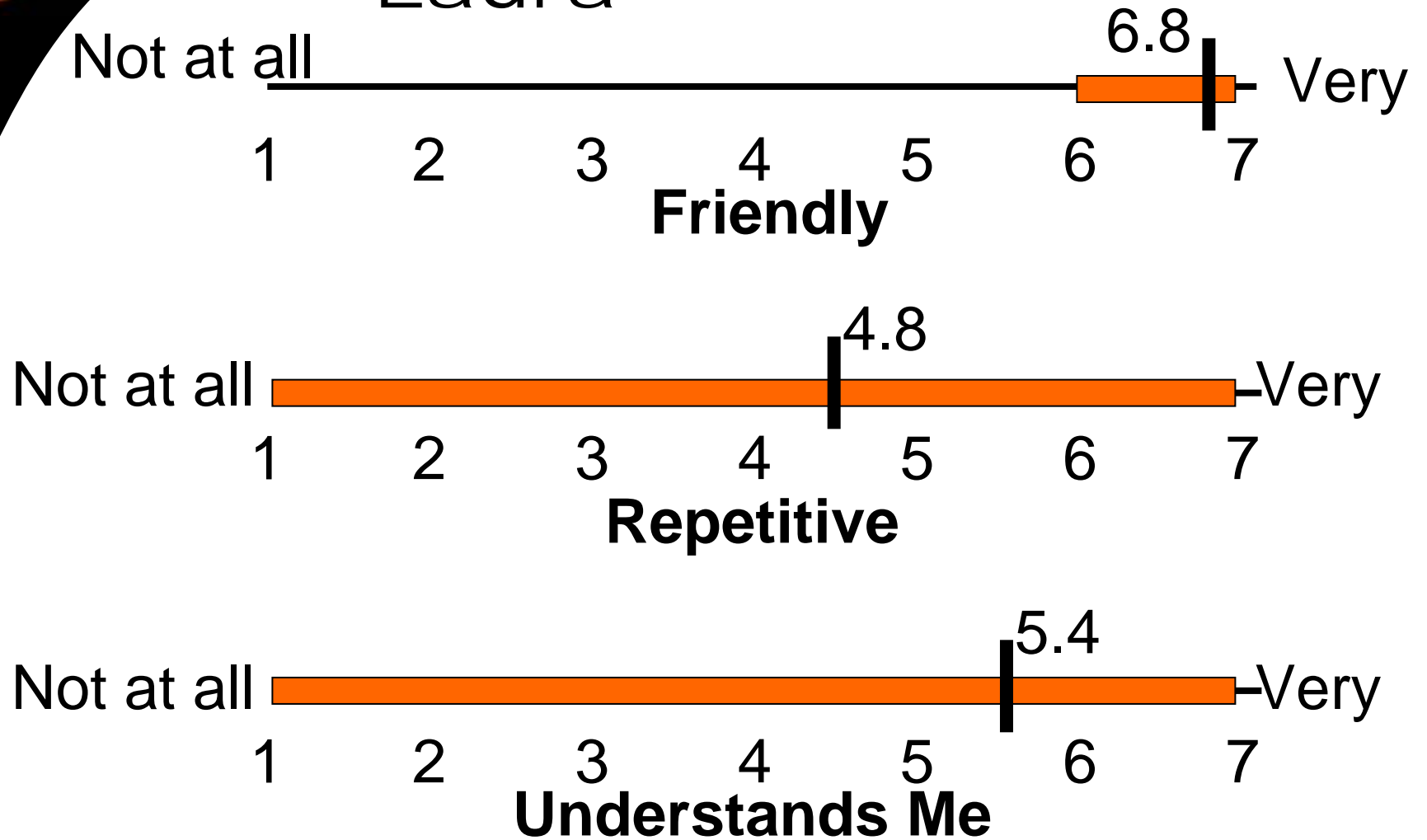


# Results: Relationship with Laura



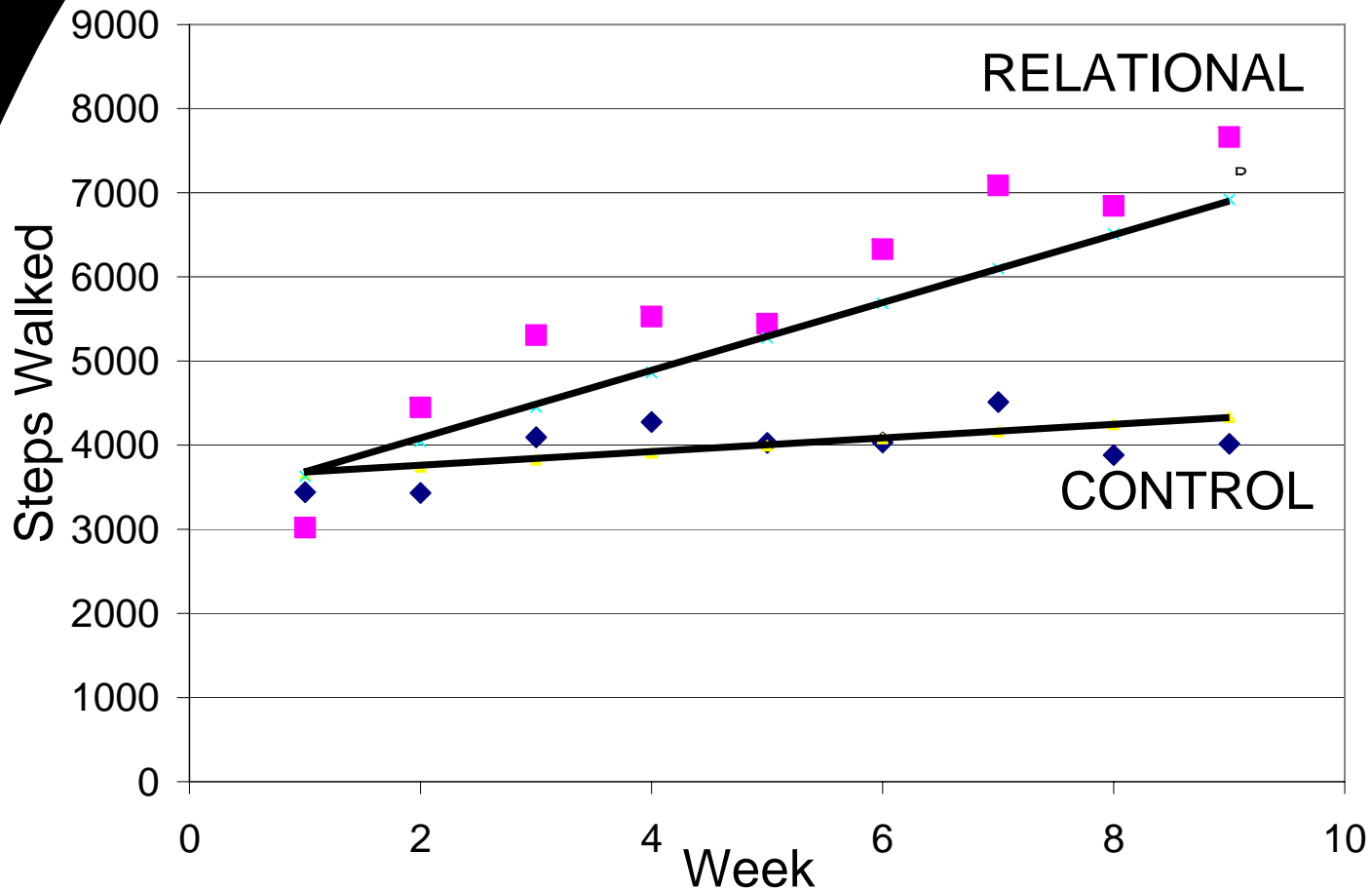


# Results: Impressions of Laura





# Results: Walking



Difference  
In slopes  
 $p=.004$



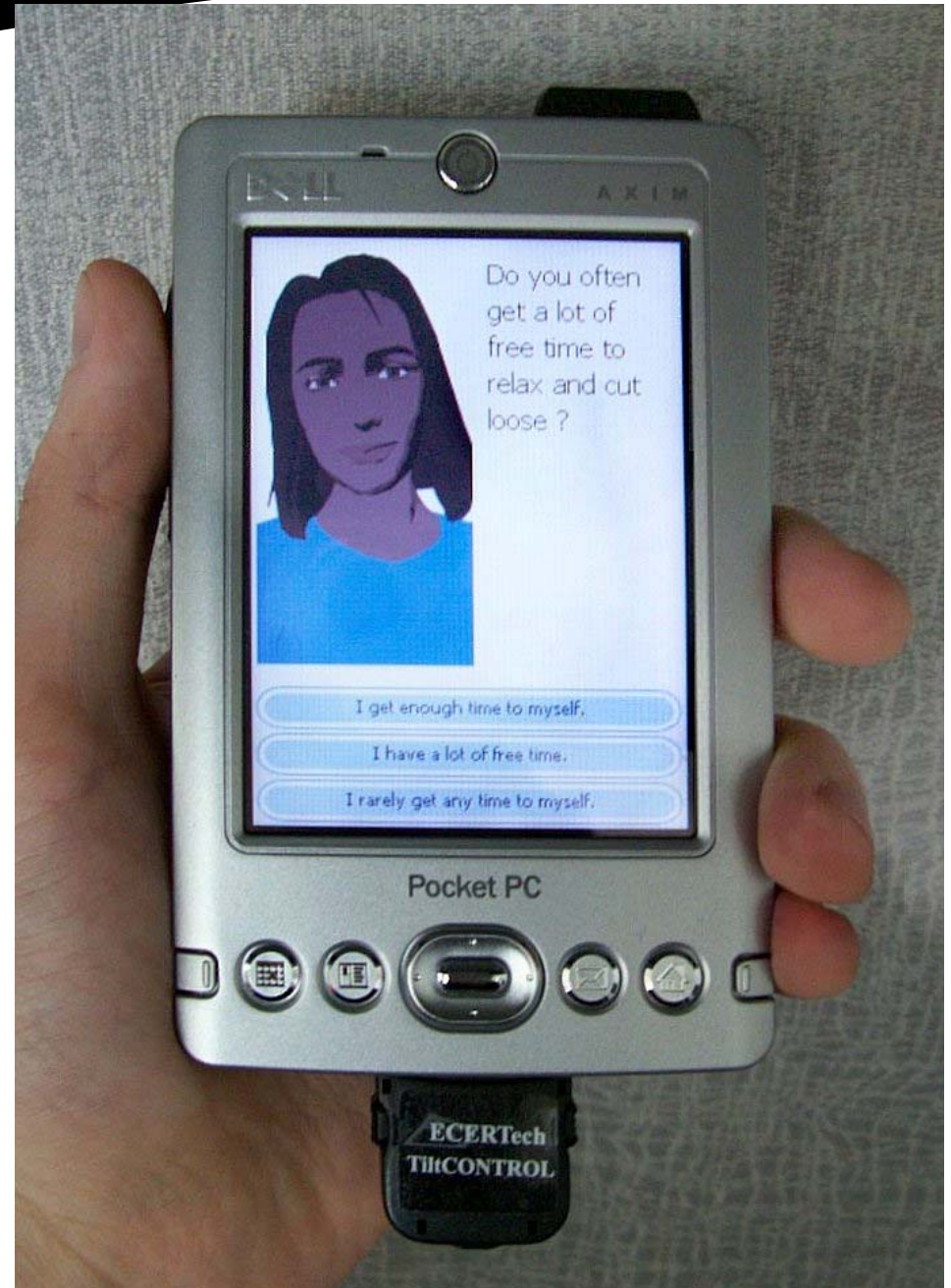
# Geriatrics Study Results

- H1: Most subjects liked the system & Laura  
*"I enjoyed her, I enjoyed Laura, and I'm quite sure somebody else would."*
- H2: Intervention subjects performed more physical activity.  
*"It was the best thing that happened to me, to have something that pushed me out and get me walking."*
- Continuing work under NSF CAREER grant.



# Just-in-Time Information for Exercise Adoption

NLM R21





## Why Wearable?

- Available at time and place of need
- With integrated sensors  $\Rightarrow$ 
  - Able to initiate interaction
  - Able to conduct context-tailored interaction
- Better relationship
  - Availability & Contact time



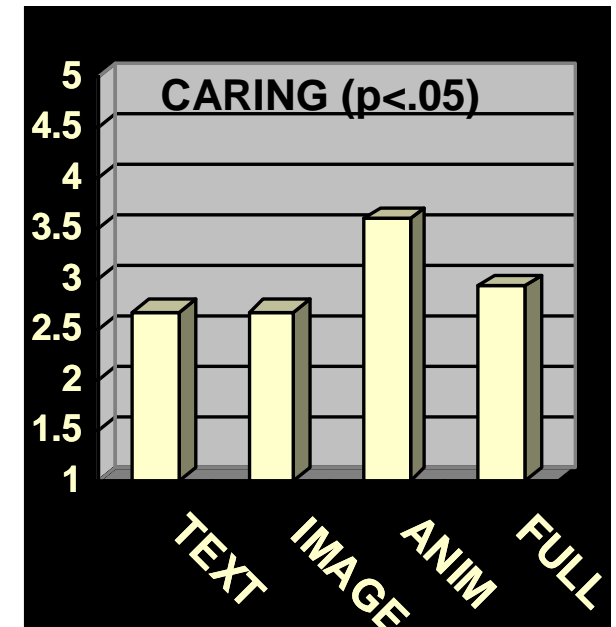
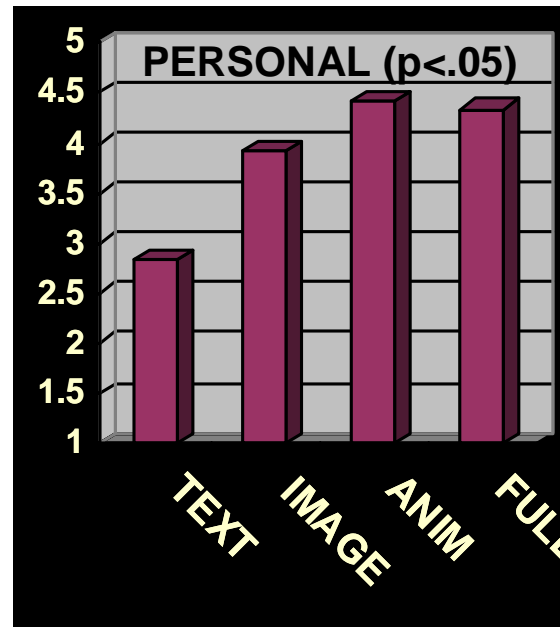
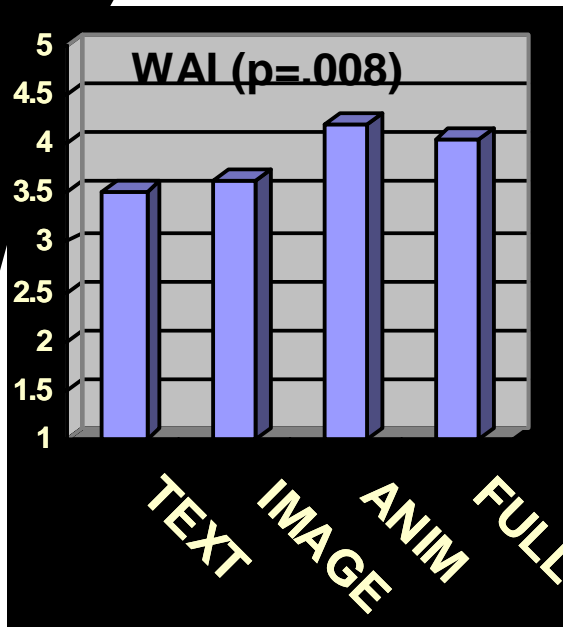
# Modality Study

- Compared 4 modalities:
  - Text only
  - Text + Static agent image
  - Animated agent
  - Animated agent + nonverbal sounds
    - Backchannels, Discourse markers, etc.





# Modality Study



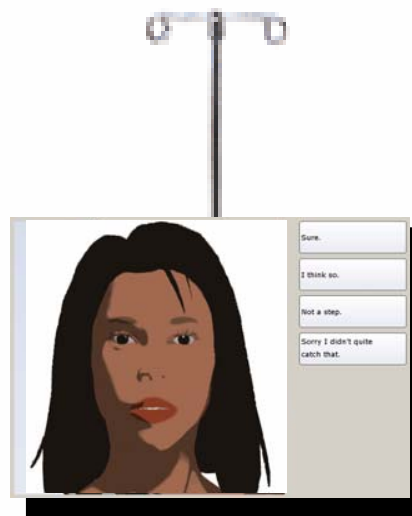
- Animated agent also scored higher (approaching significance) on *credibility of health information* and *comfort using in the workplace*.



# Just In Time Field Study

- Research questions:
  - Is intervening at the moment of decision making more effective than at the end of the day?
  - Is a relational agent more effective than text?

# Hospital Discharge Reengineering



## NHLBI R01

- 25% of hospital pts are readmitted within 90 days
- low health literacy an independent risk factor (OR 1.69)





# Medication Adherence for Young Adults with Schizophrenia

- Funded by Eli Lilly Pharmaceuticals - In collaboration with University of Pittsburgh School of Nursing
- 30 day intervention
- Pilot study: 20 subject quasi-experimental trial
- Trust & Social support especially important



## Conclusion

- “Caring machines” can be important for client satisfaction and health outcomes
- More info
  - [bickmore@ccs.neu.edu](mailto:bickmore@ccs.neu.edu)
  - <http://www.ccs.neu.edu/home/bickmore/>