

MIT MEDIA LAB
ROBOTIC
Life

MAS 965

Relational Machines

Cynthia Breazeal, Instructor

MAS 965 Relational Machines

- Syllabus and Course Description Handout
 - Instructor: Cynthia Breazeal,
 - Class mailing list
 - Course wiki

- Sign-up Sheet

MAS 965 Relational Machines

- Course Description
 - Technological artifacts that interact with people on an ongoing and extended basis to the benefit of its user.
 - Social (partner) interaction rather tool-based.
 - Social rapport between human and machine has positive impact on performance gains or value.
- How to design for a successful human-machine relationship over the long-term.

MAS 965 Relational Machines

- Sample applications include:
 - Learning companions for children,
 - Assistive robots for the elderly,
 - Therapeutic agents (physical, psychological),
 - Software agents that act as trainers or assistants,
 - Interactive game characters,
 - Machines that cooperate with humans as teammates,
 - And more...

MAS 965 Relational Machines

■ Schedule

- Week 1 Introduction: Design for Partnership and Appeal
- Week 2 Representing and manipulating relationships
- Week 3 Measuring and evaluating relationships
- Week 4 Special population interaction issues
- Week 5 Interactions with eldercare agents
- Week 6 Interaction with therapeutic agents
- Week 7 Spring Break
- Week 8 Interactions with machine teammates
- Week 9 Interactions with learning companion and tutorial agents
- Week 10 Interactions with trainers and assistant agents
- Week 11 Interactions with wearable or ambient agents
- Week 12 Interactions with entertainment agents
- Week 13 Sponsor Week
- Week 14 Final Project Presentations

MAS 965 Relational Machines

■ Grading:

- Weekly written critiques of readings, 25%
- Class participation / presentations, 25%
 - In-class exercises
 - Group or individual
 - Present concepts and discuss
- Term Project/Paper, 50%
 - Select topic at beginning of course, develop throughout semester
 - Leverage from own research topic
 - Present full summary of semester design process and outcomes
 - OR Choose a different project, with permission of instructor

Introductions

MAS 965 Relational Machines

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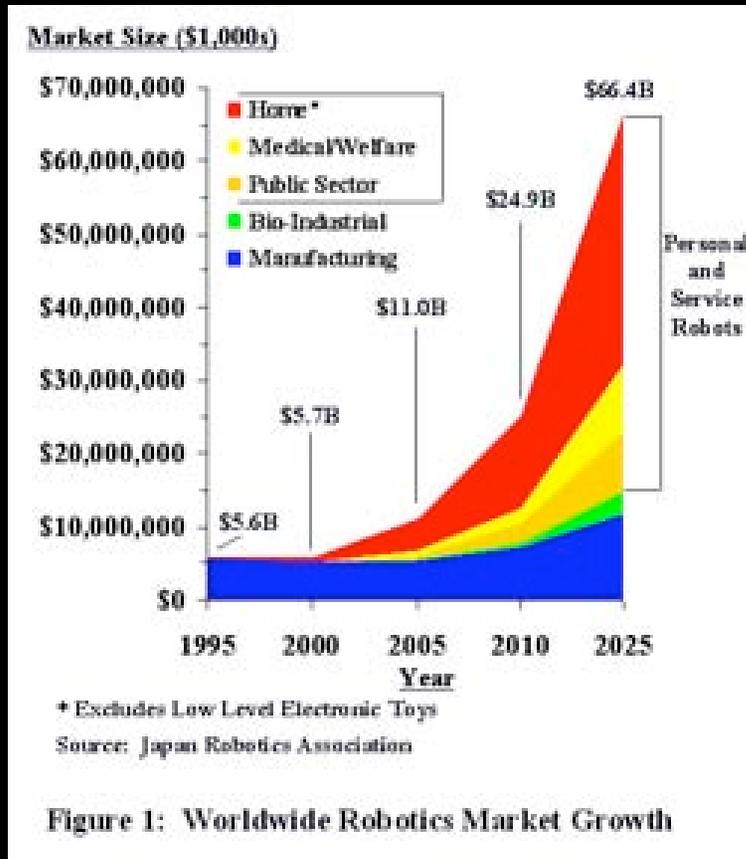
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Robots in the real world with real people

The “Final Frontier”

- Robots in YOUR home
- Interacting with the average (untrained) consumer
- On a daily basis and over the long term

Why Now?



- Personal Robots: “assist, protect, educate & entertain”
- Convergence
 - Mobile computing
 - Government mandate
 - Societal needs of aging societies

UNEC & IFR 2002 Study

Long-term interaction



Oh, the horror...the horror...

- Why are you going to welcome this thing into your home?
- What's going to keep you interacting with it?
- What benefit does it bring to you?

Consumer Appeal



Must do better than Furby

- Entertainment robots have short-term appeal for most people
- Some robot appliances (Roomba) are successful
 - Useful to people
 - People anthropomorphize them anyway
 - How can we do (benefit + relationship) well?

Design Issues

- Useful
 - Beneficial
 - User-FRIENDLY
 - Helpful
 - Trust
 - Acceptance
 - Enjoyment
 - Personalization
 - Privacy
 - Etc.
- *Cognitive abilities*
 - *Learning capability*
 - *Social interaction*
 - *Expressive*
 -
 -
 -

Interpersonal Interaction with New Media

- Computers and new media are perceived as fundamentally social and natural
 - Humans expect media to obey social and natural rules.
 - Rules come from world of interpersonal interaction, and how people interact with real world.

People Treat Computers Like People

- Social and natural responses to media **are not conscious**
- Even **simplest** of media can activate rich social responses in humans
- **All** people automatically and unconsciously respond socially and naturally to media.
 - Can reason around it, but takes **a lot** of effort to do so!
 - Difficult to “think around” when people are tired, other things compete for attention --- it is difficult to sustain

Why do People do This?

- Says something fundamental about people
- Humans did not evolve with 20th century technology.
 - Brain doesn't have to distinguish real from "seems real".
 - Automatic responses evolved that still are the basis for negotiating life and our social world.
- Any medium that is **close enough** (i.e., suggest a social presence) will be treated as human, even if they think it foolish and will deny it afterwards.

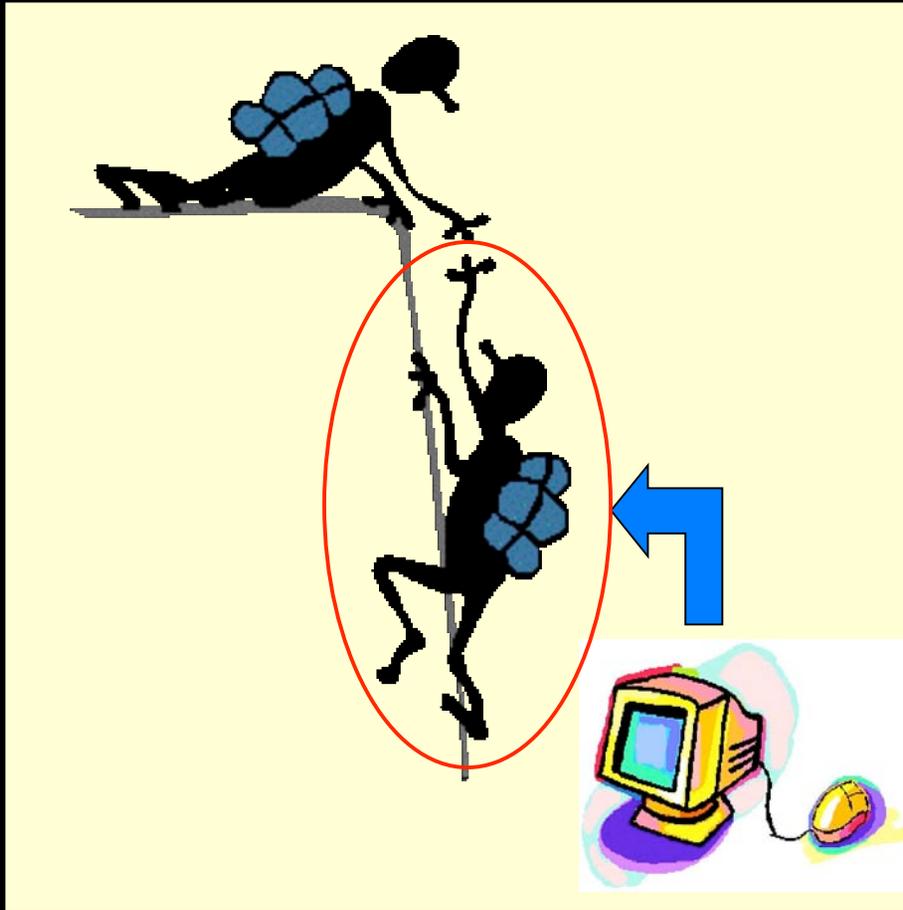
A Social Model for Robots

- Steuer (1995) identified characteristics that cue people to interact socially
 - Natural language
 - Interactivity
 - Human social roles
 - Human-sounding speech
 - Human-like physical characteristics

Consequences

- When media adheres to social and natural rules (conforms to expectations), no instruction is necessary --- people immediately become experts!
 - More enjoyable they are to use.
 - Feelings of accomplishment
 - Sense empowerment
 - Increased competence

An Example...Media and Social Roles



- Classic sociological studies, where replace one of the human subjects with an ordinary desktop computer

Teammates

- People's attitudes and behaviors are affected when they are part of a team
 - People think they are more similar to each other than to those on the outside
 - People admire and respect others in their group
 - Cooperate more with team members and agree more with their positions (group-think)

Making a Computer a Teammate

- Group identity
 - Team has a marker or a name that distinguishes it
- Group interdependence
 - Behavior of each team member can affect all other members

Making a Computer a Teammate



“The Blue Team”

- Human-computer team
 - Name: “the blue team”
 - People wear blue wristband
 - Computer has blue border and a label “Blue Team” on top
 - Told their performance would be evaluated based on their own work and that of the computer.

Making a Computer a Teammate



“The Green Computer”

- Human working alone using a computer
 - Person wears a blue wristband
 - Computer has green border and a label “Green Computer” on top
 - Told their performance would be evaluated based solely on their own work and the computer was only there to help

A Collaborative Task: Desert Survival

- Scenario: your airplane has crashed in the middle of the desert. No sign of water, but some items are salvaged from the wreckage. Rank these 12 items for their survival value: flashlight, jackknife, magnetic compass, sectional air map, etc.

Results: Changes in Attitudes

- When on the same team, subjects thought the computer teammate:
 - Was more like them
 - Solved problems in a similar manner
 - Agreed more in their ranking
 - Information was more relevant, helpful, insightful
 - Presentation of information was friendlier

Results: Changes in Behavior

- When on the same team, subjects behaved differently with computer teammate:
 - Feelings of cooperation were enhanced
 - Human tried harder to reach agreement
 - Human more open to attempts to change answers
 - Human Changed answers more to conform to computer

Take Away Message

- It's really simple to create a team, simply a name will do
- But it's far more powerful when people are asked to rely on media for their own success
- Team membership will influence how people think, feel, and behave

Status and Human-Machine Teams

- Status/role in human-computer relationship
- One-down status
 - Computer is only a tool and user is dominant and in control.
- One-up status
 - Computer as dominant. It takes charge and absorbs most of the work as possible --- e.g., wizards, guides, etc.

Status and Human-Machine Teams

- One-across status
 - But... **findings suggest balanced status is preferable**
--- e.g., computer and users as peers, teammates, etc.
 - Human feels dependent on computer without feeling superior or inferior
 - Being on same team encourages people to think that the computer is more likeable and effective
 - Promotes cooperation and better performance

Human-Robot Teammates: A Study

- Human-Robot Collaboration study (Hinds, Roberts & Jones, 2004)
- Examine effects of **status** and **appearance** on human-robot collaboration
 - Reliance upon robot
 - Cede responsibility to robot
- *3x3 Wizard of Oz* study
 - Human, human-like, machine-like
 - Superior, peer, subordinate

Robot Teammates: Hypothesis



Human-like



Machine-like

- People will rely more on and cede responsibility more to human-like robot partner
 - Why?
 - Perceived common ground
 - Shared identity
- ...Make human more confident in estimate of robot's knowledge and abilities

Findings: Effect of Appearance

- People willing to cede more responsibility to human-like robot
- People willing to attribute more credit to human-like robot
- Little difference in attributing blame
- Little difference in people's willingness to rely on robot

Findings: Effect of Status

- PEER condition: strong positive relation in willingness
 - To rely on human-like robot
 - To attribute credit to human-like robot
- SUPERVISOR condition:
 - Human Feels less responsible when things go wrong
 - Assign significantly less credit to robot when things go well
 - More likely to attribute blame (Dilbert effect)
- SUBORDINATE condition:
 - Retained more responsibility for the successful completion of task for machine-like robot

Human-Centered Design Applied to Social Robots

Psychology of Design

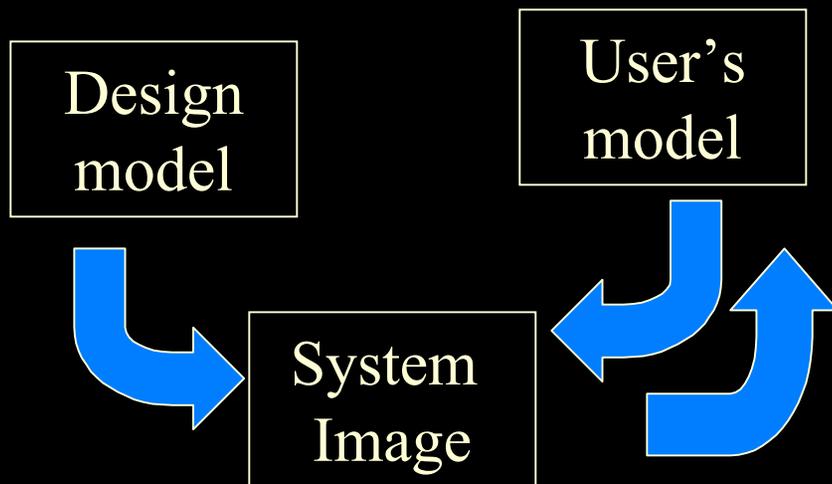
- Human mind is exquisitely suited to make sense of the world and people
- Use Natural Cues
 - Indicate what parts to operate and how
 - The mapping between intended and actual operations is intuitive
 - The effects of the operations are apparent
- Just the right things need be visible to avoid gadget overload

Don Norman

Mental Models (Don Norman)

- Mental models are the models people have of themselves, the environment, things with which they interact
- People form mental models through experience, training, instruction
- Mental model of a device is formed largely by interpreting its perceived actions and visible structure (its system image)

Communicating Mental Models



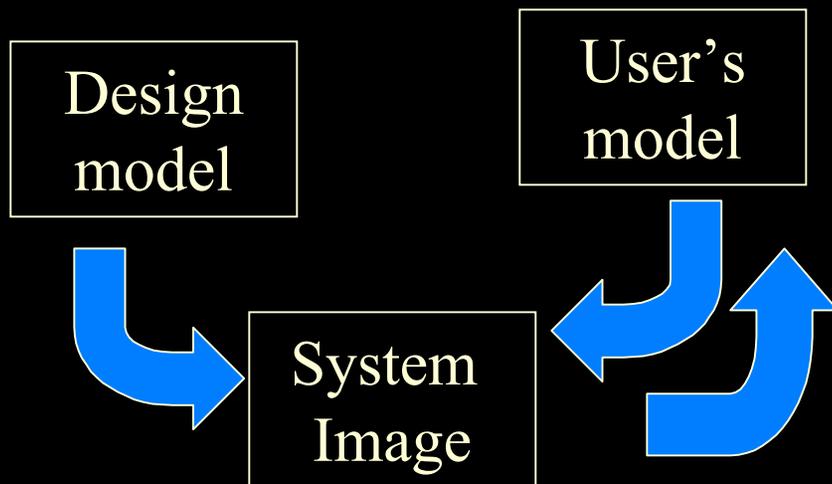
Designer communicates mental model to user through the system image

- Design model: the designer's conceptual model
- User's model: the mental model developed through interaction with the system
- System image: How the device looks and behaves

Principles of Good Design

- A good conceptual model allows user to predict the effects of his actions
- Good design communicates an appropriate conceptual model using natural cues
 - Affordances
 - Mapping
 - Feedback
 - Causality

Communicating Mental Models



Designer communicates mental model to user through the system image

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Affordances

- Affordance refers to the perceived and actual properties of the thing that determine how it could possibly be used
 - A chair affords (“is for”) support, and therefore affords sitting
- Provide strong clues for the operation of things.
 - Buttons are pressed
 - Levers are pulled, etc.

Mapping

- The relationship between two things
 - E.g. the controls and their movements --- their effects on the world
- Steering Wheel: Turn clockwise to go right
 - Visible
 - Closely related to desired outcome
 - Provides immediate feedback

Feedback

- Sending back to the user information about what action as been accomplished
- The effects of the operations are apparent
- Bridge the gap between execution and evaluation

Causality

- Something that happens right after an action appears to be caused by that action
 - False causality results in superstition
 - No visible result conveys ineffectiveness of action, often causing repetition with regret

A Social Model for Robots

- “Personality is a form of conceptual model, for it channels behavior, beliefs, and intentions into a cohesive, consistent set of behavior. (*This is a fairly dramatic oversimplification of the complex field of human personality and of the many scientific debates that take place within that field.*) By deliberately providing a robot with a personality, it helps provide people with good models and good understanding of the behavior....”
- “Personality is a powerful design tool, for it helps provide humans with a good conceptual model for understanding and interpreting the behavior of the robot and for understand how they should behave in interaction and in giving commands.”

Don Norman
How Might Humans Interact with Robots?

Robot Teammates

How to make this Fully Autonomous, Collaboratively Balanced, & Human-Centric?

DARPA/MARS collaboration
with NASA JSC

Cognitive Compatibility in HRI

- Model robot's cognitive capabilities on those of humans (A. Schultz)
- Additional constraint to consider when robots work with people as partners
 - Natural & intuitive interface=> reduced cognitive load
 - More predictable behavior => engenders trust
 - More understandable decisions=> able to recognize and quickly repair when mistakes arise
- Implementation informed by theories, studies to explain how people do such things

What makes an interaction collaborative?

- **Joint Intention Theory** (Cohen & Levesque, 1991)
 - Teamwork requires **commitment** to shared goal
 - Goals maintained over time, resisting capricious abandonment
 - Teamwork Requires **Communication for Grounding Mutual Beliefs**
 - Held by all teammates about the state of the task
 - To handle changing circumstances
 - To handle when things go wrong

What makes an interaction collaborative?

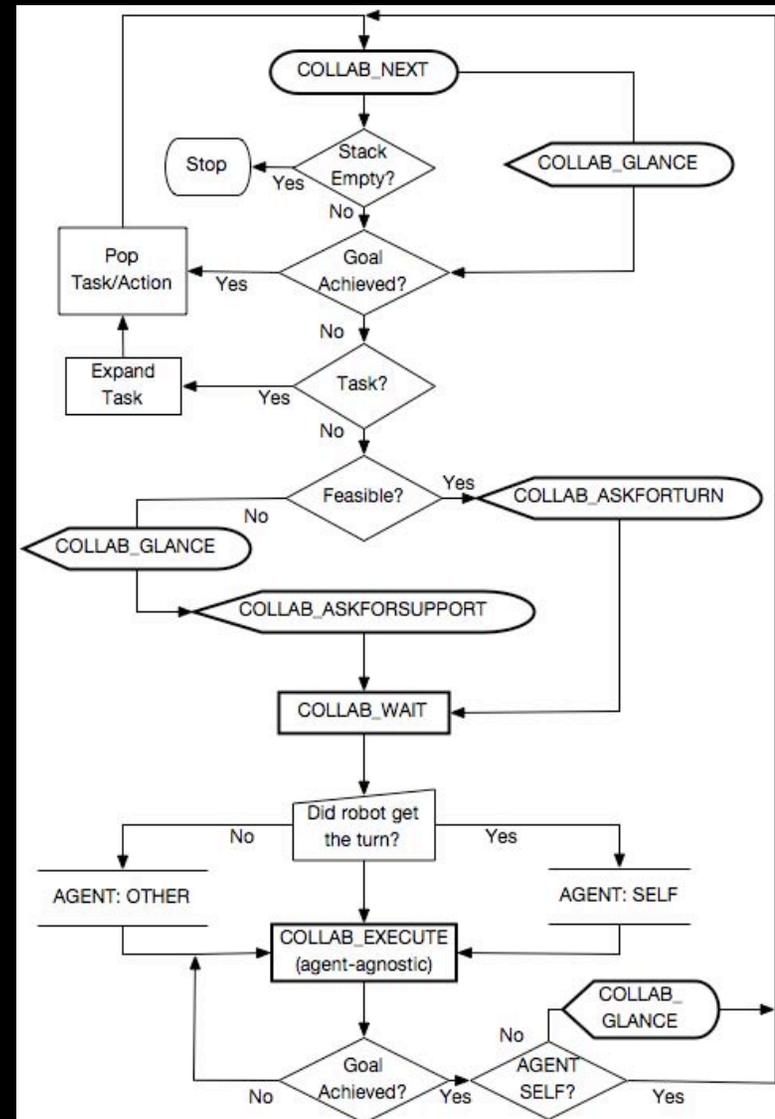
- **Shared Cooperative Activity** (Bratman 1992)
 - **Commitment to the joint activity** to accomplish shared goal
 - **Mutual responsiveness**, take other's actions into account
 - **Mutual support**, helping each other, not getting in other's way
 - **Meshing sub-plans**, coordinate joint actions in service of shared goal

Characteristics of Collaboration

- Communication for Grounding
- Mutual Responsiveness
- Commitment to Joint Activity
- Commitment to Mutual Support
- Dynamically Meshing Sub-plans

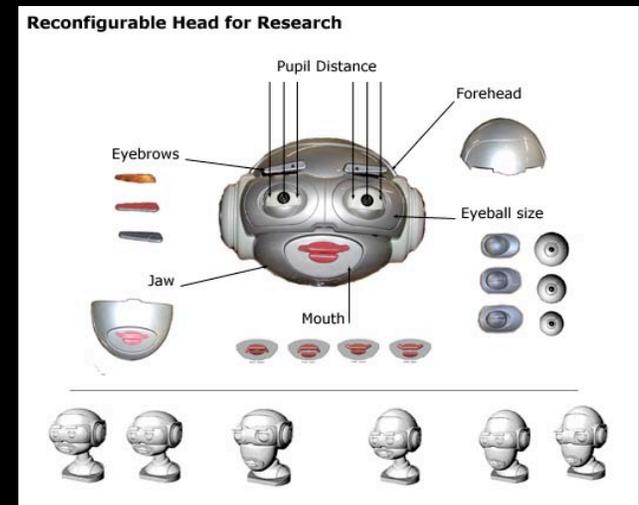


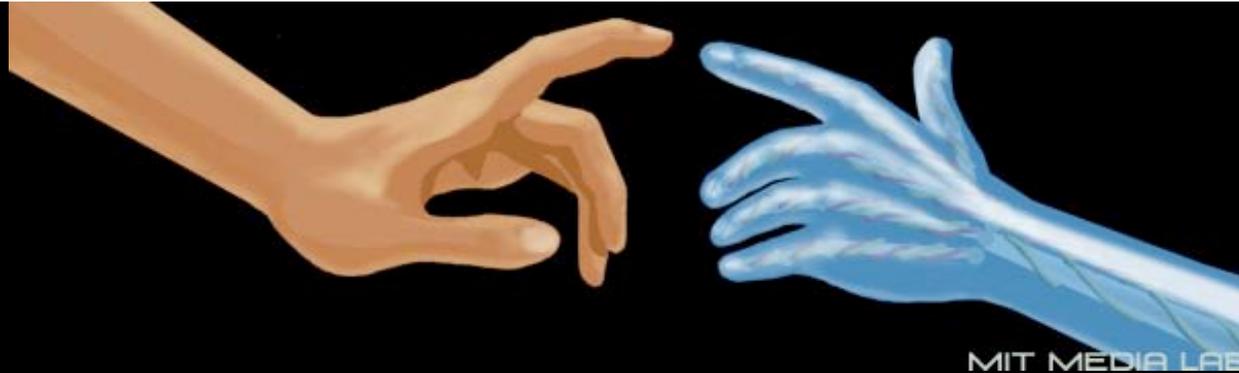
Relational Machines
Lecture 1: Design



Summary

- Good design considers how the human mind understands the world
 - Lessons from HCI, usability, etc.
 - Can be applied to social robot design
- Autonomous robots readily evoke a social model
- Impacts human behavior and attitudes
 - Can offer advantages when designed accordingly
- But important differences exist and must be understood





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Designing Relational Machines

Part II

Why care about social & emotional issues in the design of artifacts?

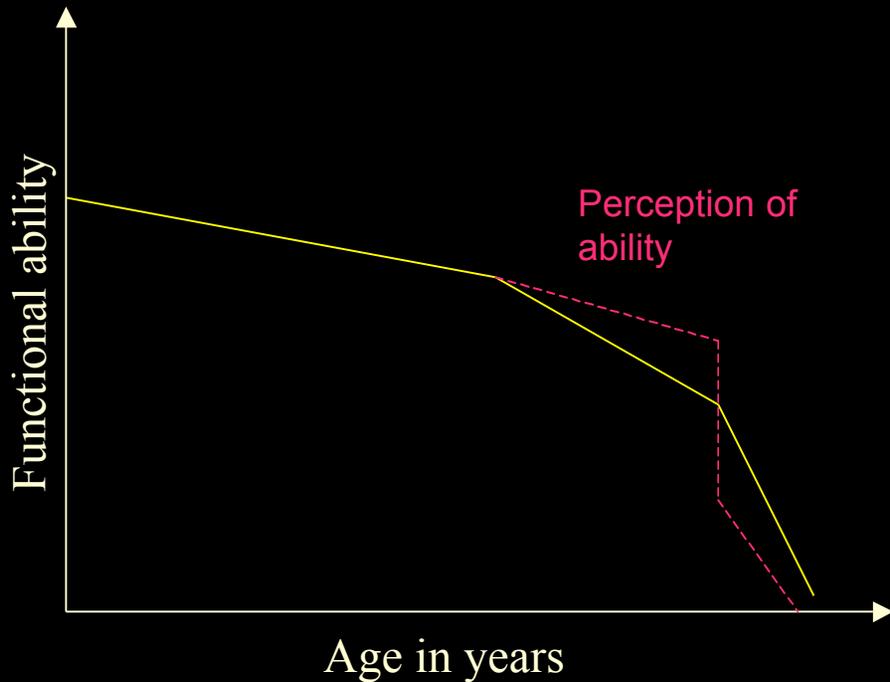
Design for Elderly

- ELDeR (Enhanced Living through Design Research)
 - Designers
 - Behavioral scientists
- 4 month study at senior's community show that
 - Emotional
 - Social
 - Environmental

factors play important role in eldercare experience and adoption and use of new products

Hirsch, Forlizzi, et. al. (2000)

Expanded Definition of Care



“one elderly woman broke her hip during a fall. After surgery she primarily used a wheelchair for mobility, even though fully recovered and able to walk. Her muscles eventually atrophied, making her totally reliant on the wheelchair.”

- Not just physical condition but quality of life (physical, social and psychological factors)
- Eldercare as a social interaction (family, friends, service, and medical personnel)
- Shifting perceptions of ability (often out of step with actual capability)

Social and Psychological Dimensions

- “Need” is not enough
 - Design can hinder adoption by highlighting disability and contribute to social stigma associated with that disability
- It’s not just what it does, but how it makes you feel (pride, fear) and how it makes you perceive yourself
 - Stigmatizing aesthetic contributes to late-life depression
 - User’s perceived need for technology is dominated by desire to not feel reliant on it
 - Contributes to over/under-estimation of functional abilities

Design for Elderly

- Might a relational agent be designed so that it is a member of an elder person's social network?

Long-Term Relationships with Agents

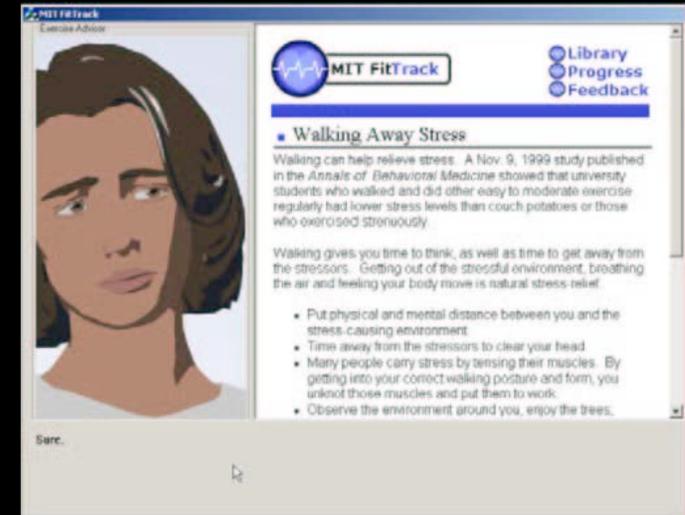
- Software Agents that build and maintain long-term social-emotional relationship with the user
 - Persistent construct spanning multiple interactions
 - Remember past history
 - Manages future expectations with users
- Sample applications
 - Behavior change coach
 - Learning companion
 - Automated sales person
 - Robotic pet therapy surrogate

Relational Behaviors

- People build relationships via language and face-to-face conversation
- Verbal Relational behaviors
 - Self disclosure,
 - Referencing shared mutual knowledge,
 - Talking about past and future together, etc.
- Non-verbal Relational behaviors
 - **Caring behaviors**: facial expressions, especially of concern,
 - **Immediacy behaviors**: Eye contact, Close proximity posture conveying openness, etc.
 - **Postural mirroring**: Synchronizing movements

Relational Agents (Bickmore, 2003)

- Laura: a relational agent that assists a user through a month-long health behavior-change program
 - 91 subjects
 - RELATIONAL vs NON-RELATIONAL condition (and CONTROL)
 - All give same information
 - CONTROL (no conversation with agent)
 - NON-RELATIONAL – agent w/out Relational behaviors
 - RELATIONAL – agent w/Relational behaviors
- 30 day intervention period, work daily with FitTrack on home PC, goal=walk 30 mins/day
- Followed by 2.5 week non-intervention
- End with follow-up interview



RELATIONAL condition

Results

- RELATIONAL condition subject report
 - Use of relational behaviors did **increase** quality of human-agent relationship on a number of measures
 - Bond
 - Liking
 - Desire to continue working with agent
- All groups showed gains in exercise self-efficacy during intervention, more with RELATIONAL
- But not in long-term adoption after intervention

"I feel Laura cares about me..." (p<.001)

"I feel Laura appreciates me." (p=.009)

(T. Bickmore, PhD 2003)

Emotional Design

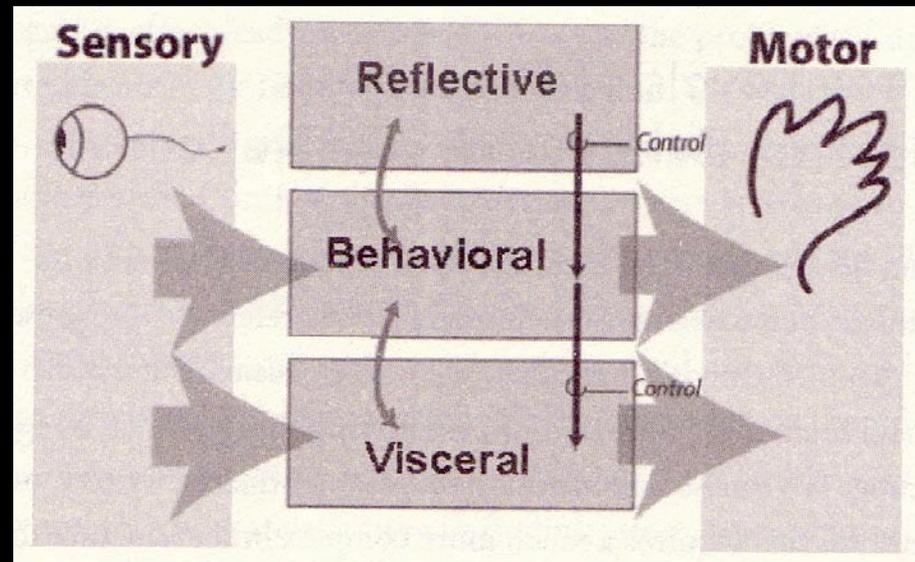
“Attractive Things Work Better”

- Understanding of emotion and affect and its interaction with cognition have implications for design
- Attractive things work better!
 - Positive affect enhances creative, breadth-first thinking
 - Negative affect focuses cognition, enhancing depth-first thinking and focusing attention
- Design should reduce stress, foster positive affect.
 - More tolerant of minor difficulties
 - More flexible and creative thinking

Norman (2004)

Three Levels of Emotional Design

- Visceral Design: appearance, appeal to senses
- Behavioral Design: the pleasure and effectiveness of use
 - performance, function, understandability, usability, physical feel
- Reflective Design: self-image, personal satisfaction, memories



Teapot Example

Steep: leaves
covered by water

Getting there: tilt so
leaves are partially
covered by water

Perfect! Stand
vertical taking leaves
out of water to avoid
bitterness

- Ronnefeldt “tilting” teapot
- Deep considerations of stages of brewing manifest in design

Emotional Design & Robots

- Cyberflora (Lieberman, Knight, McAnulty, Brasher, Breazeal)
- National Design Triennial @ Cooper-Hewitt National Design Museum, 2003

Persuasive Technologies & Captology

Emotional Design & Robots

- Cyberflora (Lieberman, Knight, McAnulty, Brasher, Breazeal)
- National Design Triennial @ Cooper-Hewitt National Design Museum, 2003

Design and Seduction

- Seduction: having alluring or tempting qualities
- Designers that design seduction
 - Video games
 - Fashion
 - Automotive
 - Industrial designers
 - Advertising
- What lessons can be extracted from these disciplines to technology design?

The Promise

- A promise, and a connection with user's goals and emotions
- Go beyond the obvious or efficient to spark curiosity, surprise, imagination
- Promise to be more than what is expected of them
- Espouse values or allude to connections with what user wants to be or to have

The Process: Enticement

- Enticement
 - Get their attention
 - Make a promise to hold attention
- Cornerstone of branding

The Process: Relationship

- Relationship (long)
 - Make progress with small fulfillments and more promises. Reward their attention
- Give reason to invest with more emotion
- Quality of interaction is critical. Function & Feel
- Reflect user's values, desired attributes, or performance
- Growth of user: emotionally, or intellectually

The Process: Fulfillment

- Fulfillment
 - Fulfill the final promises, and end the experience in a memorable (worthwhile) way.
 - Sets up expectations for next seduction

Achieving Extraordinary Quality

- Designers took the time to provide extraordinary quality
- Not just enhance quality of interactivity, but value in person's life
- Get to know your audience
- Search for “aspirational” possibilities, opportunities to build meaning and emotional connections
- Correlate possibilities with those you find in your audience. These are design priorities
- Immerse yourself in examples of seductive design
- Be a visionary designer who sees the larger issues and expects more meaningful experiences
- Make quality and amazing characteristics a priority

Homework Exercise

- Come up with a concept for a new relational artifact and do the same analysis for why it is a seductive design
- Post on wiki
- Post reading critiques