Virtual Humans as ~~Life-long Learning~~ ~~Companions~~

Jonathan Gratch
Associate Director for Virtual Human Research

In collaboration with

Ed Hovy

Patrick Kenny

Stacy Marsella

Louis-Philippe Morency

Shri Narayanan

Ram Navatia

David Traum

USC

ICT

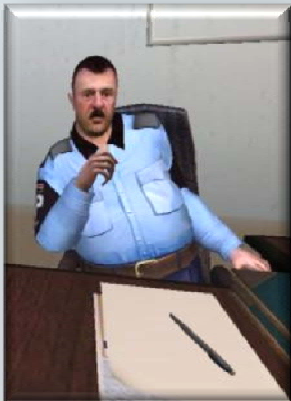INSTITUTE FOR CREATIVE TECHNOLOGIES

Overview

- **Three lines of research relevant to learning**

  – Virtual humans
     - Why they are cool
     - How to build them

  – Virtual Rapport
     - Creating immediacy behaviors between humans and virtual humans
     - Measuring their social effect

  – Modeling emotion and motivation
     - "Cognitive model" of emotion
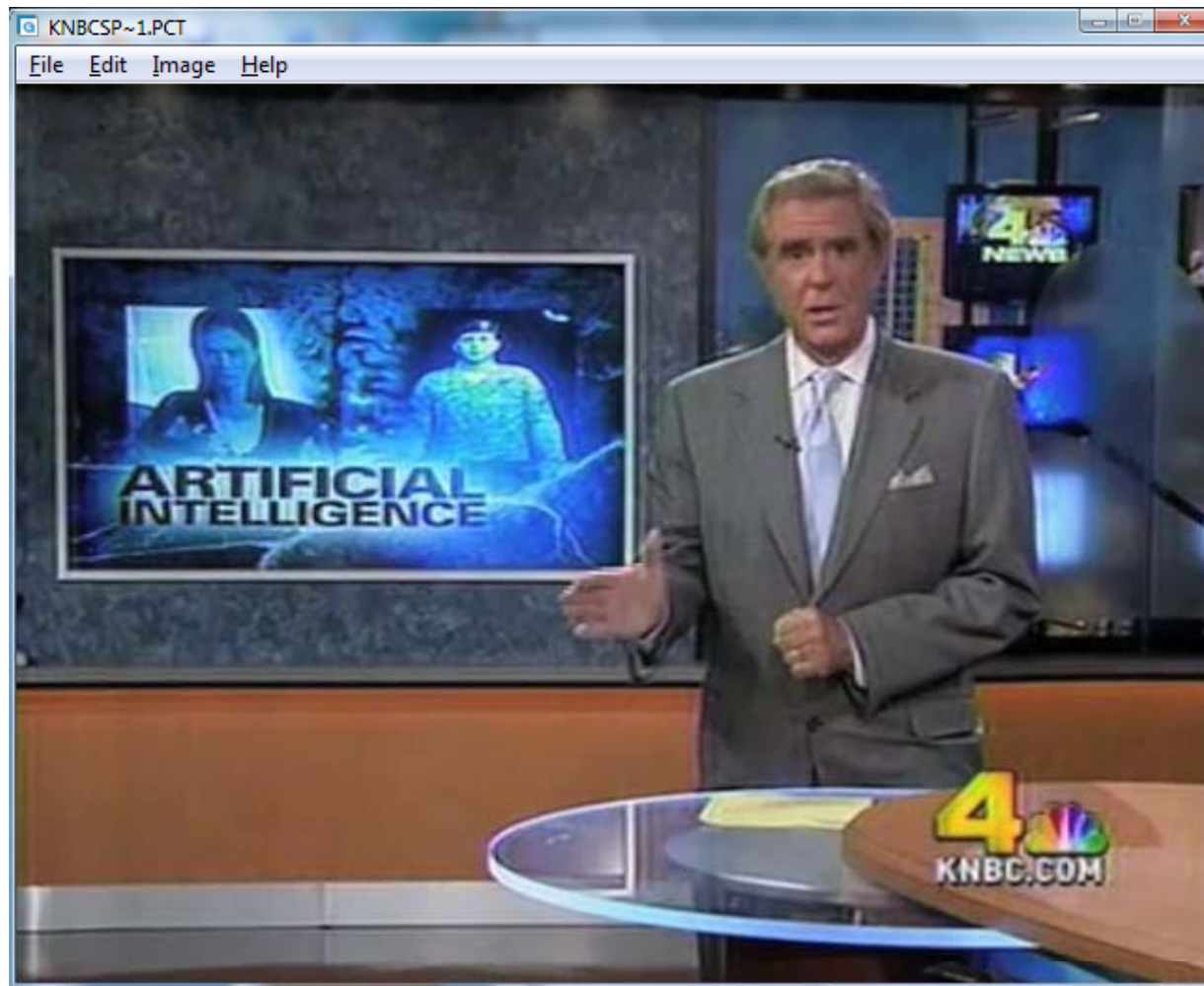   - Empirical work on relationship between emotion and task performance

Virtual Humans

Autonomous virtual characters that can have meaningful interactions with human users
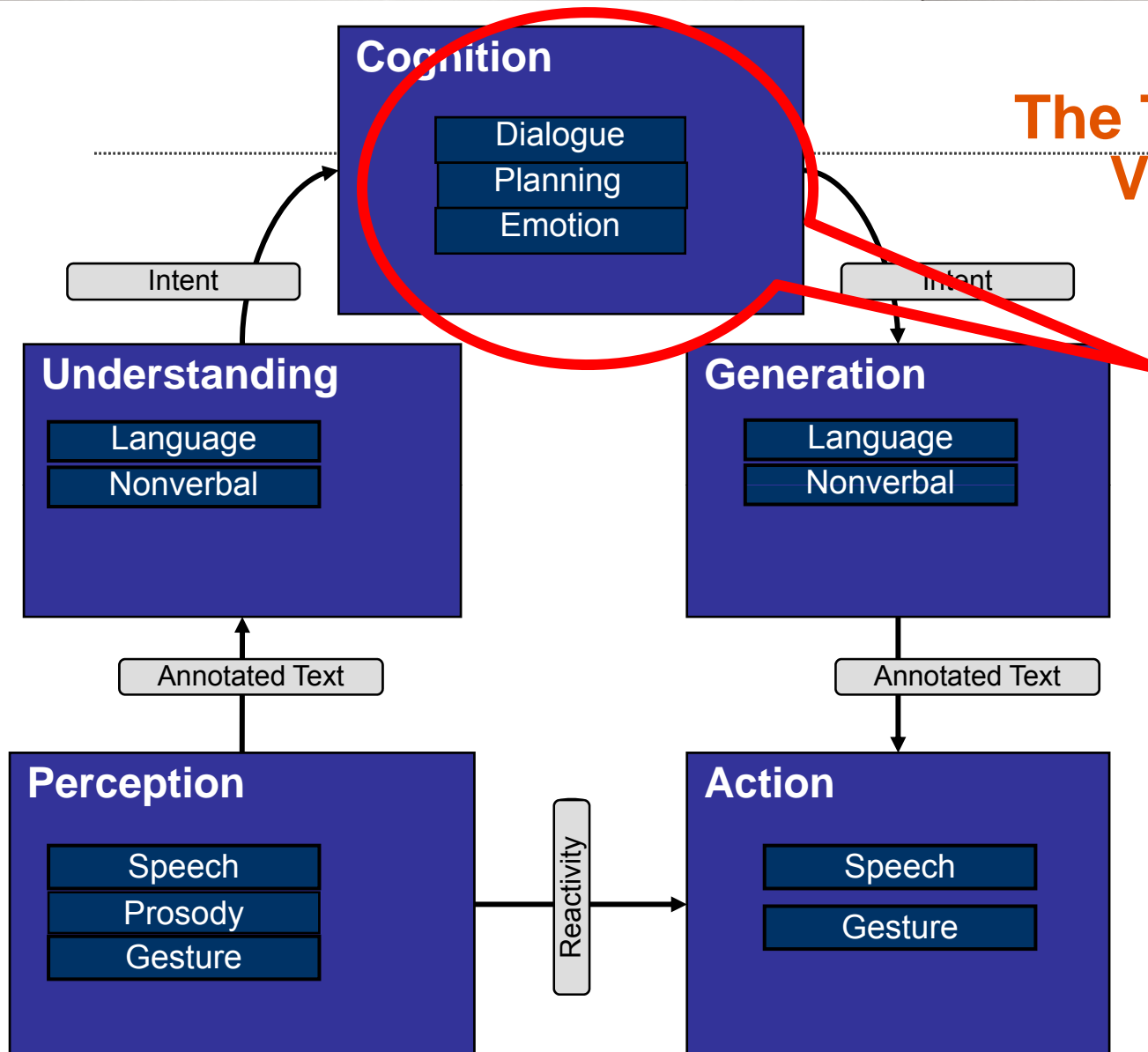
- **Reason about environment**
- **Understand and express emotion**
- **Communicate through speech & gesture**
- **Play the role of teachers, peers, adversaries**

USC

ICT
INSTITUTE FOR CREATIVE TECHNOLOGIES

Virtual Humans

The Technology of Virtual Humans

Cognition
- Dialogue
- Planning
- Emotion

Intent

Understanding
- Language
- Nonverbal

Generation
- Language
- Nonverbal

Intent

Descendent of Rickel's STEVE

Annotated Text

Annotated Text

Perception
- Speech
- Prosody
- Gesture

Reactivity

Action
- Speech
- Gesture

USC

ICT
INSTITUTE FOR CREATIVE TECHNOLOGIES

But why?

Why use a computer as surrogate for human interaction?

People respond to virtual humans as if they were real

- **Social "Facilitation" - being watched by VHuman can impact performance**
  - Helps if task is easy and agents provide positive feedback
  - Hurts if task is hard or agents provide negative feedback

Slater et al, 1999; Pertaub et al., 2001; Hoyt et al, 2003

But why?

Why use a computer as surrogate for human interaction?

People respond to virtual humans as if they were real

- **Social "Facilitation" - being watched by VHuman can impact performance**
  - Helps if task is easy and agents provide positive feedback
  - Hurts if task is hard or agents provide negative feedback

    Slater et al, 1999; Pertaub et al., 2001; Hoyt et al, 2003

- **Disclosure - People less truthful when talking to virtual human**
  - **Less likely to disclose stigmatized information (HIV positive) than if web form**

- **Trust - increases when system uses anthropomorphic interface**
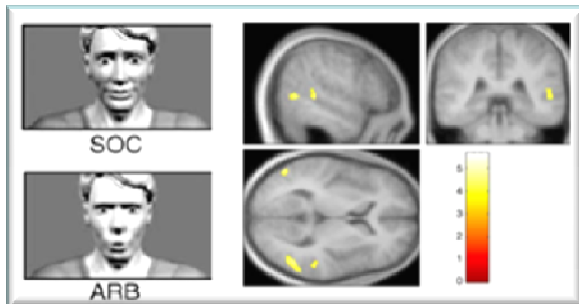
    Sproull et al. 1996; Walker, et al. 1994; Rickenberg & Reeves, 2000

- **Persuasion – more persuaded by virtual human**
  - especially if character matches user's appearance of behavior

- **Stereotype bias – Whites more threatened by black agents**
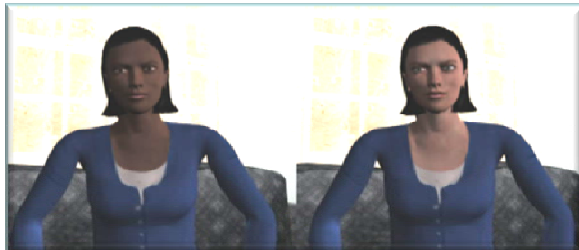
    Blascovich et al

Motivation: Enabler for basic research on human mind

**Virtual Humans are a unique tool for behavioral science research**

Evoke similar responses

▪ Assess neural correlates of being personally involved in social interaction as opposed to being a passive observer (Schilbach et al. 2006)

Precise Control of Stimuli

▪ Facial expression dynamics impact willingness to cooperate in ultimatum game (Krumhuber et al. 2007)

▪ Stereotype bias (Kenny & Parsons; Baylor; Lok)
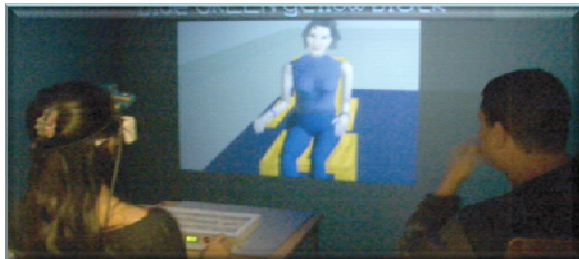
Ethical Considerations

▪ Virtual Milgram obedience study. Participants had behavioral and physiological response levels as if it were real (Slater et al. 2008)

▪ Moral disengagement

USC

ICT
INSTITUTE FOR CREATIVE TECHNOLOGIES

But why?

Why use a computer as surrogate for human interaction?

Virtual Humans have unique advantages

- **Standardization**
  - e.g., in education, every student has same experience

- **Abnormal findings**
  - virtual humans can display behaviors that are impossible for human roleplayers: e.g., physical symptoms of brain damage

- **Augmented reality**
  - virtual humans can create situations impossible in real world
    e.g. everyone in audience thinks speaker is looking at them

Lok et al.

Blascovich et al.

Virtual Human behavioral science research

ICT Virtual human technology supporting basic science

- **Culture Research**
  - With U. Chicago and MITRE (NSF Funded): explore interactional differences
  - With UTEP: explore dialogue differences
  - Socio-cultural modeling MURI with CMU

- **Media Equation**
  - With U. Duisburg (Nicole Kraemer): investigating why people respond socially to virtual humans

- **Negotiation Research**
  - With USC Business School: role of facial expressions on competitive/cooperative orientation

- **Emotion Research**
  - With University of Geneva: role of appraisal in facial expressions
  - With U. Greifswald: models as tool for cognitive science experimentation

- **Methodological Tools**
  - With ICB/WorldViz: incorporating virtual human technology into social science testbed used by dozens of social psychologists

THE UNIVERSITY OF CHICAGO

UNIVERSITÄT DUISBURG ESSEN

Ernst Moritz Arndt Universität Greifswald

UNIVERSITÉ DE GENÈVE
CENTRE UNIVERSITAIRE D'INFORMATIQUE

MITRE

ICB

WORLD VIZ

usc Marshall

UTEP

USC

ICT
INSTITUTE FOR CREATIVE TECHNOLOGIES

Motivation: Enabler for applications
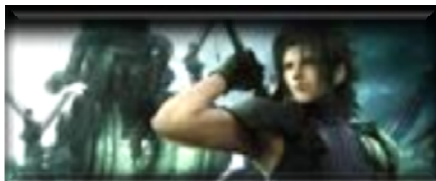

Training and Tutoring

Diagnosis and Assessment

Health Interventions

Informal Science Education

Business and Marketing

Virtual Human Toolkit

Collection of tools &software standards to facilitate transition of Virtual Human research to military and academic partnerships
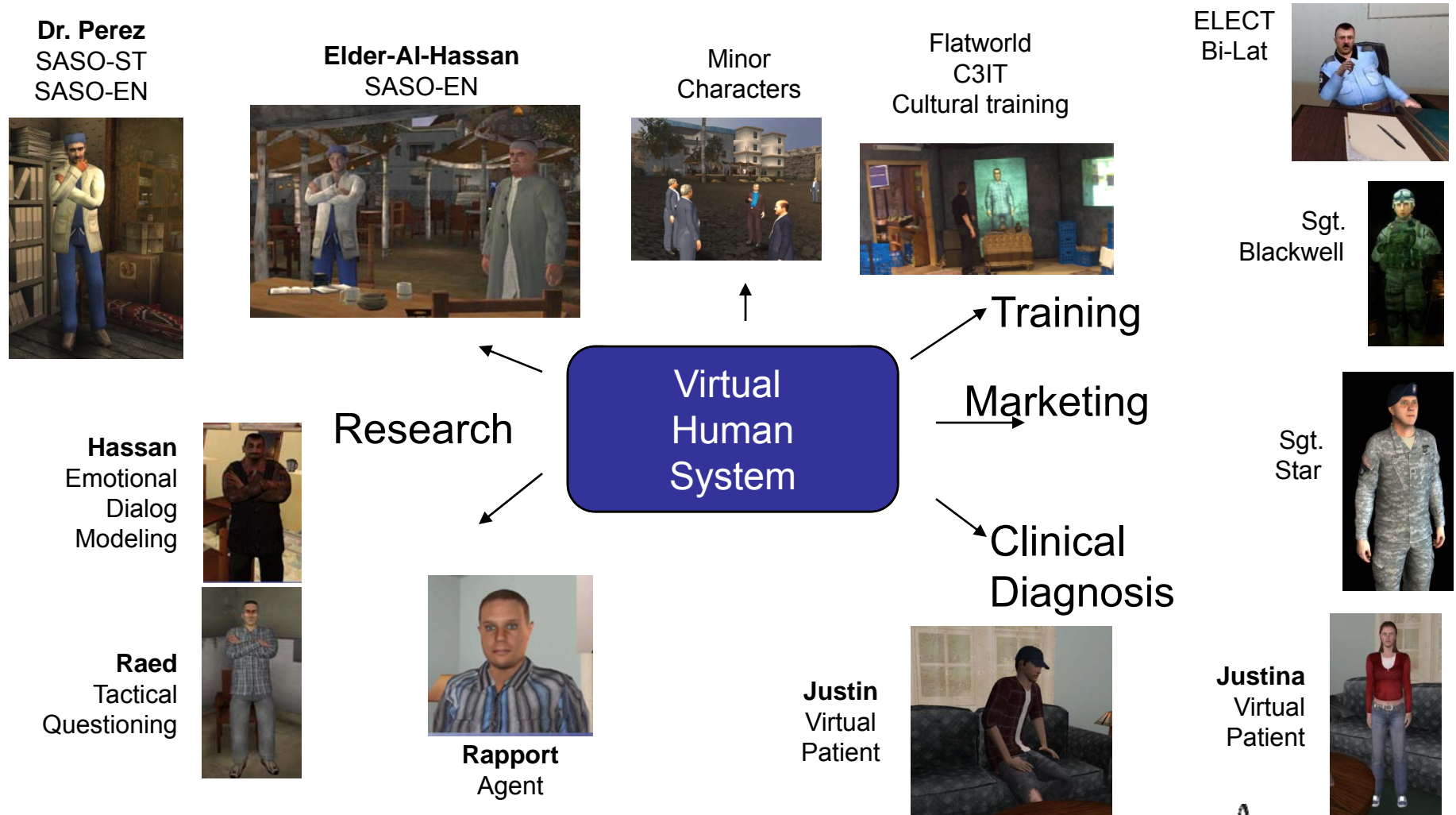
- **Impact: Facilitate transition of virtual human technology**
  - Increased use inside ICT: Sgt Star2, Virtual Patients (x3), Gunslinger, TOPS-VW…
  - Increased use outside ICT: ICB, U Chicago, Northwestern, Reykjavik University…

- **1ˢᵗ ICT Tutorial Workshop**

  26 attendees
  - Military: RDECOM (STTC), TRADOC, JFCOM, ICB
  - Academic: CMU, Stanford, Georgia Tech, ….

  Very positive feedback

  "I felt that the blend of informational talks and hands-on tutorials was perfect"

http://projects.ict.usc.edu/vhtoolkit/

ICT Virtual Human Projects- Research and Apps

Dr. Perez
SASO-ST
SASO-EN

Elder-Al-Hassan
SASO-EN

Minor
Characters

Flatworld
C3IT
Cultural training

ELECT
Bi-Lat

Sgt.
Blackwell

Hassan
Emotional
Dialog
Modeling

Research

Virtual
Human
System

Training

Marketing

Sgt.
Star

Raed
Tactical
Questioning

Clinical
Diagnosis

Rapport
Agent

Justin
Virtual
Patient

Justina
Virtual
Patient

RAPPORT

- **Review Rapport**
  - What is it?
  - Why you should want it?
  - How can agents establish it (in a limited sense)

  - In collaboration with Ning Wang, Sin-Hwa Kang, Louis-Philippe Morency

Face-to-face conversations often exhibit tight coupling between participants (e.g. contingent feedback)

Video

Video

*complements Novak and Ward

Video

*complements Jacqueline Nadel

Rapport is… (immediacy behaviors)

- Tickel-Degnen and Rosenthal (1990)
  - Positive emotions (e.g. smiles or head nods)
  - Mutual attentiveness (e.g. mutual gaze)
  - Coordination (e.g. synchronized movements)

*see also **social resonance** (Welji & Duncan), **interpersonal sensitivity** (Hall & Bernieri 2001), **social glue** (Lakin, et al. 2003), **interactional synchrony** (Bernieri & Rosenthal, 1991), **mutuality** (Burgoon), **empathy** (Sonnby-Borgstrom et al., 2003), and **distributed cognition** (Parkinson)

- Correlates with socially desirable outcomes:
  - Liking, trust (Chartrand 1999, Lakin 2003)
  - Engagement, willingness to communicate (Tatar 1997; Smith 2000)
  - Conversational fluency (Kraut, Lewis et al. 1982; Bavelas, et al. 2000)
  - Success in negotiations (Drolet & Morris, 2000)
  - Improved test performance in classrooms (Fuchs, 1987)
  - Improved quality of child care (Burns, 1984)

Virtual Rapport

Can a virtual agent establish rapport with a human?

and obtain these beneficial social effects

- Social psychological foundations
  - Rapport can be experimentally induced or disrupted by altering the presence of contingent nonverbal feedback (Bavelas, Coates, & Johnson, 2000)
  - People respond socially to virtual characters (Kramer et al 03; Nass&Reeves96)

- Technological feasibility

  Systems can respond in real-time to human nonverbal behavior
  - MACK (Cassell) responded to user gaze
  - Kismit (Breazeal) and Neurbaby (Tosa) analyze speech intonation
  - Bickmore and Cassell's REA detects pauses/disfluency

- Empirical support
  - User studies with Rapport Agent (Gratch et al06; Gratch et al 07)

Rapport Agent

- Designed for "face-to-face monologs"
  - human speaker tells a story to a silent but attentive listener
  - "Attends" through positive contingent nonverbal feedback

- Focus on short-term rapport , not long-term relationships
  (c.f. Cassell&Tepper07)

Video

- Builds on prior systems:

Laura (Bickmore07)
Grandchair (Smith00)
Gandalf (Thórisson96)
Kismit (Breazeal&Aryananda02)
Neurobaby (Tosa93)
(Ward & Tsukahara 2000)

Rapport Agent Architecture

Speaker

Stereo Camera — stereo images → Watson [1] — head postures & body moves →

Micro-phone — audio signal → Laun [2] — voice features →

Response
Uses mapping rules to generate listening behaviors in response to extracted features

Nod, Shake
Look left, Look right
Look up, Look down
Posture shift left
Posture shift right
Silence
Normal speech
Loud speech
Backchannel opportunity point
Rising intonation

Silence	→ gaze up/straight
Raised loudness	→ head nod
Backchannel	→ head nod
Speaker shifts posture	→ mimic
……	

[1] Morency, L.-P., Sidner, C., Lee, C., & Darrell, T. (2005). Contextual Recognition of Head Gestures. The 7th International Conference on Multimodal Interactions, Toronto, Italy.

[2] Lamothe, F. and M. Morales (2006). Response Behavior. Marina del Rey, CA, University of Southern California: Technical Report ICT TR 01.2006.

[3] Kopp, S., Krenn, B., Marsella, S., Marshall, A., Pelachaud, C., Pirker, H., et al. (2006). Towards a common framework for multimodal generation in ECAs: The behavior markup language. The Intelligent Virtual Agents, Marina del Rey, CA..

[4] Kallmann, M., & Marsella, S. (2005). Hierarchical Motion Controllers for Real-Time Autonomous Virtual Humans. The 5th International Working Conference on Intelligent Vir-tual Agents, Kos, Greece.

Prior Empirical Findings I (Gratch et al IVA06)

- Questions: Does agent promote rapport
  - Engagement: does it induce longer storytelling?
  - Speech fluency: does it promote fluent speech?
  - Subjective rapport: self-report
- 2-condition Design:
  - Subjects described cartoon (Tweety & Sylvester) to avatar they believed represented a person
  - Rapport Condition: contingent positive feedback
  - Unresponsive Condition: non-contingent, non-positive feedback
- Results:
  - Rapport Agent produced greater engagement
  - Rapport Agent produced more fluent speech
  - No significant difference on subjective rapport

  Disfluency
  Example

- But does Rapport Agent help or Unresponsive agent really hurt?

Prior Empirical Findings II (Gratch et al HCI07)

- Questions: Does rapport agent help compared with face-to-face?

- 3-condition Design:
  - Extended results with comparison to human face-to-face (strangers)
  - Also Tweety and Sylvester

- Results:
  - Rapport agent showed **greater engagement** than face-to-face
  - However, rapport agent showed less speech fluency than face-to-face

- But agent gives more feedback (nodding) than face-to-face (strangers)
  - Maybe quantity matters?
  - Maybe appearance matters
    - people liked talking to agents more than strangers??

Open Questions: What are critical factors

- Contingency vs. Frequency
  - We confounded frequency and contingency
    - e.g., Rapport Agent nods more than Unresponsive or Face-to-face
  - Maybe random nods would work as well

- Replicate and extend findings:
  Rapport Agent more engaging than face-to-face (for Tweety & Sylvester)
  - Would results generalize to more emotionally evocative stories
  - Some findings suggest speakers require emotional feedback
    - E.g., surprise, wincing, smiles (Bavelas: specific vs. generic feedback)

- Auxiliary Questions
  - Live vs. Virtual? Impact of avatar vs. human appearance
  - Human vs. Agent-generated feedback?
  - Dispositional influences? Impact of personality, shyness
    - Could agents benefit shy, autistic people?

Experiment Setup

Contingent agent condition

Rapport Agent

Confederate

Agent Avatar

Face-to-face condition

Microphone

Listener

Cameras

Speaker

Non-contingent agent condition

Confederate

Previous subject's feedback

Mediated condition

Listener

Speaker Video

Listener Avatar

Speaker
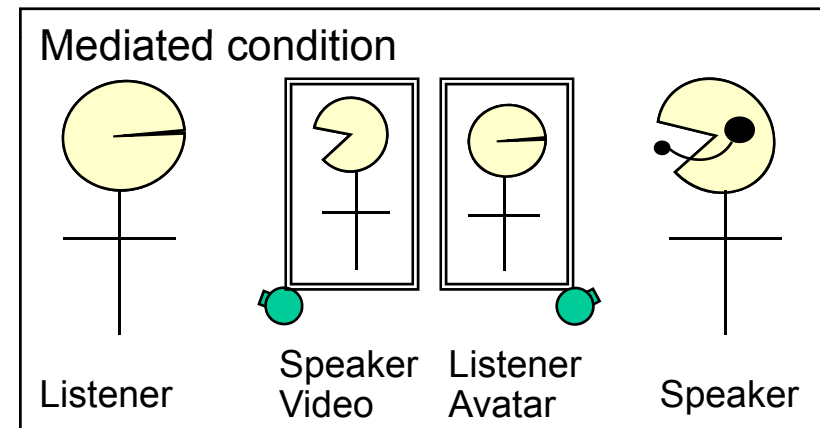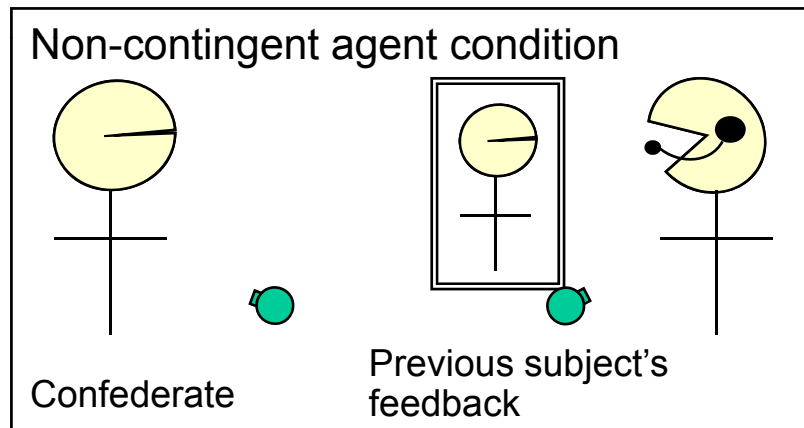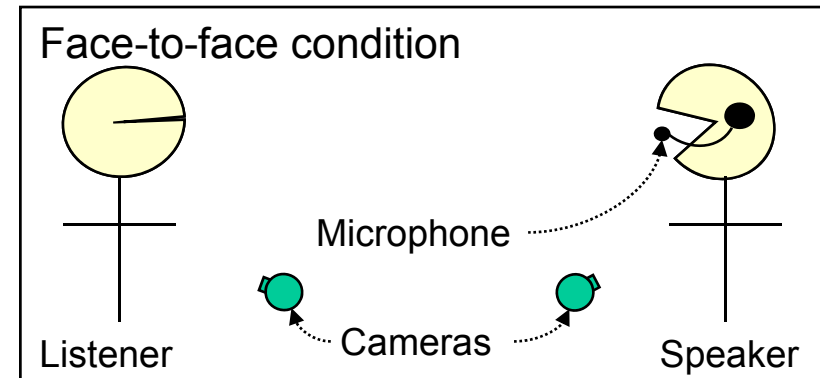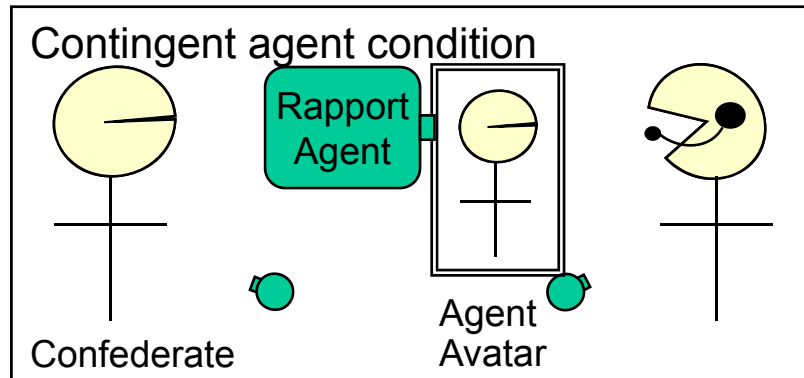
- 128 subjects, 4 conditions
- Approx 20 sessions per condition
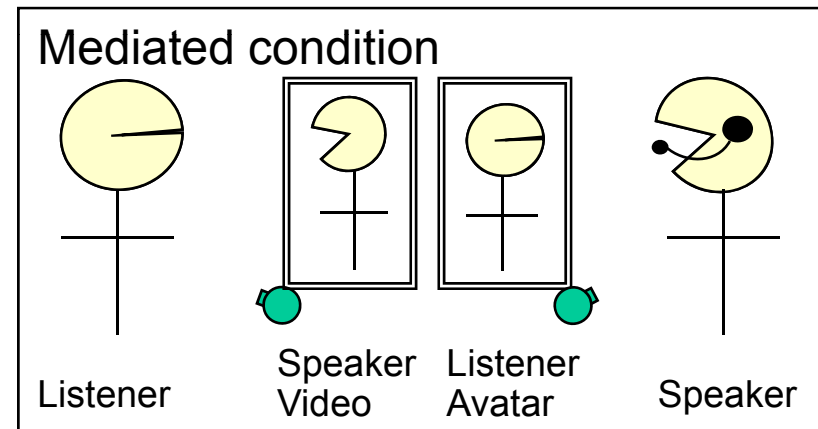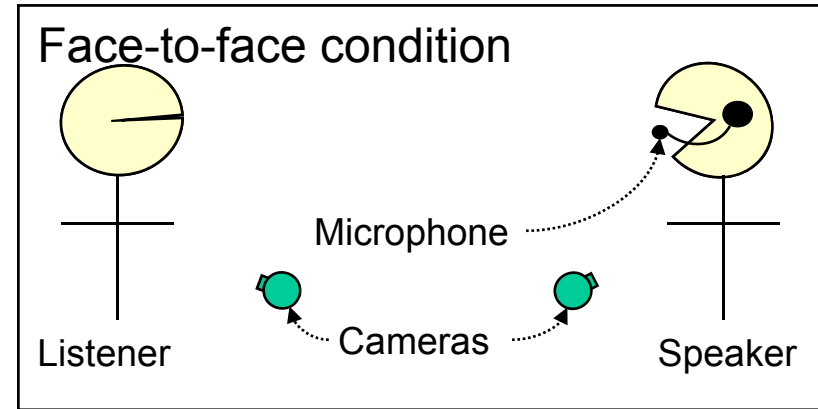- Subjects recruited over internet from Los Angeles area

Experiment Setup

Contingent agent condition
Rapport Agent
Agent Avatar
Confederate

Non-contingent agent condition
Confederate
Previous subject's feedback
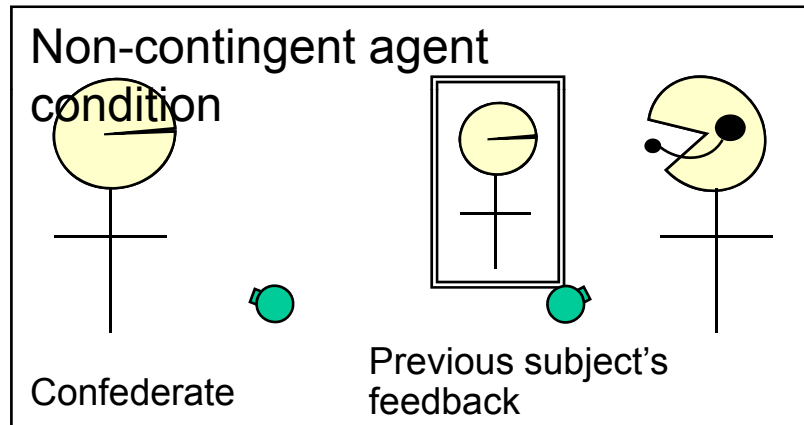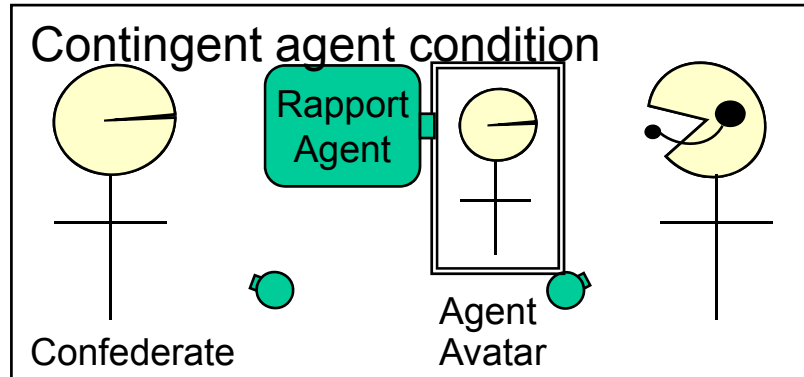
Control for contingency

- Used Yoked design (Bailenson and Yee)

- One subject sees rapport agent
  - Record the feedback
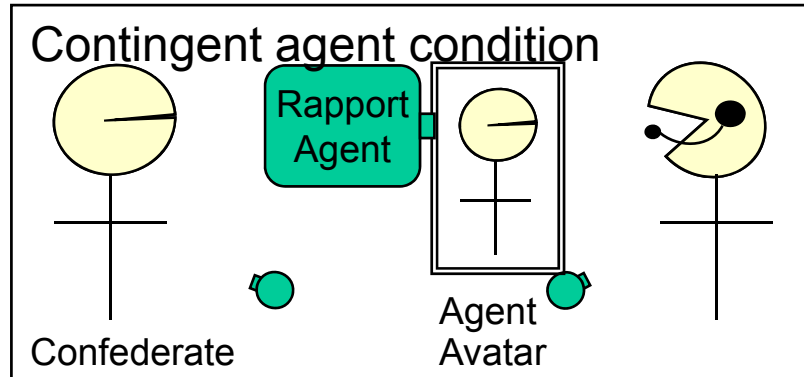- Replay feedback to next subject

Experiment Setup

Face-to-face condition

Microphone

Listener   Cameras   Speaker

Mediated condition

Listener   Speaker Video   Listener Avatar   Speaker

Live vs. Real: Control for feedback "quality"

- Face-to-face condition
- "Mediated condition"
  - Display real listener feedback on an avatar (same motion quality)

Experiment Setup

Contingent agent condition
Rapport Agent
Confederate
Agent Avatar

Face-to-face condition
Microphone
Cameras
Listener
Speaker

Mediated condition
Listener
Speaker Video
Listener Avatar
Speaker
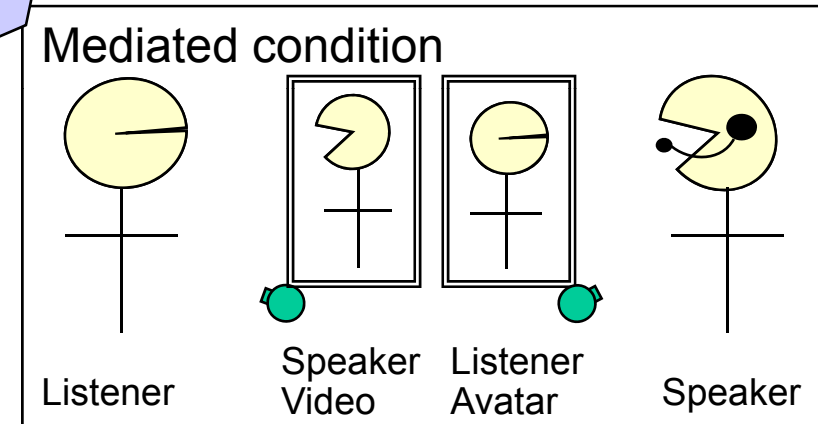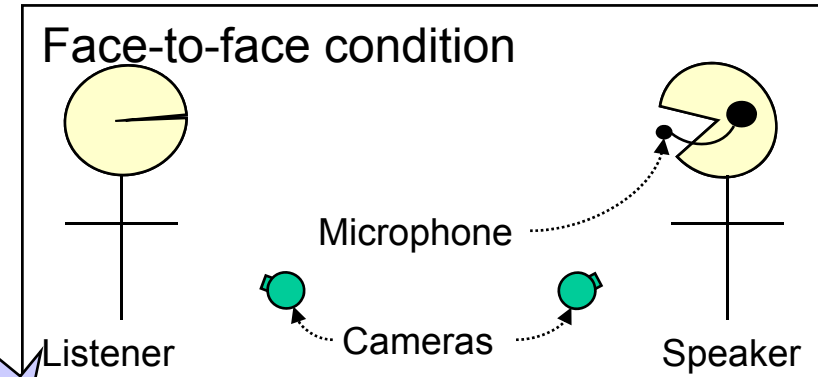
- ■ Real vs. Synthetic motion:
  Control for appearance
  - ▪ Mediated condition has same appearance as contingent but uses feedback motion generated from real listener

Emotionally Evocative Stimulus

- ■ 2 scenes from sexual harassment movie

Courtesy Edge Training Systems

Face-to-face

■ Responsive

■ Non-contingent

USC

Rapport Measurement

■ Design: Watch movie and retell to silent, attentive listener

Engagement →

How long is the interaction?

- Total time to tell the story
- Number of words in the subject's story
- Number of "meaningful" words

Conversational fluency →

How fluid is the speech?

- Number/rate of filled pauses (um's)
- Number/rate prolonged words
- Number/rate incomplete words

Sense of rapport →

Ratings of rapport using questionnaire

- "Did you feel a connection with the other person?"
- "Do you think the other person understood the story?"

■ 128 Subjects
  - Face-to-face: 20 speakers, 20 listeners
  - Mediated: 20 speakers, 20 listeners
  - Responsive agent : 24 speakers
  - Non-contingent agent: 24 speakers

Results: Contingency

- Hypothesis: Contingent nonverbal feedback promotes rapport
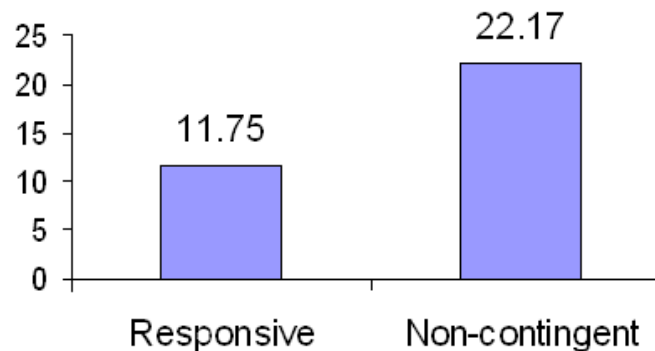- Results: Significant effect for speech fluency

Number of Pause Fillers p=0.01
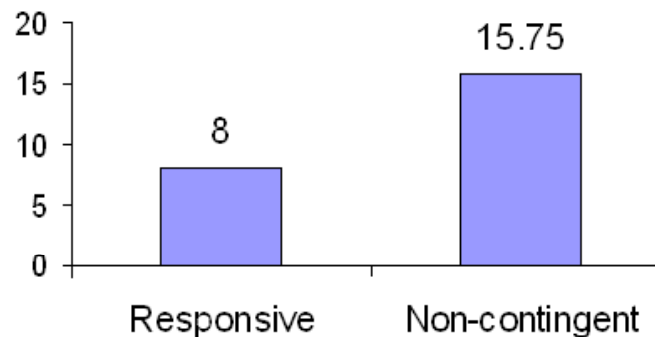
Pause Filler Rate p=0.03
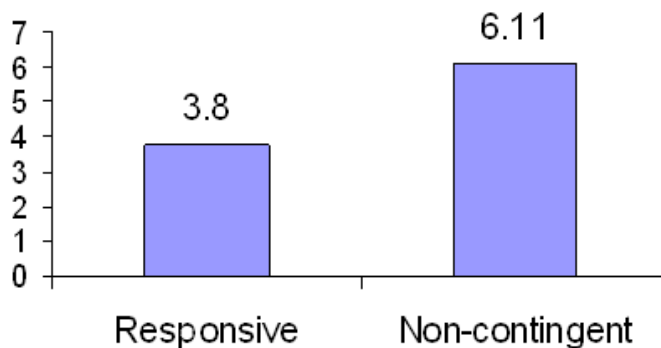
Number of Disfluencies p=0.04

pause filler + incomplete words

Accomplishment: Empirical Findings

- **Timing of Virtual Human feedback crucial**
  - Poor timing produces disfluency, lower rapport (Gratch et al IVA07)

- **Individual differences in how virtual humans impact users**
  - Shy subjects heavily influenced by virtual human nonverbal behavior Extroverts less sensitive (Kang et al AAMAS08)
  - Agreeable subjects like agreeable agents (Kang et al AAMAS08)

- **In progress**
  - Cultural differences in rapport-eliciting signals (w/ McNeil Lab)
    - Iraqi arabic vs. Mexican vs. American
  - Impact of immediacy cues on learning (Ning Wang)
    - Assessing story recall immediately and after 3 days
  - Impact of immediacy cues on self-disclosure (Sin-hwa Kang)

Social Interaction Testbed

Watson (Morency)

Aizula (Ward)

CERT (Bartlett)

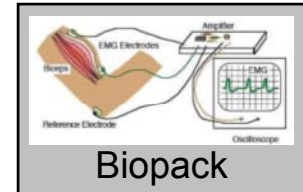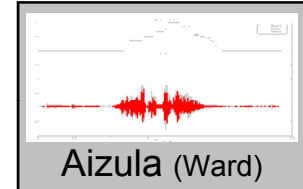Biopack
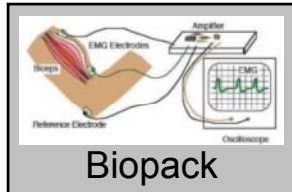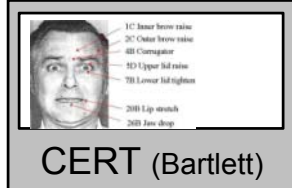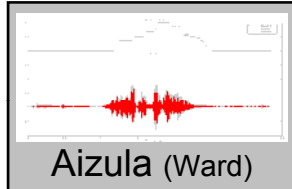
Vary task setting

- Human-to-human, human-to-Vhuman

Synchronized data collection and analysis

- Voice, gesture, face, physiology

Automatic learning of behavior models

- Gesture toolkit (Morency)

Watson (Morency)

Aizula (Ward)

CERT (Bartlett)

Biopack

USC

ICT
INSTITUTE FOR CREATIVE TECHNOLOGIES

Data-driven social behavior models
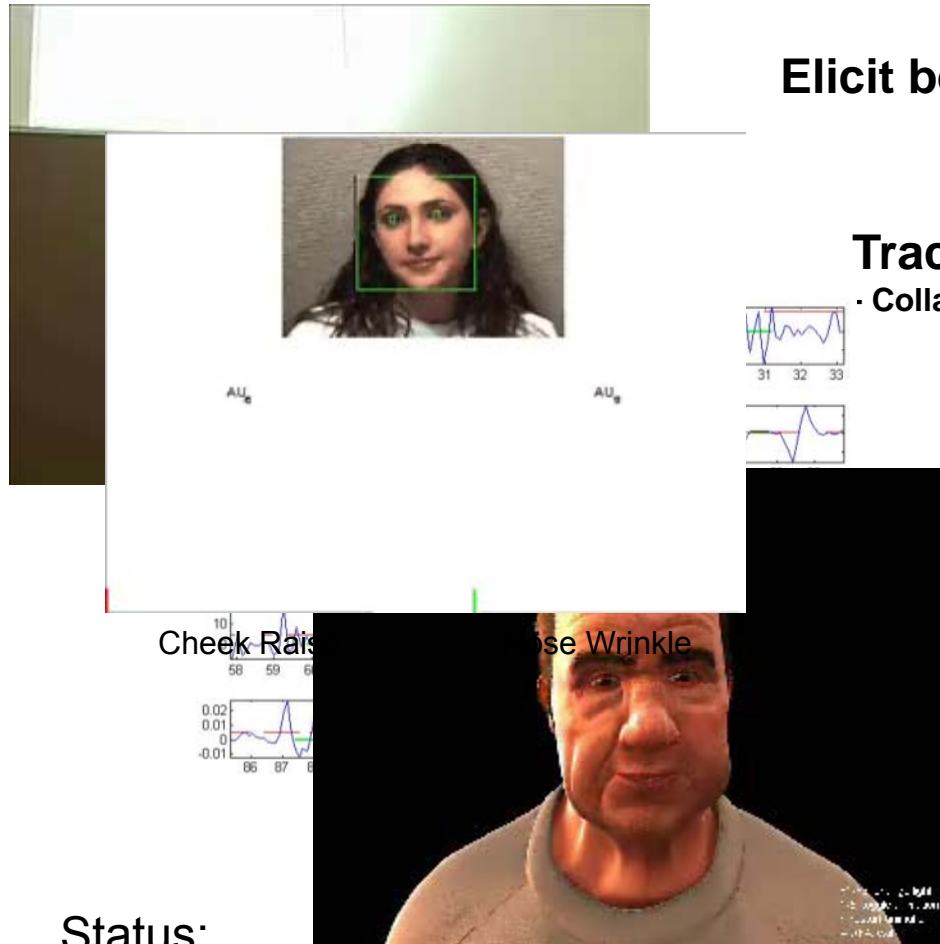
Elicit behavior from user studies

Track using machine vision techniques
· Collaboration with Movellan (UCSD), Morency (MIT/USC)

Cluster and recognize with machine learning techniques
- Using LDCRF (Morency)
- Collaboration with French Military Academy

Synthesize behavior
- Collaboraion with Filmakademie Baden-Wuerttember

Cheek Rais... ...ose Wrinkle

Status:

Good results with learning to produce head nods [Morency, deKok, Gratch IVA08]

FEAR

'Emotional Inflation' Leads To Stock Market Meltdown

Main Category: Psychology / Psychiatry
Also Included In: Mental Health; Anxiety / Stres
Article Date: 29 Apr 2008 - 15:00 PDT

Bailout Failure Intensifies Fear in Stock Market

TOPICS: Banking | Stock Market
SECTORS: Banks
COMPANIES: Washington Mutual, Inc. | Washington Mutual Inc | Lehman Brothers Holdings Inc | Merrill

By Jeff Cox | 29 Sep 2008 | 02:57 PM ET

CFO.com

| Magazines | Europe | Topics A-Z | Blog | Careers | Webcasts |

Capital Markets

You are here: Home : Topics A-Z : Capital Markets : Article

Do Fundamentals or Emotions Drive the Stock
Market?

Email Pri

Fear grips stock market

Local advisers say wise investors can profit

AP

Emotions change human behavior (e.g. Anger)

- **Emotions change thought**

  Limits predictive power of classical models

  - Blame others/outgroups (Keltner et al 93; Mackie et al 00)
  - Quicker to act aggressively (DeSteno et al 2000/2004)
  - Underestimate risk (Lerner & Keltner 2000/2001)

- **Emotions change the body**

  - Prepare aggressive responses (Keltner & Haidt 1999)
  - Characteristic displays (Spoor&Kelly04, Parkinson01, Ekman)

- **Emotions change behavior of others**

  - Anger elicits fear (even subliminal presentation) (Dimberg&Ohman96)
  - Negotiators concede more to angry partner (van Kleef et al. 2007)

- **Impacts learning**

  - Lepper, Bower, …

Emotion

- ## Can we model
  - Emotional antecedents: task/situational factors that elicit emotion
  - Emotional consequences: impact of emotion on beliefs, desires and intentions

- ## Can we use these models in learning setting
  - User-model to inform pedagogical interventions (e.g., Conati)

USC

ICT
INSTITUTE FOR CREATIVE TECHNOLOGIES

Growing interest in modeling emotion processes
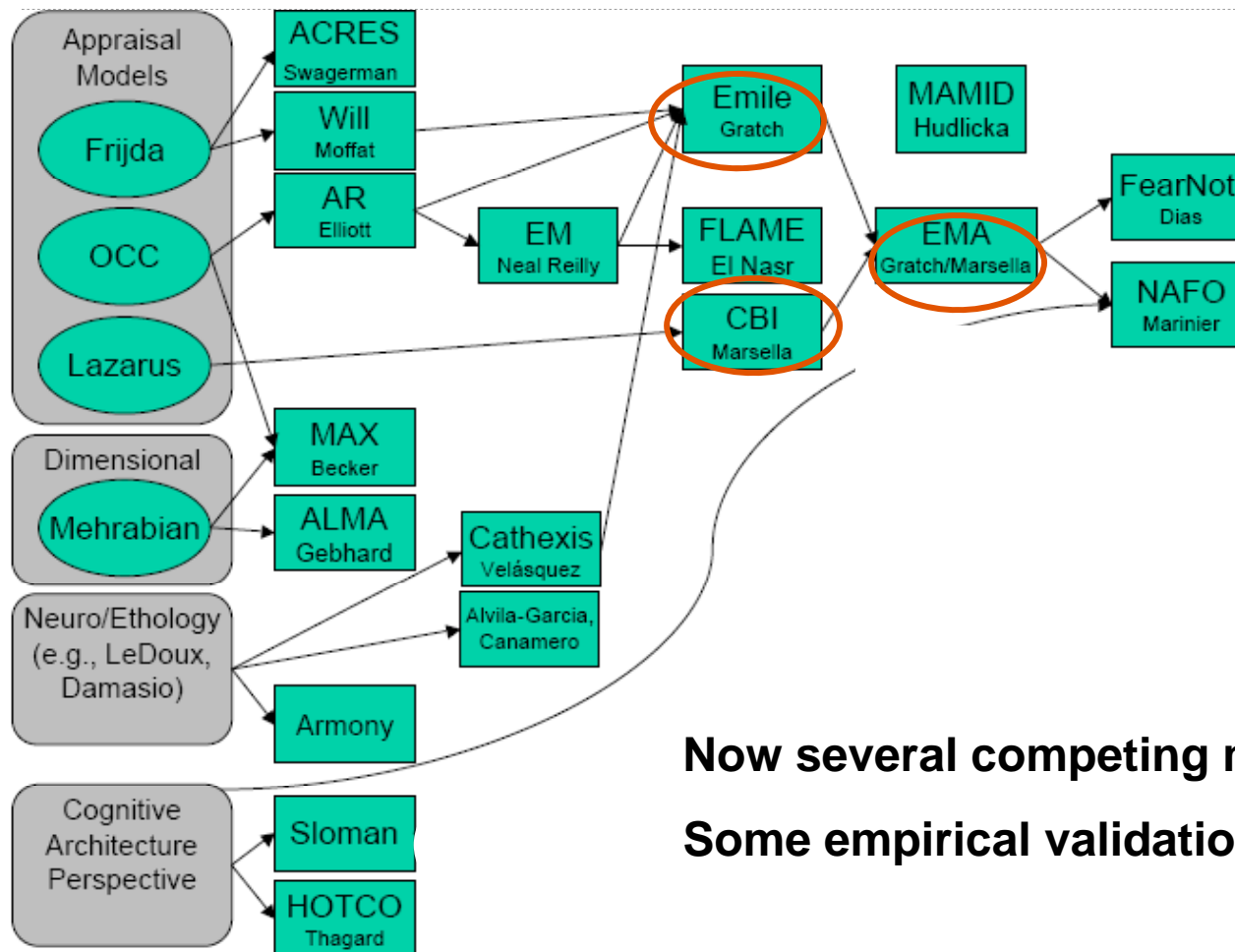
Now several competing models

Some empirical validation
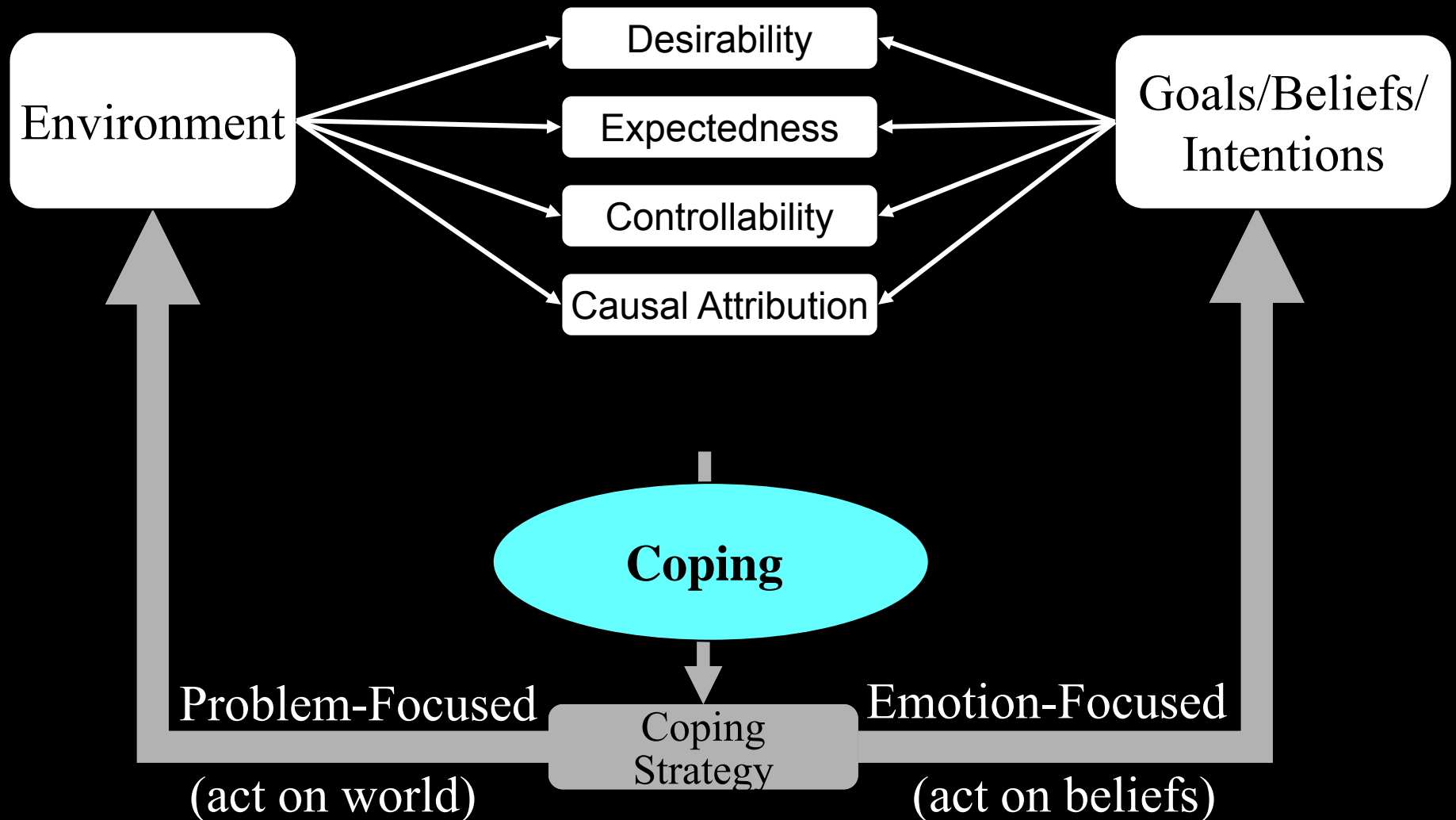
Magda Arnold

Theories of cognitive emotion

- Top down theories
    - Cognition influences emotion

    - Appraisal Theory   (Arnold, Lazarus, Frijda, Scherer, Ortony et al.)
        Emotion arises from an *evolving subjective interpretation* of person's relation to their environment and informs cognitive and physical acts
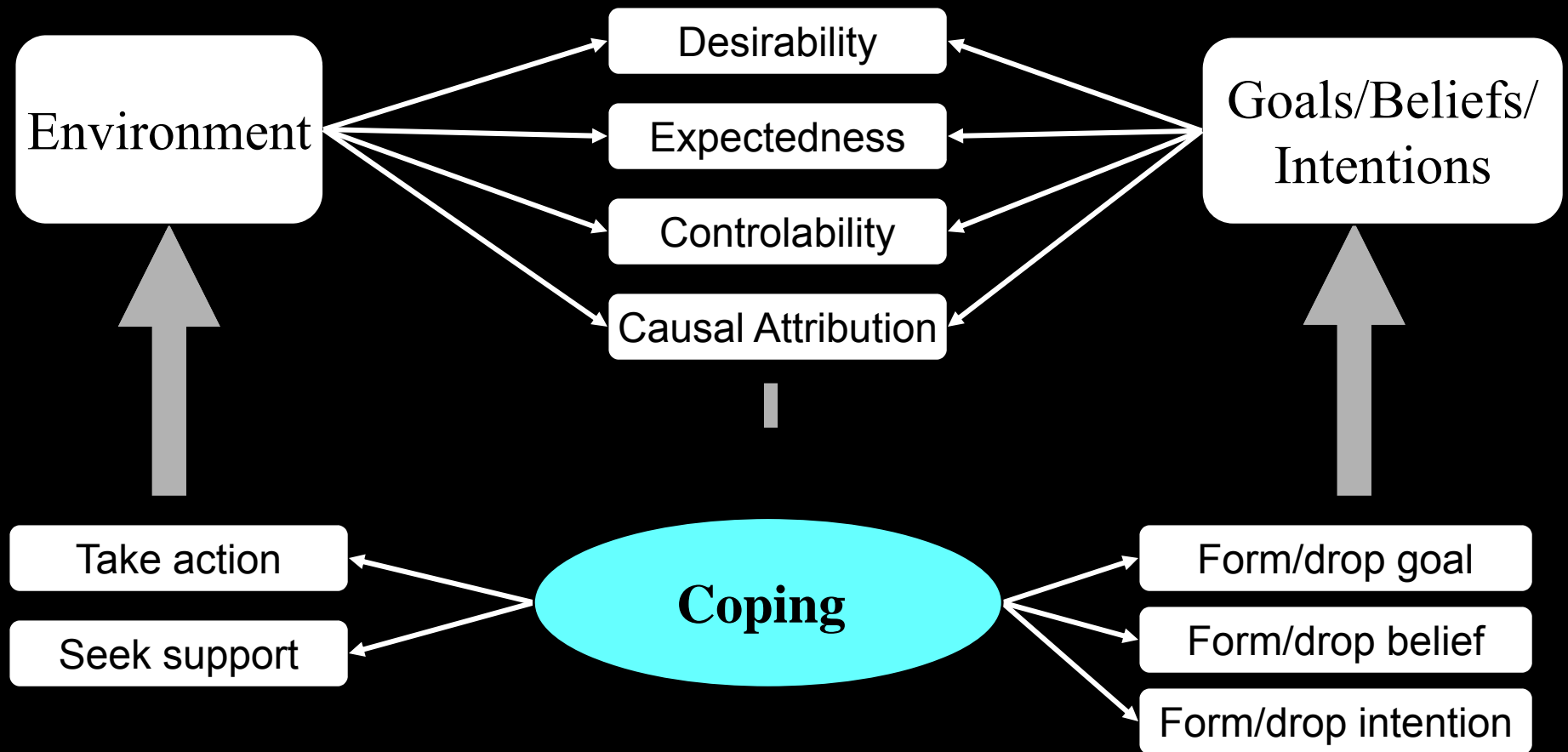
Appraisal Theory

Smith and Lazarus91 cognitive-motivational-emotive system

Environment

Desirability

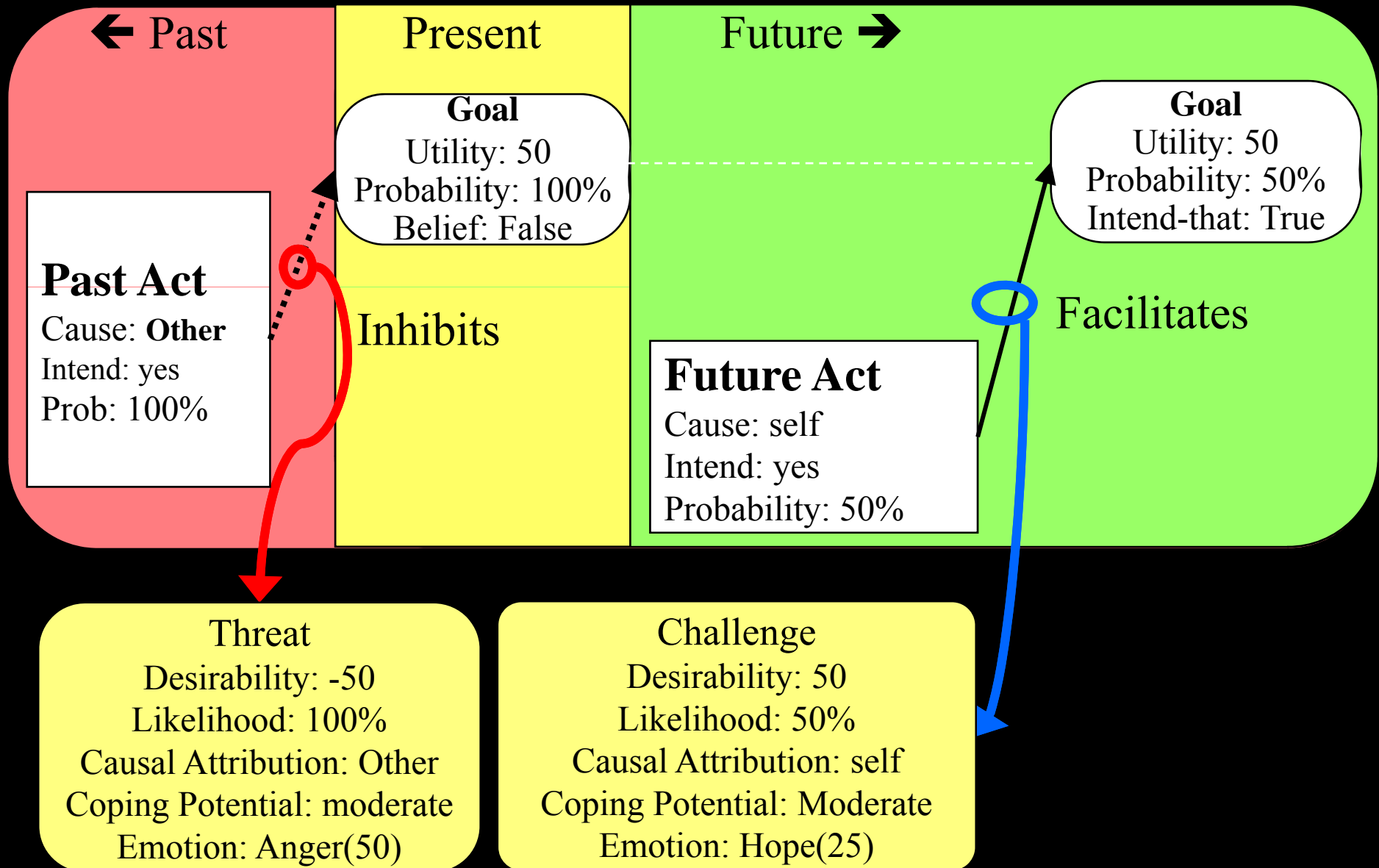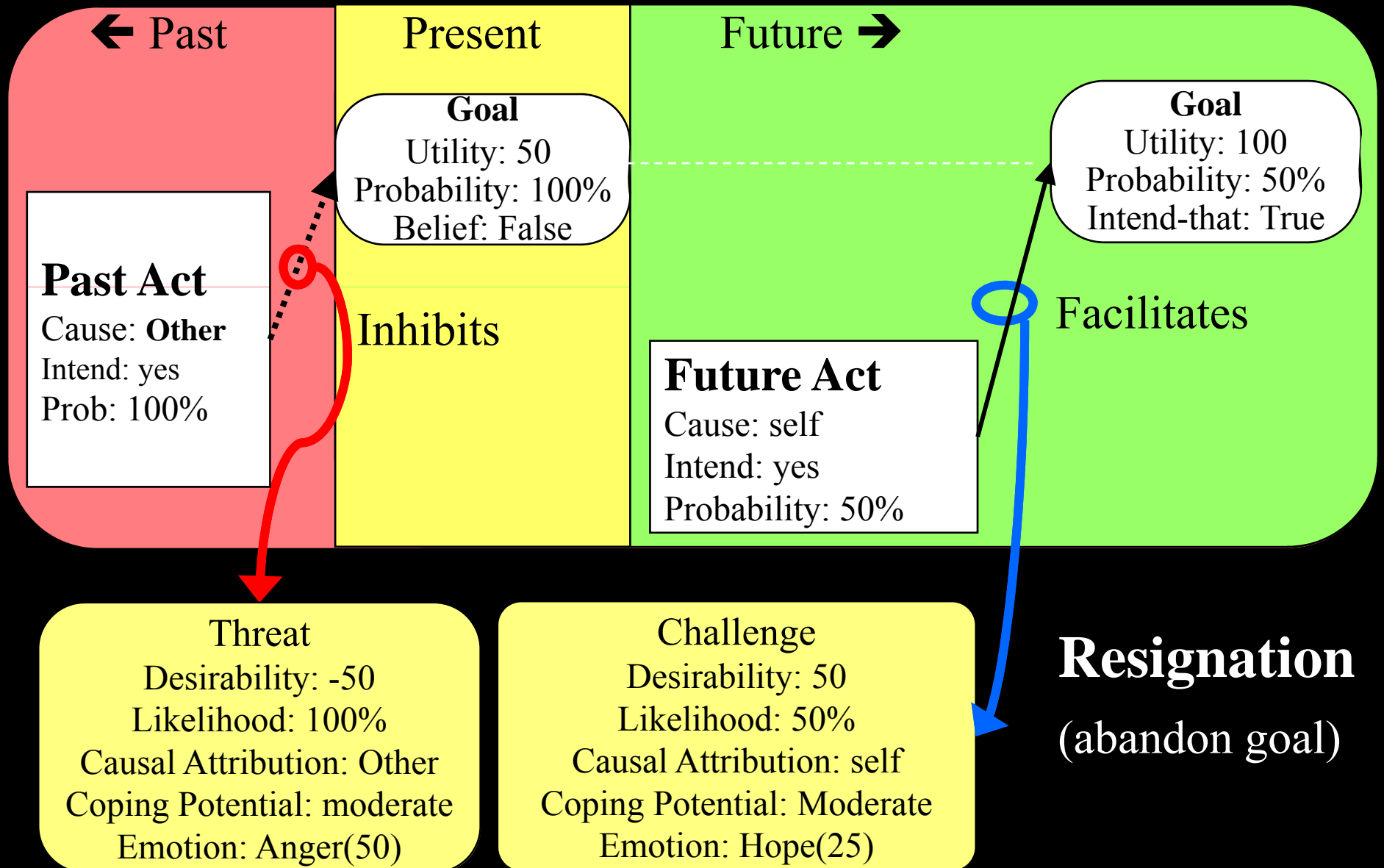Expectedness

Controllability

Causal Attribution

Goals/Beliefs/Intentions

Coping

Coping Strategy

Problem-Focused

(act on world)

Emotion-Focused

(act on beliefs)

Appraisal Theory

Smith and Lazarus91 cognitive-motivational-emotive system

Appraisal

← Past | Present | Future →

Goal
Utility: 50
Probability: 100%
Belief: False

Goal
Utility: 50
Probability: 50%
Intend-that: True

Past Act
Cause: **Other**
Intend: yes
Prob: 100%

Inhibits

Facilitates

Future Act
Cause: self
Intend: yes
Probability: 50%

Threat
Desirability: -50
Likelihood: 100%
Causal Attribution: Other
Coping Potential: moderate
Emotion: Anger(50)

Challenge
Desirability: 50
Likelihood: 50%
Causal Attribution: self
Coping Potential: Moderate
Emotion: Hope(25)

Coping

← Past | Present | **Future →**

Goal
Utility: 50
Probability: 100%
Belief: False

Past Act
Cause: **Other**
Intend: yes
Prob: 100%

Goal
Utility: 100
Probability: 50%
Intend-that: True

Inhibits

Facilitates

Future Act
Cause: self
Intend: yes
Probability: 50%

Resignation
(abandon goal)

Threat
Desirability: -50
Likelihood: 100%
Causal Attribution: Other
Coping Potential: moderate
Emotion: Anger(50)

Challenge
Desirability: 50
Likelihood: 50%
Causal Attribution: self
Coping Potential: Moderate
Emotion: Hope(25)

Model-driven Experimentation

Encode Game in EMA
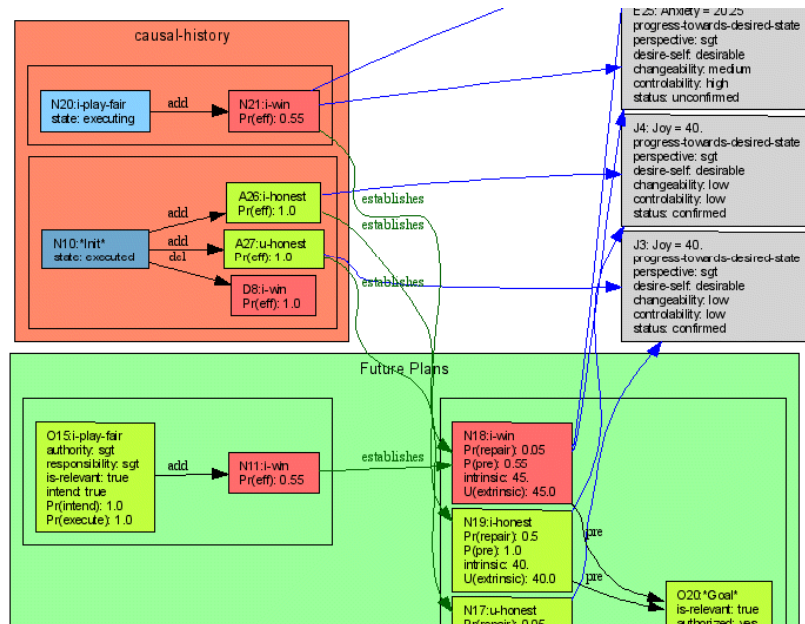
Generate specific predictions
- Antecedents of emotion
- Biases on beliefs, desires and intentions
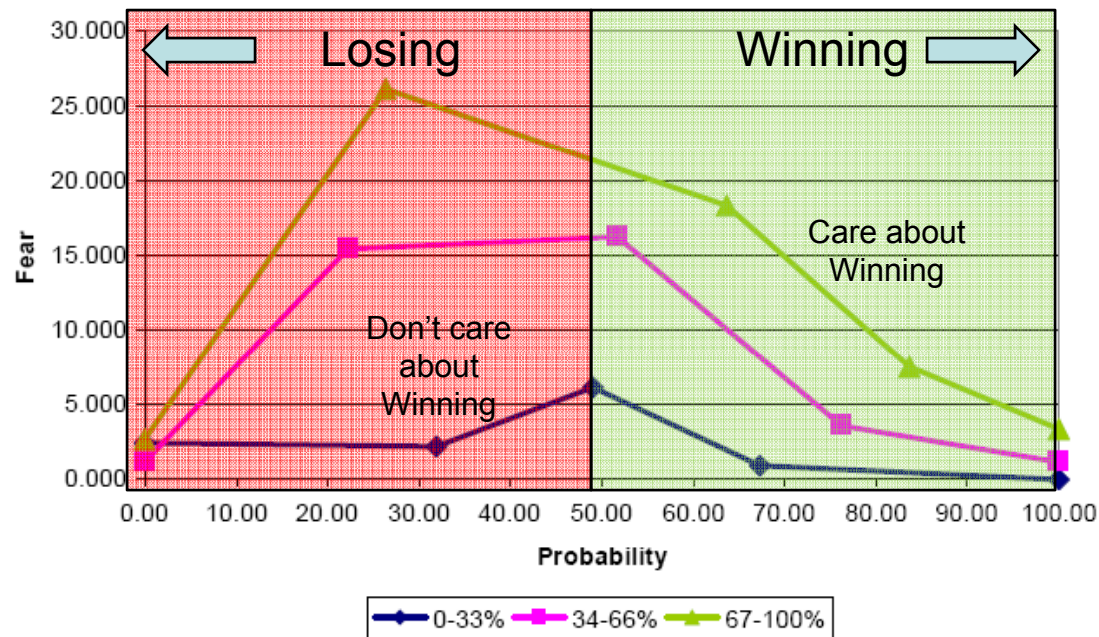- Temporal dynamics

Contrast with human data

Battleship Study
100 participants (2 x 2 design)

- Collect self-report and behavioral measures
- Indexed at 3 stages of game
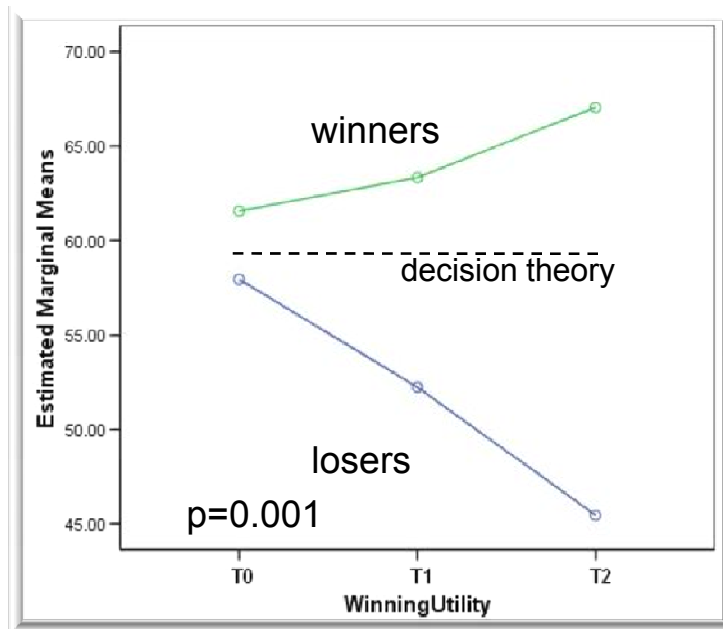- Compare with model predictions

Antecedents of Emotion

As predicted, Emotional response as function of
   * Strength of motives
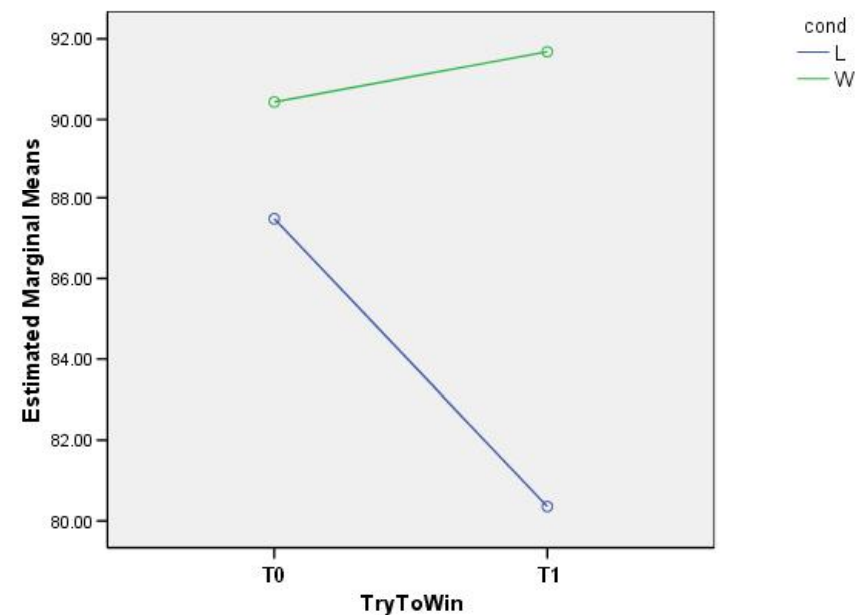   * Perception of task success

Consequences of Emotion

- **Motives are a function of emotion (contradicts decision theory)**
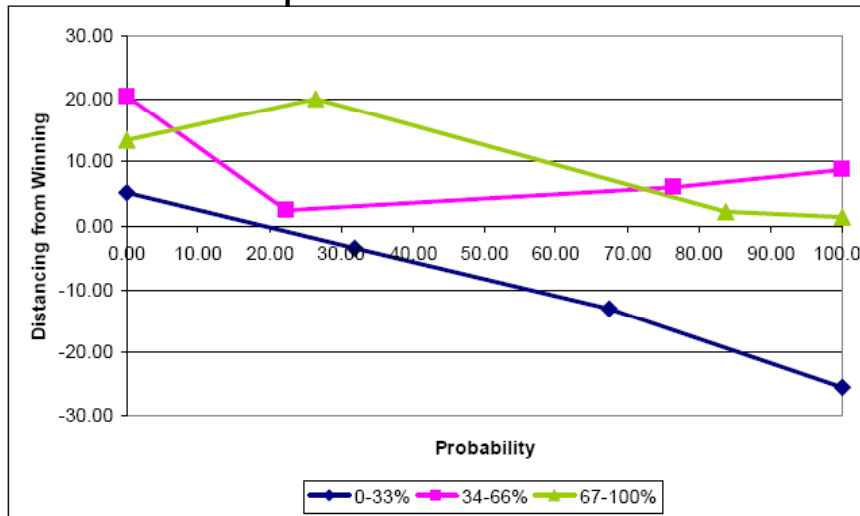
Self-reported desire
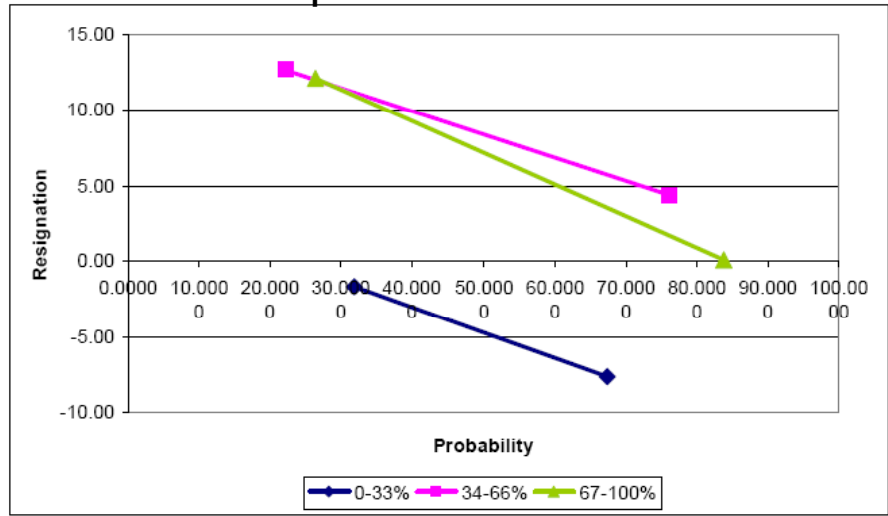to win

Self-reported effort

Drilling down…

Self-reported desire to win

Self-reported effort

Losing decreases motive to win and effort

BUT: It is not that winning increases effort

    2 groups of subjects:

        Those that want to win in the beginning (Hi Achievers)

        Those that don't

Increase in desire, motives only occurs in subjects we tricked into winning

Discussion

- ## Virtual humans
  – Technology for practice-based learning

- ## Nonverbal communication and social effects

- ## Modeling emotion
  – Potential for user modeling and tutorial interactions

USC

ICT
INSTITUTE FOR CREATIVE TECHNOLOGIES