U.S. Army Research, Development and Engineering Command

Cognitive and affective modeling in intelligent virtual humans for training and tutoring applications

ARL

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Army Research Laboratory - Human Research & Engineering Directorate (HRED)

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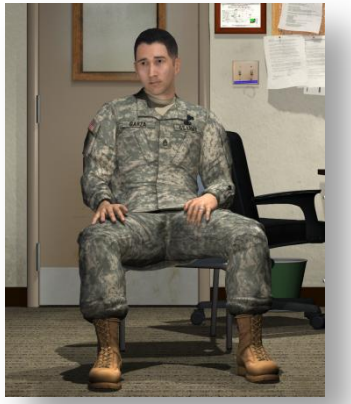
Presentation Outline

- Artificial life forms & virtual humans
- Virtual humans in training and tutoring
- Human Cognition and Affect
- Cognitive and Affective Models
- Future directions
- Questions

Artificial life forms

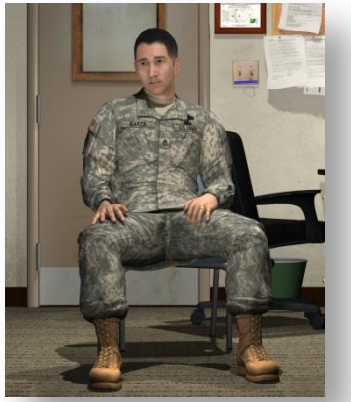


- **We will be talking about virtual humans… can you identify these artificial life forms?**

Composites

- **Human-like entities composed of living tissue created outside of normal reproductive processes**
- **driven by its own goals, cognitive and affective processes**
- **includes clones, replicants, and graveyard compilations of reanimated tissue**

Artificial life forms



Robots

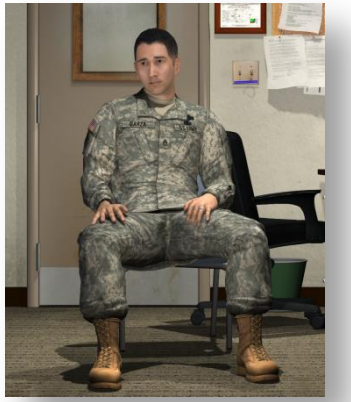
- **electromechanical machines driven by goals and cognitive processes defined by its creator**
- **constrained by the three laws of robotics?**

yes

no

- A robot may not injure a human being or, through inaction, allow a human being to come to harm.
- A robot must obey the orders given to it by human beings, except where such orders would conflict with the First Law.
- A robot must protect its own existence as long as such protection does not conflict with the First or Second Laws.

Artificial life forms

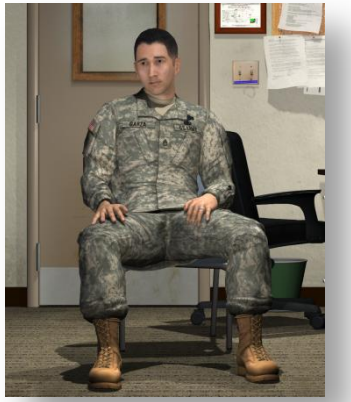


Avatars

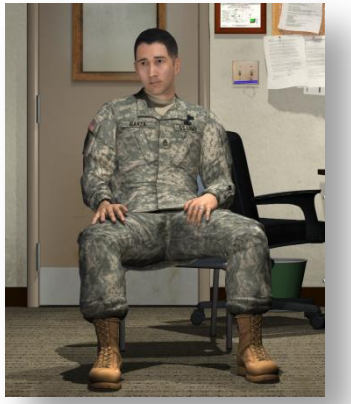
- **Graphical representation of a user or a user's alter-ego**
- **Usually driven by the goals and behaviors /actions of the user (aka role player)**

users

Artificial life forms



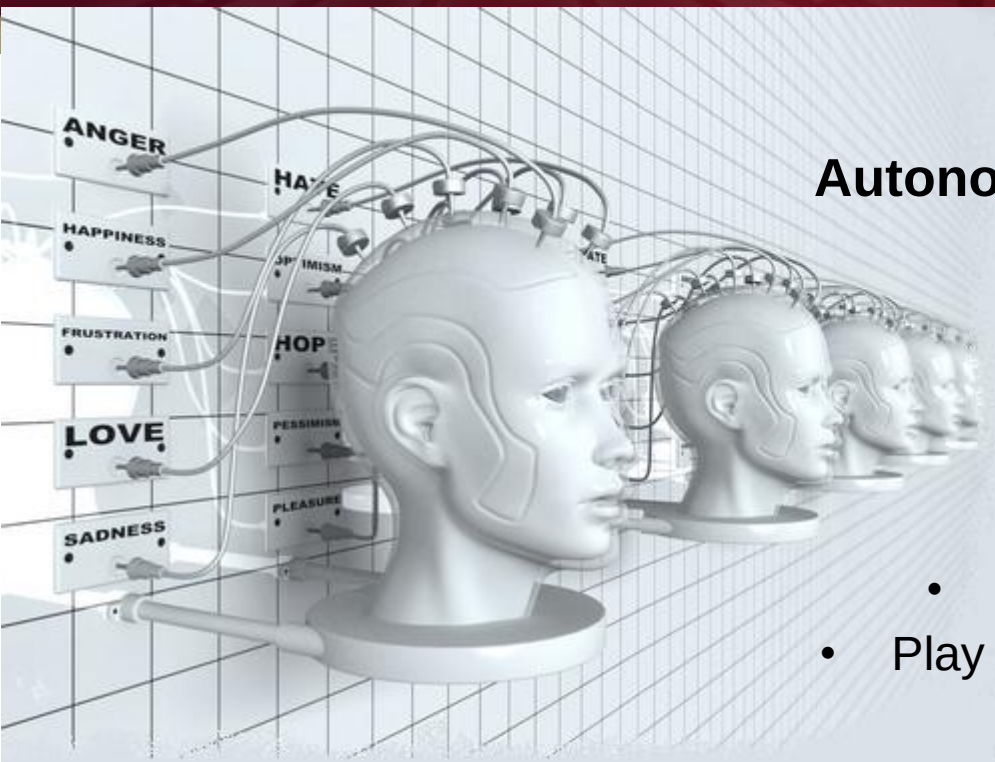
Virtual Humans



- **VH are intelligent agents that facilitate meaningful interpersonal interactions with human users in virtual reality**

- **VH are graphical representations of human behaviors driven by cognitive and affective processes**

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

Human Cognition and Affect

- **Cognitive processes**
  - **behaviors indicating increasingly complex and abstract mental capabilities**
  - **Remembering (low)**
  - **Understanding**
  - **Applying**
  - **Analyzing**
  - **Evaluating**
  - **Creating (high)**

Source: Anderson and Krathwohl's Taxonomy (2000) aka Bloom's Revised Taxonomy

- **Affective processes**
  - **behaviors indicating emotional growth**
  - **Receiving (awareness)**
  - **Responding (interest)**
  - **Valuing (appreciation)**
  - **Organizing (responsibility)**
  - **Characterizing (commitment)**

Source: Krathwohl's Taxonomy

Virtual Humans are interdisciplinary science

Human Cognition

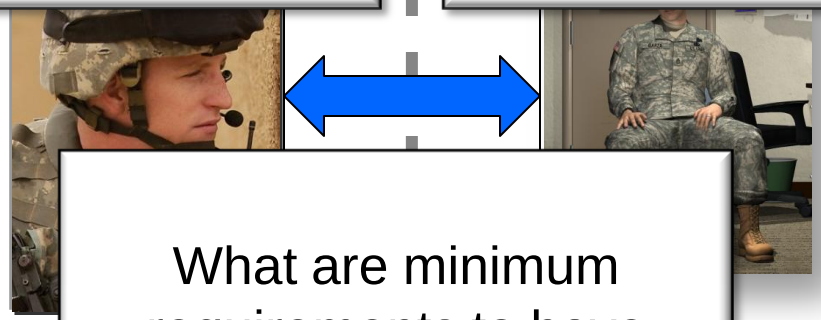
- Psychology
- Education
- Neuroscience

How do people look, sense, act, think?

How can computers simulate this?

Artificial Cognition

- Planning
- Decision-theory
- Cognitive models



Human Physiology

- Mechanics
- Anatomy
- Physiology

What are minimum requirements to have meaningful outcomes

Virtual Physiology

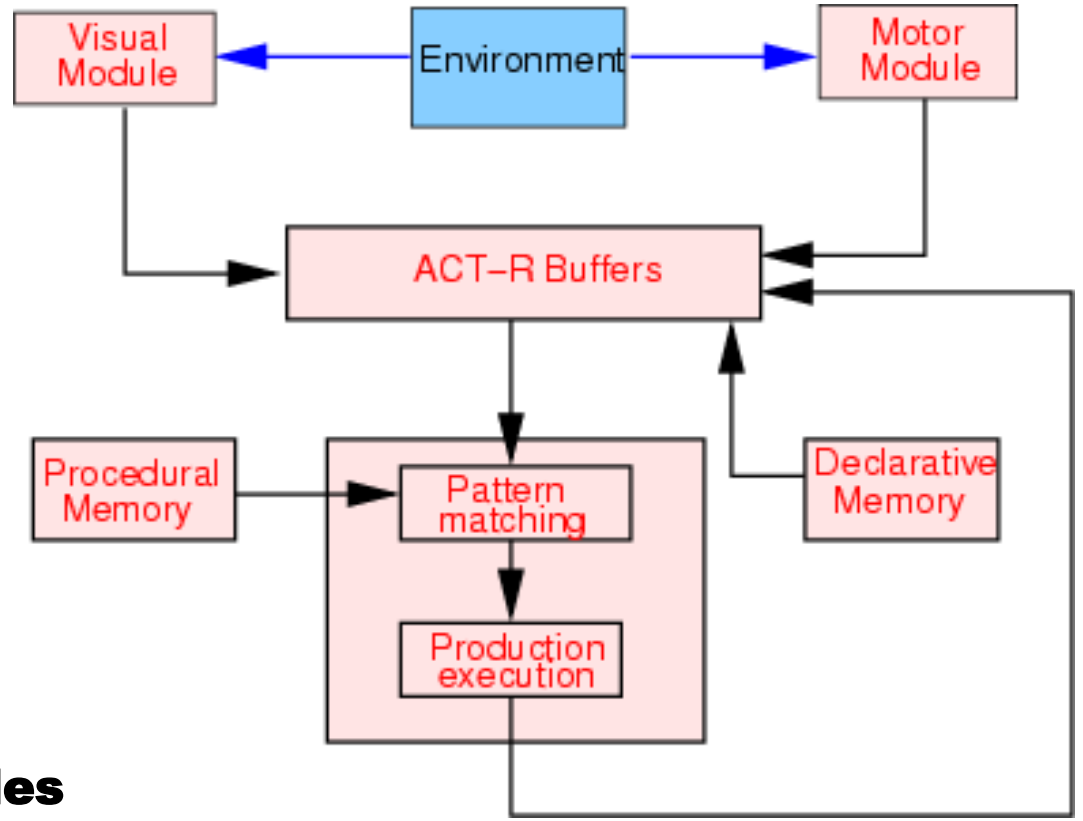
- Ergonomics
- Surgical manikins
- Physio models

Human-Computer Interaction

Courtesy of the Institute of Creative Technologies

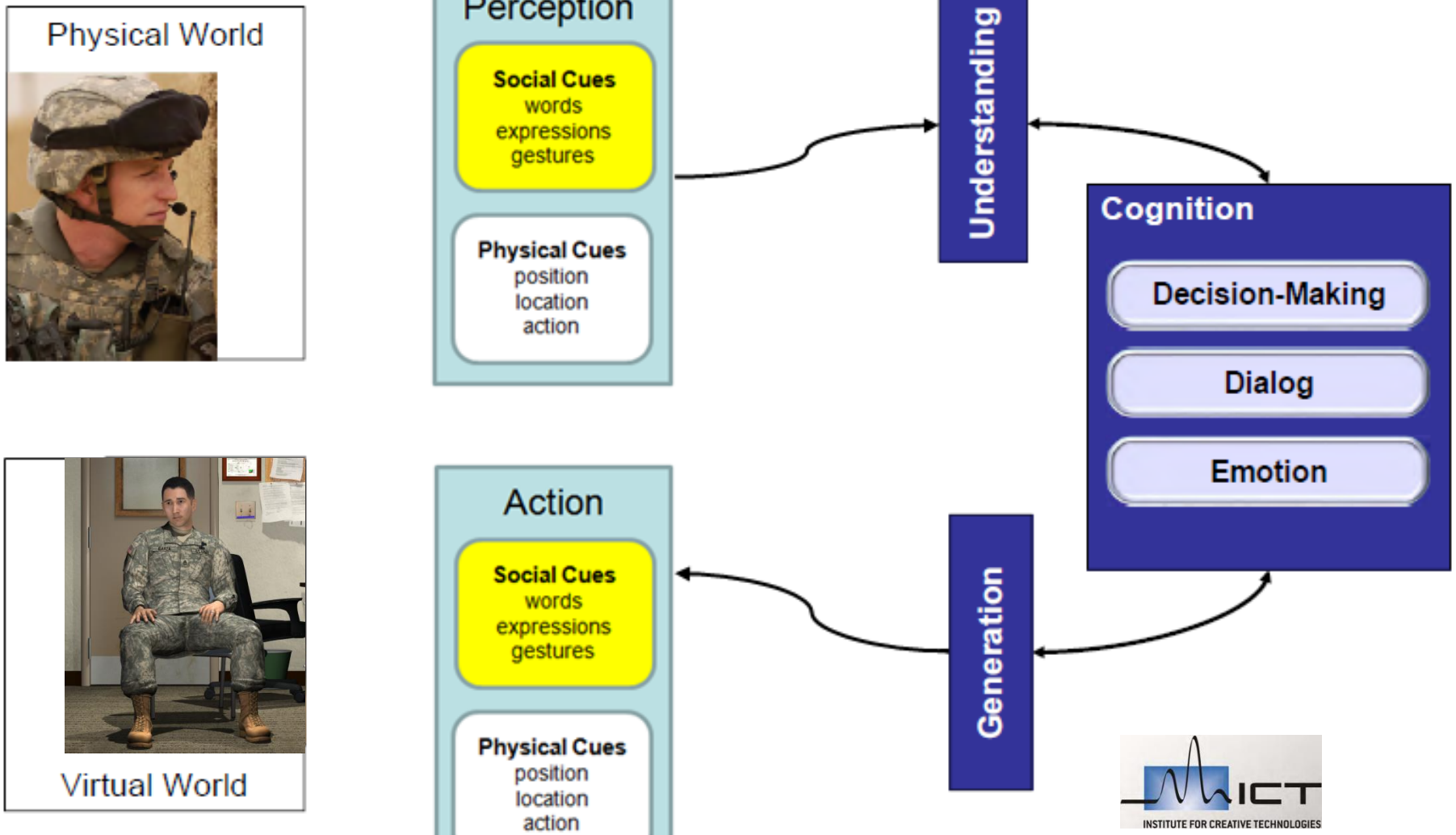
Cognitive Architecture ACT-R

- **Adaptive Control of Thought—Rational**
- **a theory for simulating and understanding human cognition**
- **ACT-R's main components are:**
  - **modules, buffers, and a pattern matcher**
- **Modules**
  - **perceptual-motor modules**
  - **memory modules**
  - **declarative memory (facts)**
  - **procedural memory**
    - **productions (how we do things)**



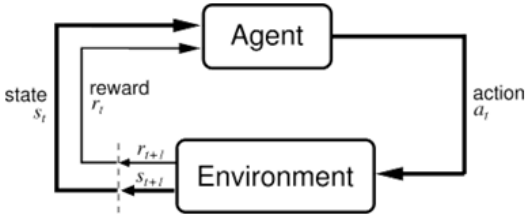
Anderson, J. R., Bothell, D., Byrne, M. D., Douglass, S., Lebiere, C., & Qin, Y . (2004). An integrated theory of the mind. *Psychological Review 111,* (4). 1036-1060.

A cognitive-affective VH framework

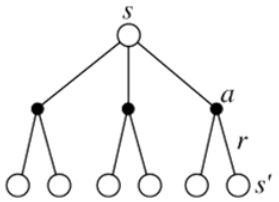


Courtesy of the Institute of Creative Technologies

Virtual Humans in computer-based tutoring



tutoring agent(s)



agent observes world

agent acts to change world (scenario adaptation)

agent observes effect of changes on learning objectives

agent observes learner

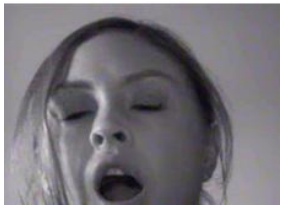
agent acts to provide feedback or instruction via VH

agent observes effect on learner

learner acts on world

world

learner



learner observes world

Desired Affective Capabilities for VH

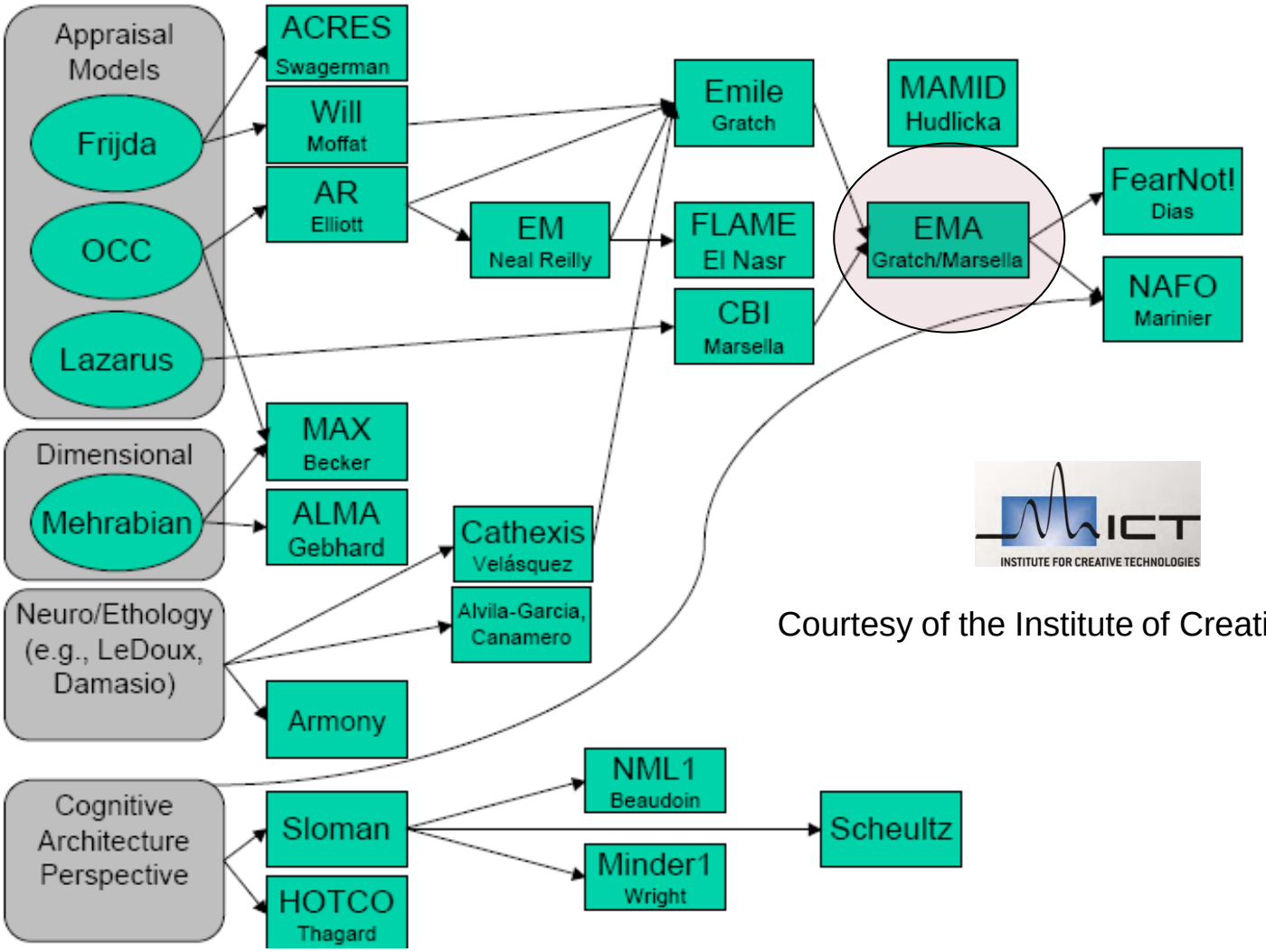
- **Recognize the human's emotional state (e.g. motivated, engaged, frustrated);**
- **Make the human aware of his affective state (e.g. emotional state, mood) so he can participate in managing his affective state;**
- **Provide options (e.g. strategies) for the human to manage/control his affective state;**
- **Use emotion to motivate the human to achieve established objectives.**

Salovey, P. & Mayer, J. D. (1990). Emotional intelligence. Imagination, Cognition, & Personality, 9, 185-211.

Goleman, D., (1995). Emotional Intelligence. Bantam Books: New York.

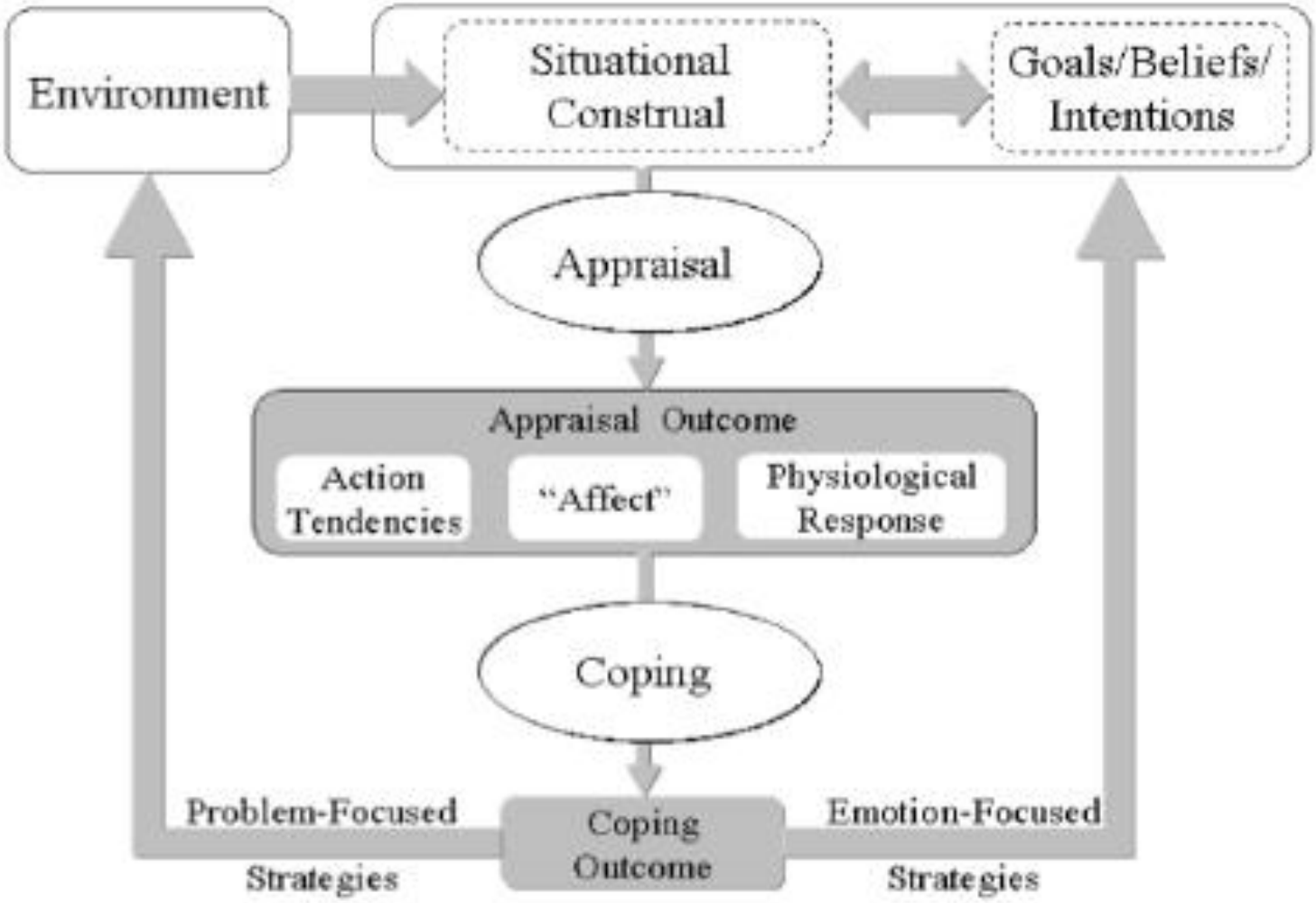
"No matter how intelligent a [virtual human] is, it will eventually become annoying if it does not have emotional intelligence." (Picard, 2006)

Affective Modeling - EMA



Courtesy of the Institute of Creative Technologies

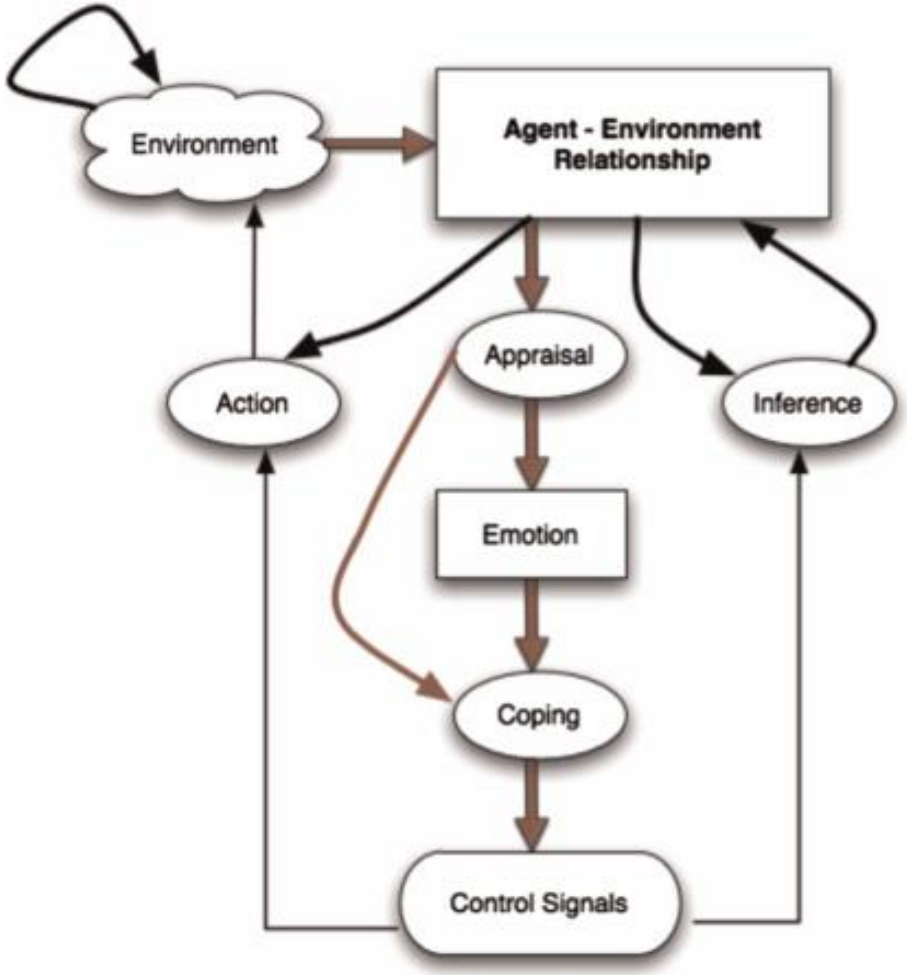
Appraisal Theory



Emotion and Adaptation (EMA) Model

- **Based on appraisal theory**

- **Attitude**
- **Affect**
- **Judgement**

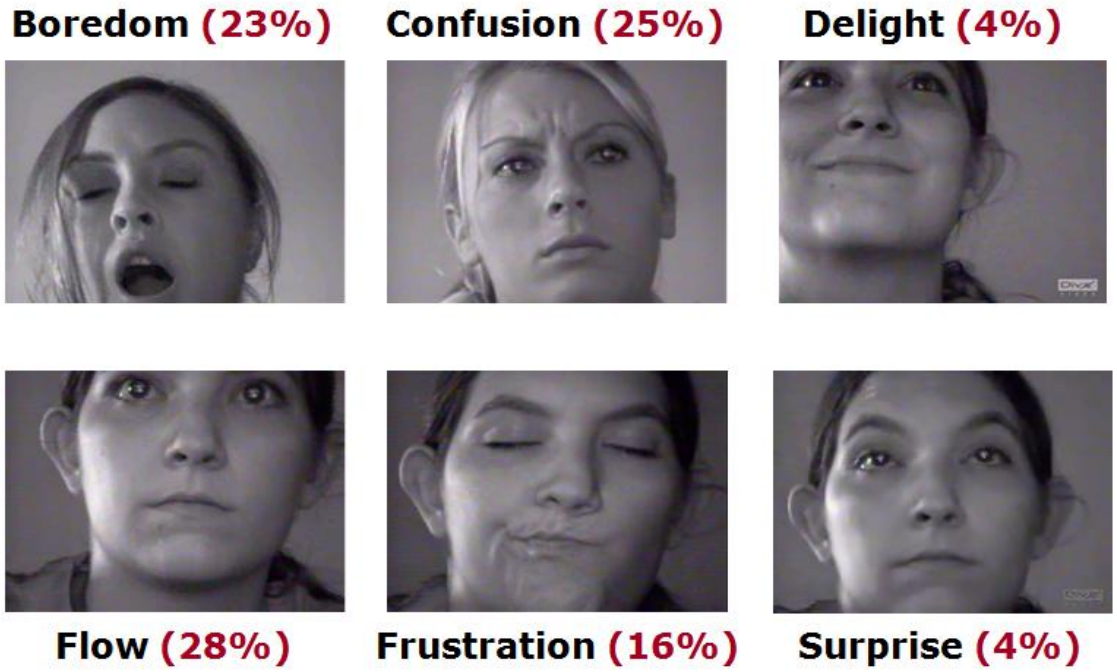


Marsella, S., and J. Gratch. 2009. EMA: A process model of appraisal dynamics. *Cognitive Systems Research* 10, no. 1: 70–90.

Virtual Humans as Affect-Sensitive Tutors

- ***What does the VH need to know about the learner during tutoring?***

- ***what does the tutor need to know about the learner to classify their affect?***
- ***how does the tutor get that information?***
- ***which affective states are important to recognize?***
- ***how does classification of state influence instructional decisions?***



Graesser, D'Mello, Craig, Person, Baker, Rodrigo (2012, in press)

Future Directions for VH

- **Values – modeling the influence of values on:**
  - **virtual human decision making (e.g., moral judgments)**
  - **preferences (e.g., personality)**
- **Sensory capabilities**
  - **better perception of humans, VHs and the world**
- **Persistent models of:**
  - **memory to support long-term rapport (e.g., personal learning assistants)**
  - **previous actions to support reinforcement learning (e.g., expert modeling)**

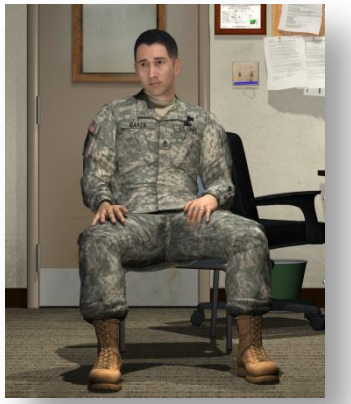
Future Directions for VH

- **Cognitive Architecture for VH (Rosenbloom, 2011)**
  - **Broadly and incrementally functional**
  - **Theoretically elegant and simple for simple things**
  - **Mixed and hybrid**
  - **Support truly robust systems**
  - **Maintainable and extendible**

  - **Enhance VH:**
    - **learning, perception, problem solving**

Rosenbloom, P. S. (2011). From memory to problem solving: Mechanism reuse in a graphical cognitive architecture. Proceedings of the Fourth Conference on Artificial General Intelligence

Virtual humans in training & tutoring



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Stuff we talked about...

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Thank you for your attention

Questions?