



# Nonverbal Behavior Generator for Embodied Conversational Agents

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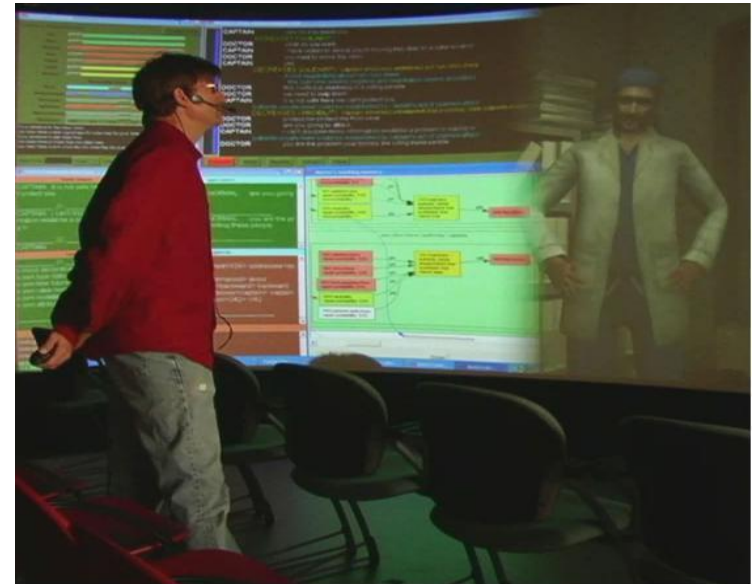
## Virtual Humans

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- Goal: Virtual humans that act like real humans
- Behaviors not pre-scripted
  - Behave induced by understanding and reasoning about the current situation
- Communicate in Natural Language
  - Language Recognition & Generation
- Understand social situation
- Respond emotionally to situation

## Virtual Human Project at USC - SmartBody

- Joint work between Institute for Creative Technologies and Information Sciences Institute
- Related Research Topics
  - Emotion modeling
  - Multi-party dialogue model
  - Speech recognition in noisy environments
  - Natural language pragmatics
  - Social reasoning
  - Negotiation about tasks



# Virtual Human Body

- Capabilities:
  - Basic Physical Behavior
  - Walking, grasping
- Nonverbal, expressive behavior
  - Gestures, facial expressions, gaze
- Requirements:
  - Spontaneous, interactive
    - Behaviors on the fly
    - Responsiveness to events



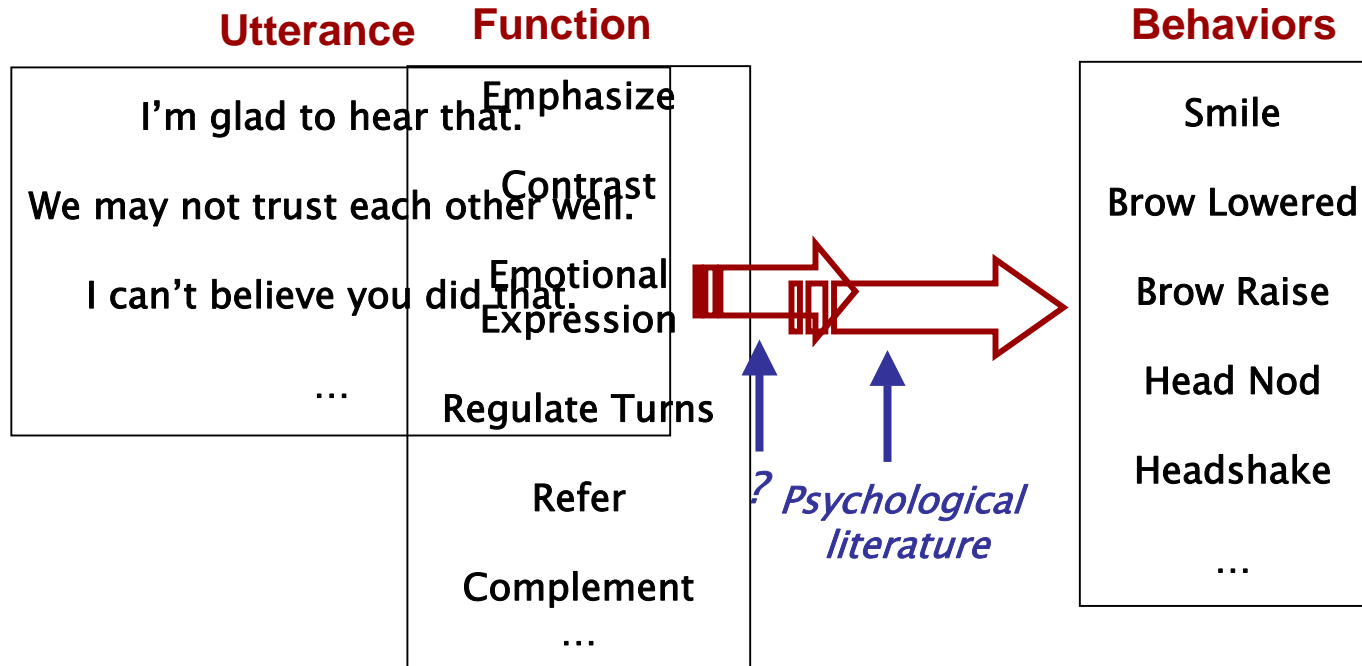


## Nonverbal Behaviors

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- Nonverbal communication
  - All the messages other than words that people exchange in interactive contexts. (Hecht, DeVito, and Guerrero)
- Nonverbal Behavior (NVB)
  - Behaviors people make that convey communicative functions
  - Gestures, facial expressions, gaze, etc.
- Nonverbal behaviors serve various functions

# Problem



## • Challenge

- To find the mapping between utterance and function
- To model the nonverbal behavior generation for ECA using this mapping without a rich markup



## Goals for NVB Generator

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- Robust NVB Generation that can use markup of communicative function if provided, but can also extract/infer it if not
- Extraction that leverages syntactic and semantic analysis of text
- Use open-source tools
- Use evolving standards for markup
  - SAIBA framework (FML & BML)
  - Clear distinction of function and behavior

# Example of Nonverbal Behavior Generation

## Surface Text:

Yes, Prudence. Many times. I actually quite like you

## Function:

Affirmation

Intensification

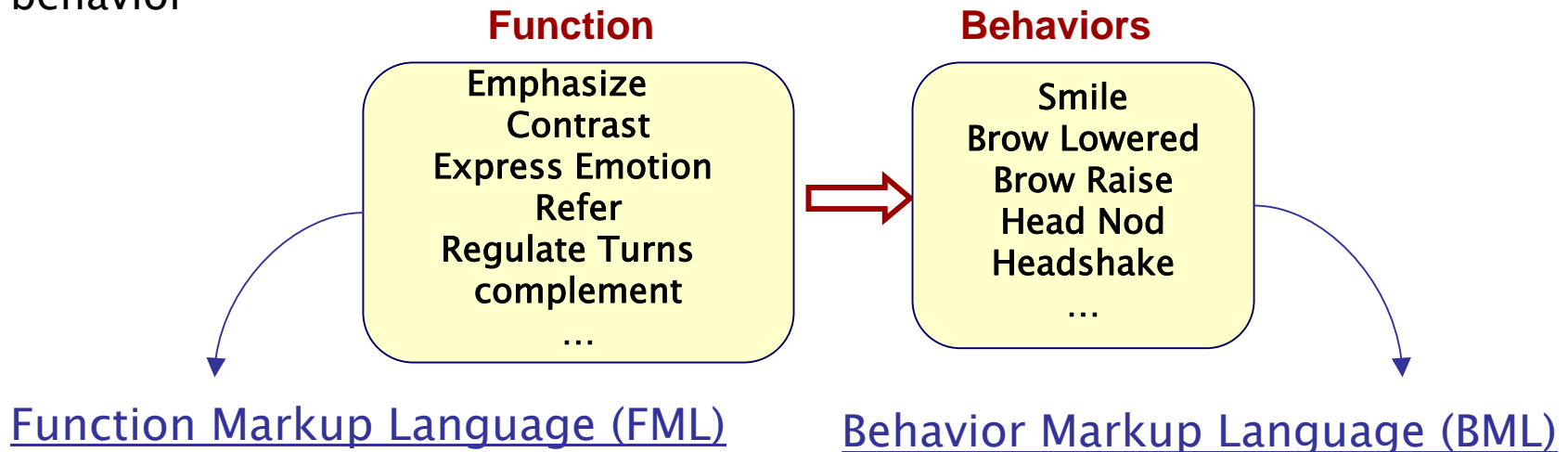
## Behavior:

Head nods

Head nod & brow frown  
on word

# SAIBA Framework

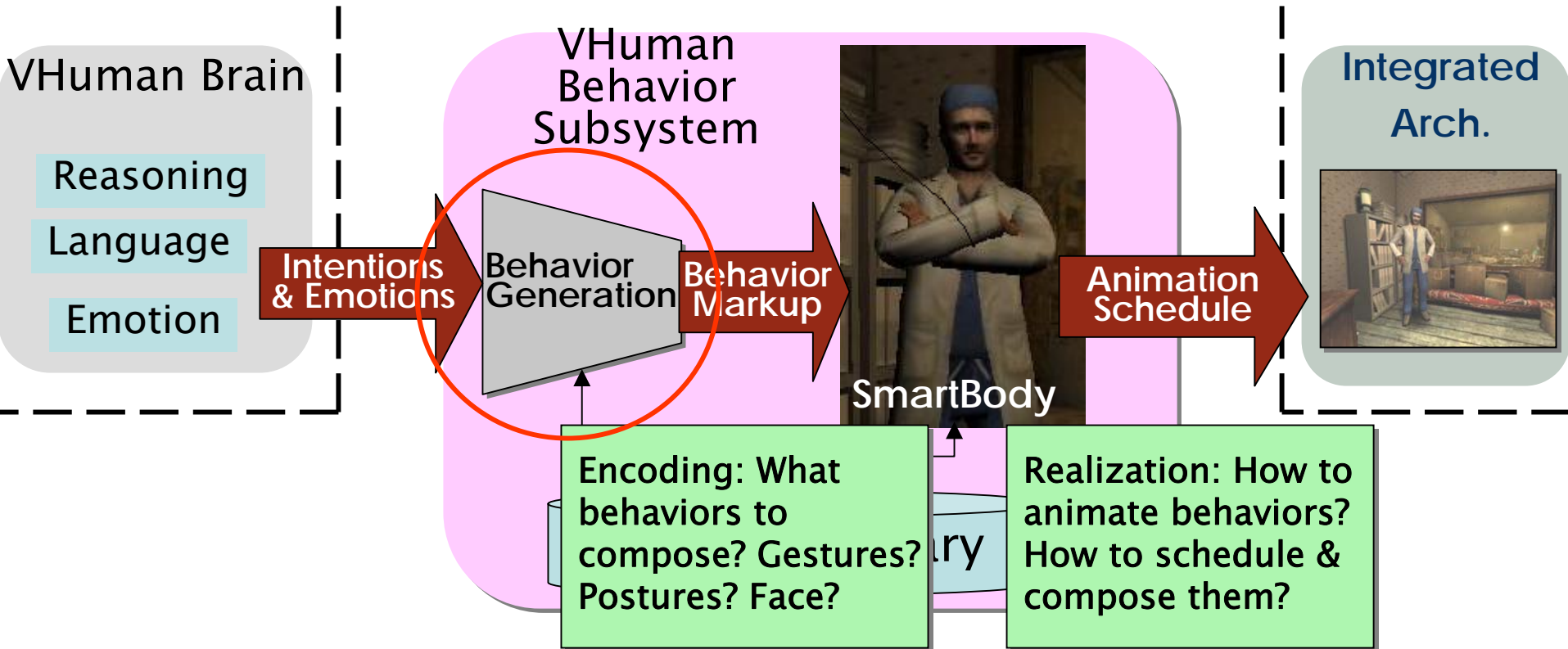
- SAIBA [Kopp et al., 2006] – Situation, Agent, Intention, Behavior, and Animation
- A distinction between communicative function and communicative behavior



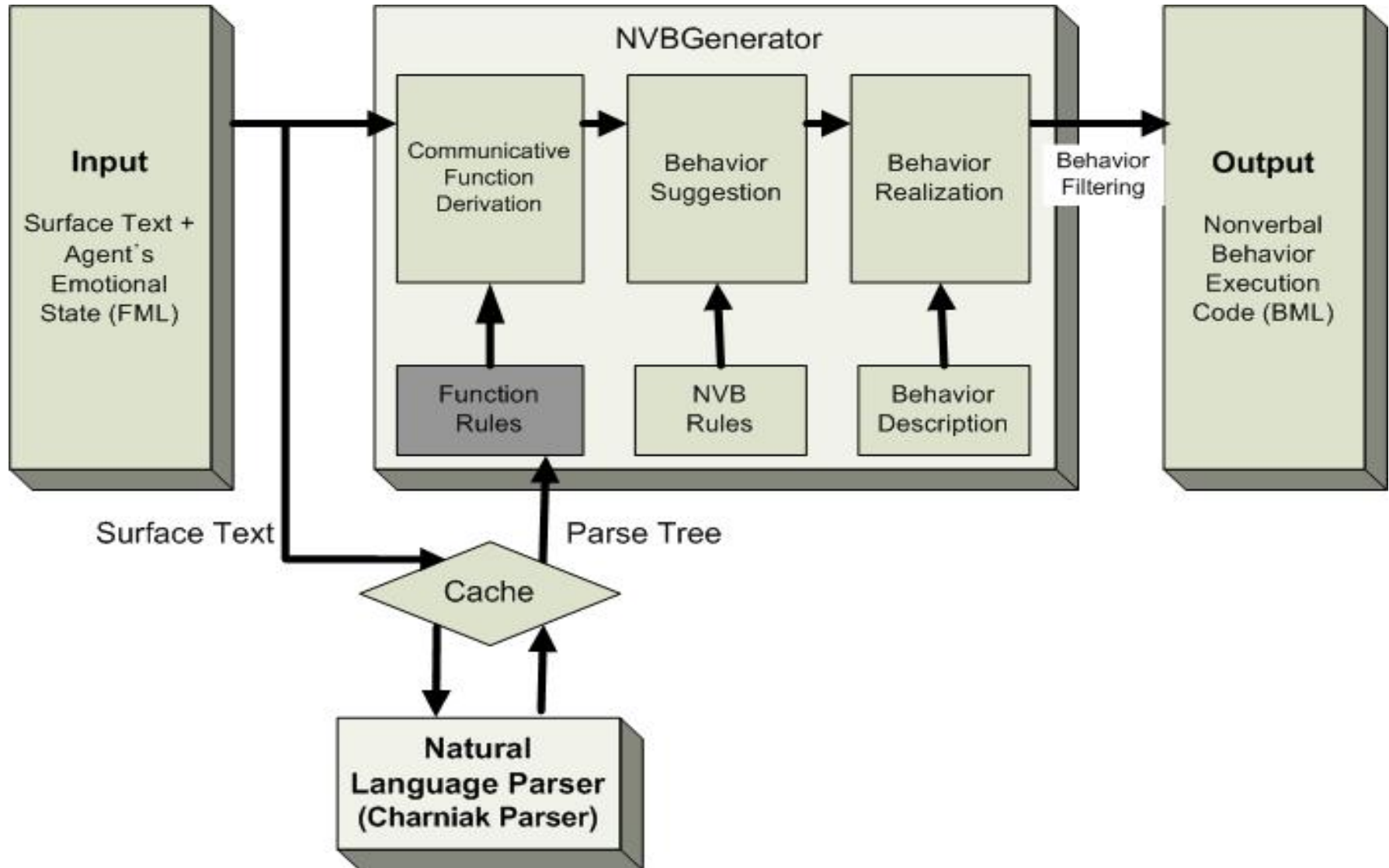
- Specifies the communicative and expressive intent of the agent.
  - AFFECT, INTENT, TURN
  - Persistent Features:  
PERSONALITY, CULTURE,  
GENEDER

- Elements roughly correspond to the parts involved in the behavior
  - BODY, GESTURE , HEAD, FACE,  
GAZE, LIPS, SPEECH

# Virtual Human Body Embodiment



# NVB Generator System Architecture





## Possible Approaches

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- How do we extract the communicative function from linguistic features?
  - Information from the natural language generator (comm. Intent / affect)
    - e.g. Multi-modal NLG [Krenn et al., 2002]
  - Machine learning techniques using a gesture corpora
  - Top down analysis of video data

# Psychological Literature

- Literature on NVB
  - e.g. Ekman, Hadar, Kendon, McClave, etc.

Function	Behavior
Signs of affirmation	Head nods
Backchannel (response) requests	Head nod
Self correction	Head shake
Concepts of inclusivity (i.e. everyone, all)	Lateral sweep or head shake
Listing	Head moves with succeeding items
Uncertainty (I guess, I think...)	Lateral shakes
Negative expression	Head shake
Superlative or intensified expression (i.e. very, really)	Head shake Brow frown
Mark Contrast	Head movement

## Analysis of Video Data

- To validate what's found in the literature
- Find out the dynamic properties of behaviors
  - speed, repetition, span of behaviors (word/phrase, cross-syntactic boundaries)
- To see what the actual NVB look like
  - Do head nods across different functions appear differently?
- Relation between the behavior and linguistic properties of the surface text
  - Guide rule construction
- Sensitive Artificial Listener [HUMAINE, 2004]





# Nonverbal Behaviors Observed

- Head
  - Nod, shake, tilt, moved to the side, pulled back, pulled down
- Eyebrow
  - Raised, frowned (lowered), flash
- Eyes / Gaze
  - Look up, look down, look away, squinted, squeezed, rolled
- Others
  - Shoulder shrug, mouth pulled on one side

*Breakdown of the number of utterances with corresponding function*

Function	# of utterances (out of 223)
Negation	62
Intensification	62
Affirmation	36
Assumption	28
Word Search	23
Contrast	23
Interjection	13
Response Request	10
Listing	9
Obligation	9
Inclusivity	7



## Interesting Features from Video Analysis

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- Interjection
  - *Yes, no*: labeled as interjection
    - big nod once on word
  - e.g. No, you're not.  
Yes, please.
- Word Search
  - *Well, um, uh* labeled as interjection
- Intensification
  - Literature: head shake and lowered brows on intensifying word
  - Video: big head nod and lowered brows on intensifying word



# Nonverbal Behavior Rules

Derivation	Function	Behavior
No, not, nothing, cannot, none	Negation	Head shakes on phrase
Really, very, quite, great, absolutely, gorgeous...	Intensification	Head nod and brow frown on word
Yes, yeah, I do, We have, It's true, OK	Affirmation	Head nods and brow raise on phrase
I guess, I suppose, I think, maybe, probably, perhaps, could	Assumption / Possibility	Head nods on phrase
Um/uh/well + interjection from parser	Word Search	Head tilt, brow raise, gaze away
But, however	Contrast	Head moved to side and brow raise



# Nonverbal Behavior Rules

Derivation	Function	Behavior
Yes, no + interjection from parser	Interjection	Head nod on word
You know	Response Request	Head move to side and brow raise on word
X and Y	Listing	Head moved to one side and to the other on word
Everything, all, whole, several, plenty, full...	Inclusivity	Lateral head sweep and brow flash on word
Have to, need to, ought to	Obligation	Head nod once on phrase

## Priorities of NVB Rules

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### Example

*She wouldn't be really happy.*

- > Head shakes over the whole sentence
- > negation overrides intensification

### Algorithm

1. Find all the utterances where two or more rules co-occur
2. Mark which rule overrides the other (looking at the behavior) in the matrix of rules and count the frequencies of these cases

### Result

1. Interjection
2. Negation
3. Affirmation
4. Assumption/possibility, obligation
5. Contrast, word search, response request
6. Intensification, inclusivity, listing

# Example of Nonverbal Behavior Generation - Revised

Surface Text:

Yes, Prudence. Many times. I actually quite like you

Function Rules:

~~Affirmation Rule  
Priority 3~~

Interjection Rule  
Priority 1

Intensification Rule  
Priority 6

Behavior Rules:

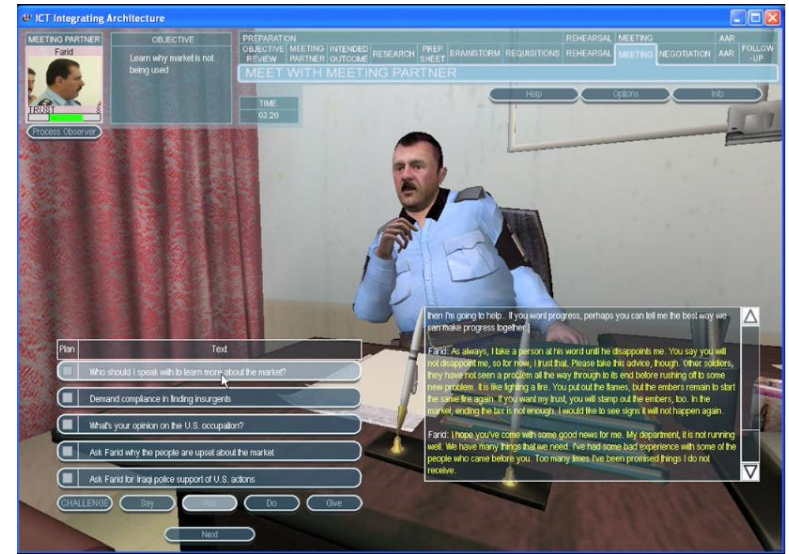
~~Head nods on phrase~~

Head nod on word

Head nod & brow frown  
on word

# Status

Work is at a preliminary phase, but...



**ELECT<sup>1</sup>**: A cultural training application.

**SASO<sup>1</sup>**: A leadership and negotiation skills training application.

<sup>1</sup> Developed at USC Institute for Creative Technologies



## Conclusion and Future Work

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- A framework for NVB generator that extracts the communicative function from the input text and generates appropriate NVB
- Designed for easy modification and extension of the rules
- Module was incorporated into several applications
- Evaluation of the system and behaviors generated needed
- Machine learning techniques to aid us in the process of behavior generation
  - Requirement: large gesture corpora
- Modify and customize the current behavior generation for different gender, cultures, or personalities
- Model the affective state of the user interacting with the ECA