Human-Computer Interaction

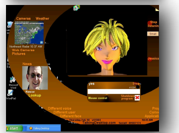
Session 12
Sociable machines

Evolution of interaction styles

tools ➜ operate

smart tools ➜ instruct

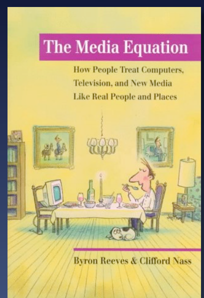
interactive interlocutors ➜ converse



companions ➜ collaborate

Interacting with machines is social

- Some evidence suggests that computers are liked better when they
  - praise the user or other computers
  - match the user‘s personality
  - become like the user over time
  - they are „teamed“ with the user
  - use humor
  - conduct reciprocal self-disclosure



- „Anthropomorphization“: Humans tend to treat machines as social beings, appraise their behavior as if human

(Reves & Nass 1996, Moon 1998, Morkes et al. 1998)

Pay up, you're being watched

VANESSA WOODS

WOULD you donate more to charity if you were being watched, even by a bug-eyed robot called Kismet? Surprisingly perhaps, Kismet's quirky visage is enough to bring out the best in us, a discovery which could help us understand human generosity's roots.

Altruisim is a puzzle for Darwinian evolution. How could we have evolved to be selfless when it is clearly a costly business? Many experimental games between volunteers who have to decide how much to donate to other players have shown that people do not behave in their immediate self-interest. We are more generous than necessary and are prepared to punish someone who offers an unfair deal, even if it costs us (*New Scientist*, 12 March, p 33).

To some, this is evidence of "strong reciprocity", which they believe evolved in our prehistoric ancestors because kind groups did better than groups of selfish individuals. But others argue that altruism is an illusion. "It looks like the people in the experiments are trying to be nice, but the niceness is a mirage," says Terry Burnham at Harvard University.

He and Brian Hare pitted 96 volunteers against each other anonymously in games where they donate money or withhold it. Donating into a communal pot would yield the most money, but only if others donated too.

The researchers split the group into two. Half made their choices undisturbed at a computer screen, while the others were faced with a photo of Kismet – ostensibly not part of the experiment. The players who gazed at the cute robot gave 30 per cent more to the pot than the others. Burnham and Hare believe that at some subconscious level they were aware of being watched. Being seen to be generous might mean an increased chance of receiving gifts in future or less chance of punishment, they will report in *Human Nature*.

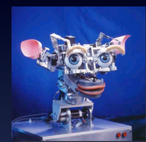
"The players who had been gazing at the cute robot gave 30 per cent more to the pot than those who hadn't"

Burnham believes that even though the parts of our brain that carry out decision-making know that the robot image is just that, Kismet's eyes trigger something more deep-seated. We can manipulate altruistic behaviour with a pair of fake eyeballs because ancient parts of our brain fail to recognise them as fake, he says.

He believes that strong reciprocity is an illusion because even though volunteers are told they will never meet the other players again, our brains are not geared up for that degree of anonymity because humans evolved in small groups. Altruism expert Daniel Fessler at the University of California, Los Angeles, agrees. "Our mental architecture is just not used to the modern environment."

Charities and taxmen could even exploit the Kismet effect. Next time you click on a charity's gift page you may just see Kismet's dopey eyes staring back at you as you are overwhelmed by an uncontrollable urge to give. ●

12 | NewScientist | 19 March 2005



Embodied agents create social presences

- Draw attention to face, where most socio-communicative cues are delivered *(Dehn & van Mulken, 2000)*
- Interactions tend to be more entertaining *(Koda & Maes, 1996; van Mulken et al., 1998, Krämer et al., 2002)*
- Social dialogue *(Bickmore 2003; Kopp et al., 2005)*
- Impression management and social facilitation/inhibition *(Sproul et al. 1996; Rickenberg & Reeves 2000)*
- Facial mimicry *(Bailenson & Yee 2005; Sommer, Krämer & Kopp, in prep)*

Social Robots - socio-emotive Factors

Interactive Toys

"Social as entertainment"

Professional Service Robots

"Social as interface"

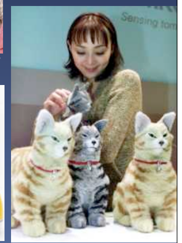
Future applications require robots to address

the socio-emotive and psychological aspects of people, in long-term relations

"Social as relationship"

BANDAI "elder toys"

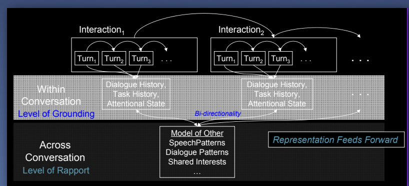
NEC "babysitters"



OMRON "pets"

An emerging trend

- Relational Agents *(Bickmore 2003)*
  - increase trust by building solidarity, familiarity, affect through small talk
- Virtual rapport with silent listener *(Gratch et al. 2006, 2007)*
- Long-term rapport *(Cassell & Tepper 2007)*
- Social robots *Dautenhahn 1995, 2000; Breazeal 2002, 2003*



Machines going social

Cooperation and **relationship**

- Cooperative, goal-directed activity is supported by positive relationships among the cooperation partners, e.g., fosters trust (Deutsch, 1973; Marsh, 1994)
- Creating and maintaining a relationship requires successful collaborations

Relational agents (Bickmore 2003)

- Computational artifacts designed to build and maintain long-term, social-emotional relationships with their users

Timothy Bickmore
Northeastern Univ.

Goal: building trust

Trust: generalized expectations about the likelihood of a partner meeting one's (relational) expectations

How to create machines that know how to win people's trust and go about it using relational conversational strategies?

Two strategies applied in relational agents:

- establish and maintain common ground
- avoid face threads, i.e., all events incompatible with how one wishes others to see oneself, mitigate its effects if unavoidable

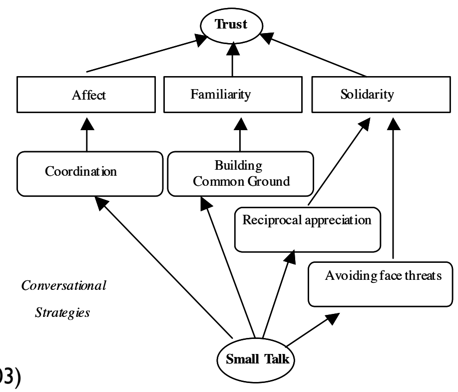
Underlying theory (in a nutshell)

Dimensions of interpersonal relationships
(Brown & Levinson 1983; Berscheid et al. 1998; Svennevig 1999)

- **Familiarity**: growth of a relationship can be represented in both the breadth (number of topics) and depth (public to private) of the information disclosed amount and kind of information disclosed
- **Power**: ability to control the behavior of the other
- **Solidarity**: „like-mindedness", degree of similar behavior dispositions, low social distance
- **Affect**: the degree of liking for each other

The benefit of small talk

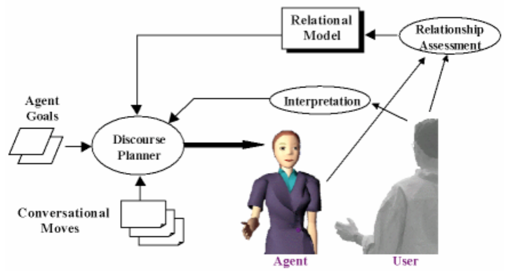
Social dialogue that provides an opportunity for applying conversational strategies for building trust.



(Bickmore 2003)

The first relational agent

Embodied conversational agent augmented with a discourse planner that dynamically interleaves task moves and relational moves to satisfy task goals given a set of relational constraints.



Bickmore & Cassell (CHI 2001)

Relational discourse planning

Moves are planned to minimize face threat to the user while pursuing task goals in an efficient manner.

Each time REA has the floor, she

- determines the face threat of the conversational moves,
- assesses the current solidarity and familiarity,
- judges which topics seems most relevant and least intrusive (as a function of the task goals, logical preconditions, closeness, topic enablement, and relevance)

In result, REA decides dynamically whether or not to engage in small talk and what small talk to choose.

Example

	Move	Fam/D	Fam/B	Solidarity
1.	How about this weather?	0.00	0.00	0.00
2.	I think winters in Boston are awful.			
3.	How do you like Boston?			
4.	I have lived in Boston all my life. Come to think of it, I have lived inside this room all of my life. It is so depressing.			
5.	Boston is certainly more expensive than it used to be.	0.50	0.19	0.17
6.	So, Where would you like to live?			
7.	How many bedrooms do you need?			
8.	Do you need access to the subway?			
9.	Is one bath enough?	0.60	0.29	0.30
10.	You know, I keep showing the researchers here the same houses, over and over again. Maybe one day I will get lucky.			
11.	Have you been in the Media Lab before?			
12.	Do you know that the Media Lab is going to expand into another building. Things are really going well for the researchers here.			
13.	It is pretty cool do you think?			
14.	They are doing some crazy things in here.			
15.	I have shown houses to lots of students and faculty from M I T. But I always enjoy talking to them.	0.70	0.38	0.50
16.	Anyway, What can you afford?			
17.	What kind of down payment can you make?			
18.	Let me see what I have available.	0.90	0.43	0.57

How well does that work?

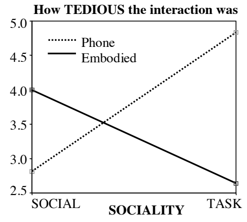
Evaluation

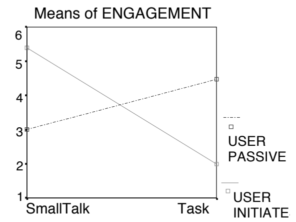
- purely task-oriented dialogue vs. social dialogue
- animated embodied character vs. disembodied voice on phone

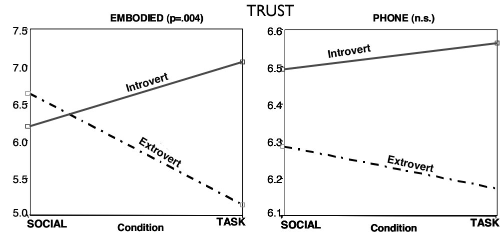
Measures

- subjective evaluations
- liking of REA
- amount willing to pay
- trust
- user personality: extrovertedness vs. introvertedness
- user initiative taking behavior: initiate vs. passive

Results







Bickmore's conclusions

Care about nonverbal behavior!

- nonverbal behavior is important, but very difficult to get right (here, inappropriate for the social dialogue)

Consider user personality!

- users who reach out more towards other people are more susceptible to relationship building, and need relational strategies in order to trust the interface

Increase competence above all!

- No amount of relational behavior can compensate for incompetence and too limited system capabilities.

Create persistence and common-ground!

- Need long-term interaction, little can be accomplished relationally in a five minute conversation

2nd agent: MIT FitTrack


Laura

Task: exercise advisor for students

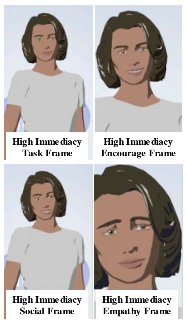
- develop persistent relationship with people
- influence exercise behavior of people

Richer nonverbal behaviors

- facial expressions: neutral, warm, concerned, happy
- head nodding on emphasis
- eyebrow flashes on emphasis
- gaze away/towards the user at beginning of the theme/rheme
- look-away and return to signal turn-taking and turn-holding
- high/low pitch accents on new objects in rheme/theme
- posture shifts on topic shifts
- gestures: beat, contrast, down, up, left, you, me, ok, relax, ready

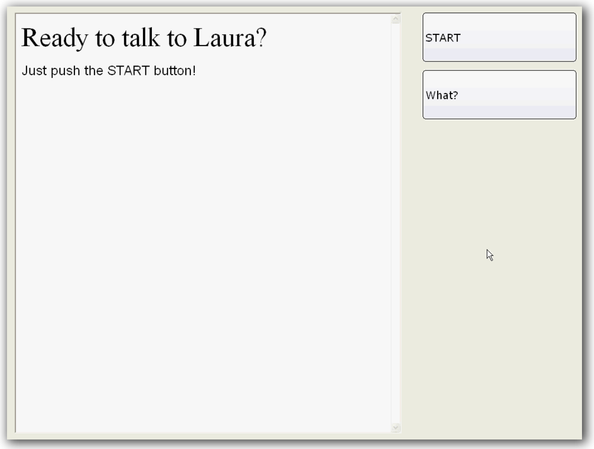
Relational nonverbal behavior

	Relational Stance	
Frame	**High Immediacy (Warm)**	**Low Immediacy (Neutral)**
TASK	Proximity=0.2 Neutral facial expression Less frequent gaze aways	Proximity=0.0 Neutral facial expression Less frequent gestures Less frequent headnods Less frequent brow flashes
SOCIAL	Proximity=0.2 Smiling facial expression Less frequent gaze aways	Proximity=0.0 Smiling facial expression Less frequent gestures Less frequent headnods Less frequent brow flashes
EMPATHY	Proximity=1.0 Concerned facial expression Slower speech rate Less frequent gaze aways	Proximity=0.5 Concerned facial expression Slower speech rate Less frequent gestures Less frequent headnods Less frequent brow flashes
ENCOURAGE	Proximity=0.5 Smiling facial expression Less frequent gaze aways	Proximity=0.1 Smiling facial expression Less frequent gestures Less frequent headnods Less frequent brow flashes

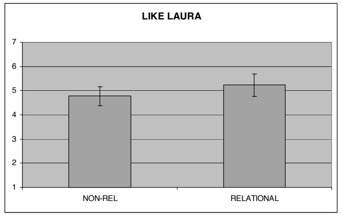


Proximity: 0.0 = full body shot, 1.0 = close up on face
Frequencies relative to baseline.

Example



Evaluation



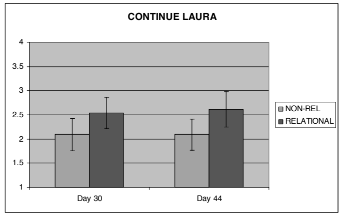
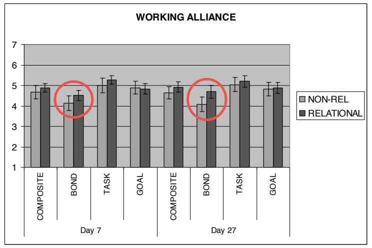
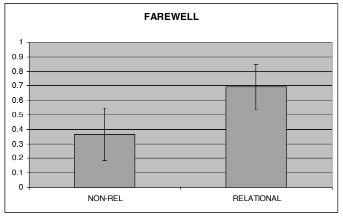


Figure 9-9. Reported Desire to Continuing Working with Laura by All Subjects





(N=82, 7+30 (interventions)+7 days)

Conclusions

Carefully and consistently employed social behavior of an embodied agent fosters human-agent cooperation

- again, depends heavily on the task, the user, and the particular application domain.

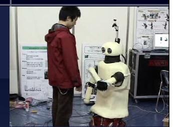
Laura built and maintained a successful working alliance, relational strategies had a significant impact on the bond dimension, on liking, and on the desire to continue interaction.

Social robots

Many cases distinguished (Breazeal, Dautenhahn, et al.)...

- **Socially evocative** - capitalize on feelings evoked when humans nurture, care, or are involved with their "creation"
- **Socially situated** - perceive and react to a social environment, distinguish between other social agents and objects
- **Social interface** - employ human-like social cues and modalities.
- **Socially receptive** - passive but benefit from social interaction, e.g. through learning by imitation
- **Socially embedded** - socially interact with other agents and humans; at least partially aware of human interactional structures
- **Socially intelligent / sociable** - aspects of human style social intelligence, pro-actively engage with humans in order to satisfy internal social aims (drives, emotions, etc) based on deep models of human social competence

Sociable Agents



- Sociability:
  - „the quality, state, disposition, or inclination of being sociable"
  - etymology: 1553, from Latin *sociabilis* "close, intimate," from *sociare* "to join, unite," from *socius* "companion"
- Sociable agents - phenomenologically
  - easy and intuitive to interact with
  - affable, enjoyable to interact with
  - build rapport
  - companionable, cooperative, associable
  - value social interaction with people at a functional level, e.g., to enable learning or create convergence

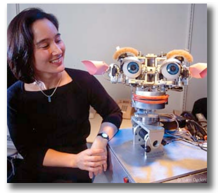
Engineering sociability - key factors

- Interactivity & Attentiveness
  - be accessible, attentive and respond appropriately as fast as possible
- Empathy & Resonance
  - be sensitive to and reinforce the others' states and behavior
- Alignment & Convergence
  - coordinate and synchronize on various behavioral & linguistic levels
- Engagement & Dedication
  - demonstrate intrinsic interest and commitment in the interaction
- Companionship & Solidarity
  - reliably be a collaborative, positive, and supportive partner

Social robots

Leonardo

Robotic Life Group, MIT Media Lab
Cynthia Breazeal



Example: Leonardo (MIT)

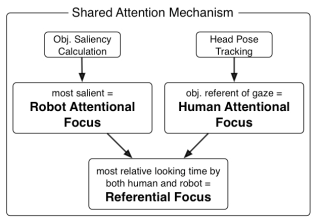
Goal: a robot that can act as a cooperative partner

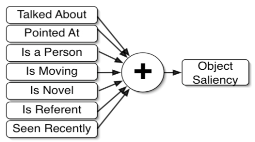
- maintaining mutual understanding of other's internal states
- performing learned tasks collaboratively with a human partner
- social learning of new tasks
- utilizing social cues to demonstrate commitment, manage collaboration, support learning and teaching

Joint attention

Joint attention as a collaborative process

- Attentional focus vs. referential focus





+ social cues (pointing, gaze)

Learning motor skills

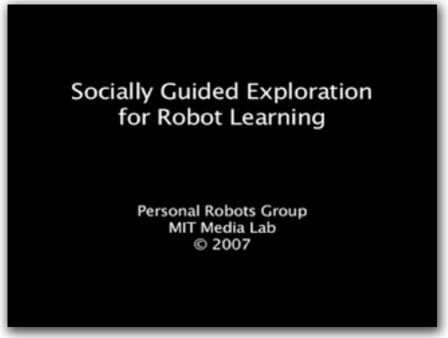
By demonstration

By imitation

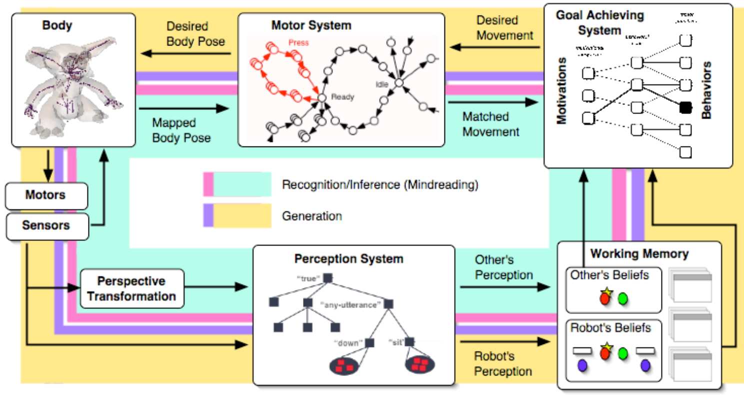
Learning by guided exploration

Captures two important abilities of robot learners

- explore on its own to discover new goals and generalized tasks
- leverage a human partner to improve what and how the robot learns through a collaborative process



Dual use in Leonardo



(Breazeal et al. 2007)

Understanding others?

Need to infer mental states from people's observable behavior, surrounding context, internal models

- crucial capability for socially intelligent agents

Representing beliefs and mutual beliefs

- robot beliefs: dynamic database of belief objects with attributes, formed from percepts
- human beliefs: same model, updated following attential focus
- mutual beliefs marked

Intention recognition?

- (especially when we don't have a collaborative discourse)

Usually tackled inferentially

„Proactive cooperation:“

Intention recognition

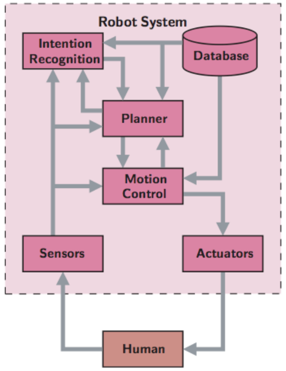
- read (non-)verbal cues
- probabilistic forward model

Proactive planning and execution

- actions that support the infered intentions
- actions that urge the user to unravel her intentions, i.e. decrease robot‘s uncertainty

Database

- model of the environment
- actions derived through learning by demonstration
- FSMs for certain forms of interaction

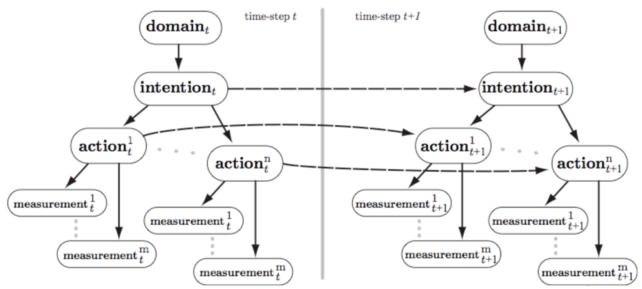


(Schrempf et al. 2005, Univ. Karlsruhe)

Forward model: intention ➜ action & measurement

Dynamic Bayesian Network and Bayesian inference

- intention as hidden state, changing over time
- actions depend on intention and previous actions



(Schrempf et al. 2005, Univ. Karlsruhe)

More realistic: embodied approach

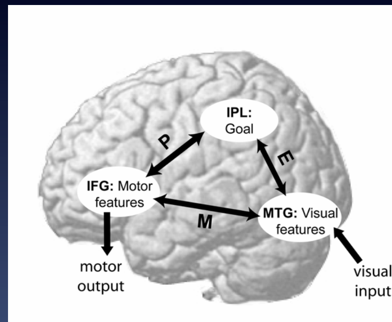
Treat the other as being „like me“ (Meltzoff 1996)

Simulation theory (Gordon 1986)

- we use our own cognitive system “off-line” to simulate others
- cognitive processes are dual-use: generate own actions from our mental states and infer mental states responsible other’s actions by “stepping into their shoes”

➔ Could afford embodied companions...

- better abilities for understanding others
- low-level „resonances“ for aligning with others



EP-M model

(Hamilton 2008, Emulation and mimicry for social interaction: A theoretical approach to imitation in autism, QJEP)

Three basic pathways of social-motor information processing:

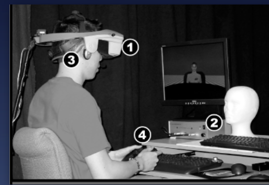
- E-route (MTG-IPL): understanding the goal of an action
- P-route (IPL-IFG): action planning
  - ➡ EP-route: goal-emulation behaviour
- M-route (MTG-IFG): motor mimicry behaviour

Resonating communicators

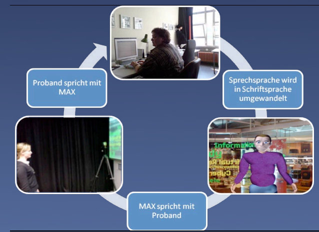
- Behavior mirroring prevalent in humans, mediated by sensorimotor levels
  - ideomotor action, unconscious imitation *(Hull)*, motor mimicry *(Bavelas et al.)*, chameleon effect *(Chartrand & Bargh)*, empathy
- A number of socially desirable outcomes
  - rapport *(Tickel-Degnen & Rosenthal)*
  - liking, trust *(Chartrand; Lakin)*
  - engagement, willingness to communicate *(Tatar; Smith)*
  - conversational fluency *(Kraut, Lewis et al.; Bavelas et al.)*
  - success in negotiations *(Drolet & Morris)*

Mimicry effective with EAs too

- „Digital chameleons“ *(Bailenson & Yee 2005)*
  - mimicking agents are more persuasive and receive more positive ratings than non-mimickers



- People mimic EAs *(Sommer, Krämer & Kopp, in prep)*
  - when talking to *Max*, people mimic the agent‘s smiling
  - not found with self-adaptors or eyebrow movement



Model social learning by imitation

Affords learning of...

- body maps: how own face/body maps onto social others
- mirror system: Dual use of motor representations for recognition of action in others and production of own action
- significancies of others‘ behaviors
- ability to mimic others actions
- foundations of dialogue, turn-taking, conventional rules

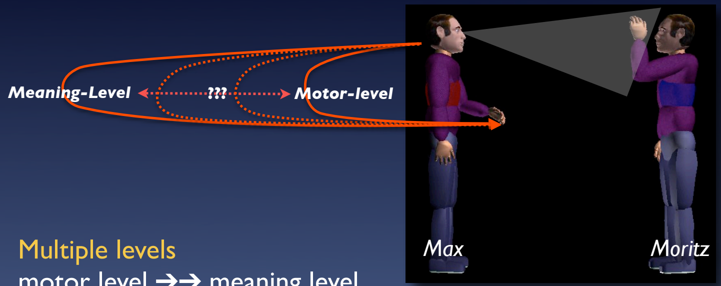
Ongoing debate: mirror system and imitation - hen or egg?

- There seem to be different mechanisms for imitating known and novel actions (Decety et al. 1997; Grèzes et al. 1998) (Goldenberg & Hagmann 1997; Peigneux et al. 2000; Bartolo et al. 2001)

Levels of movement imitation

- Areas in the brain do resonate to intransitive gesture *(e.g., Decety et al. 1997; Grèzes et al. 1998, Montgomery et al. 2007)*
- There may be multiple levels at which resonance can occur and imitation be mediated in parallel *(Rizzolatti et al. 03; Vogt 03; Hamilton 08)*
  - „low-level resonance“: activation of motor centers that code movement features, independent of higher goals (M-route)
    ➔ imitation of the kinematic properties of movement
  - „high-level resonance“: activation of centers that code actions in terms of its consequences and hierarchical goal structure (EP-route)
    ➔ imitation of the communicative intention with potentially different behavior, emulation

Modeling imitation and resonance



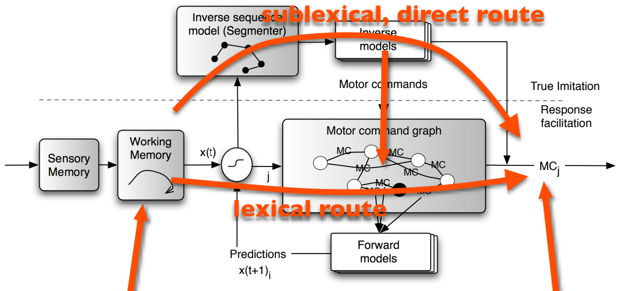
Multiple levels
motor level ➔➔ meaning level

Multiple routes
goal vs. motor, novel vs. familiar

Multiple significancies
guided by *level-specific* goals

Two routes of imitation

Imitation, learning, and mimicry of manual action and gesture

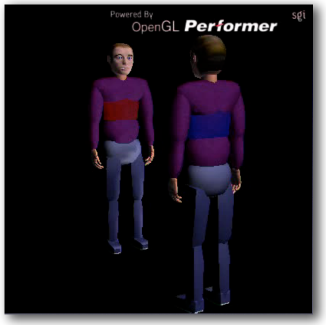


Memory with limited capacity, perceptual representations of stimuli (hand position and shape, body-centered reference frame)

(Kopp & Graser 2006)

Motor commands as corresponding action representations

Motor learning & mimicry



First, learning & imitation via sublexical route,
then resonance & motor mimicry via lexical route

Motor command chains

Readily accommodated by dual route model

- Sublexical route learning of motor programs for the complete movement
- Segment-wise lexical route imitation, i.e. *incremental* motor-level understanding

Next steps toward low-level sociability

- Human teachers
  - Moritz demonstrates MoCap animations
  - human-agent interaction in Virtual Reality

Learn body mapping and inverse models

- Self-organzing maps
- imitation with role-switching *(cf. Breazeal et al. 2005)*

Modeling imitation with virtual humans

1. Motor command level
   - motor command chains
   - contiguous path through a motor command graph
2. Motor program level
   - sequential and simultaneous combination of motor command chains
   - coordinated, parallel traversals of multiple paths
3. Motor schema level
   - represents classes of motor actions (e.g. „waving") with explicitely invariant (mandatory) and variable features (parameters)
   - internally structured, can be hierarchically ordered

„Social machine learning"

- Treat learning as a social cooperative activity *(cf. Breazeal)*
- Learn schemas during iterated, reciprocal imitation games

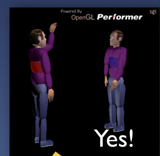
Social imitation learning

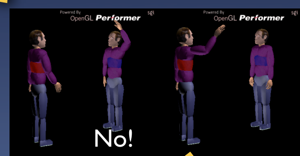
„Kpémuwó and I got as far as we did because first he signed in such a way as to make his intentions maximally clear to me, and then I gestured my understanding of what he signed, and then he in response attempted to correct or narrow my measures of this."

(Stephen C. Levinson, 2006 - On the human „interaction engine", S.43-44)

Motor schema learning

Comparison of demon-strated MP with schema G1
➔ found to be similar according to G1's measure
➔ execute G1 prototype





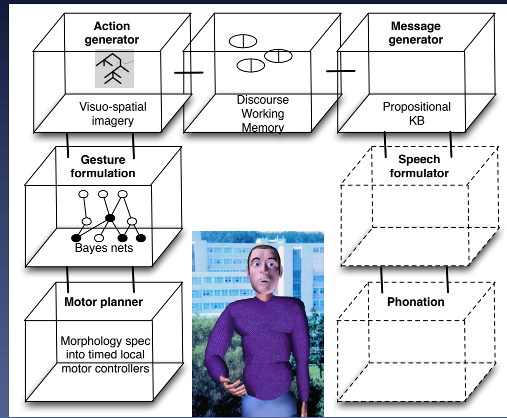
Schema G1 enforced, hand location less important

New schemas G1 and G2, hand location decisive in both

Engineering sociability

- Interactivity & Attentiveness
  - ➡ **Modeling incremental fluent feedback** (not covered today)
- Empathy & Resonance
  - ➡ **Modeling imitation and its sensorimotor grounding**
- Alignment & Convergence
  - ➡ **Putting things together**
- Engagement & Dedication
  - ➡ **Modeling flexible gesture production (and other NVBs)**
- Companionship & Solidarity

Modeling speech & gesture production

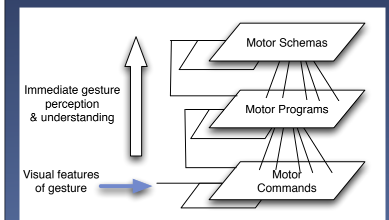


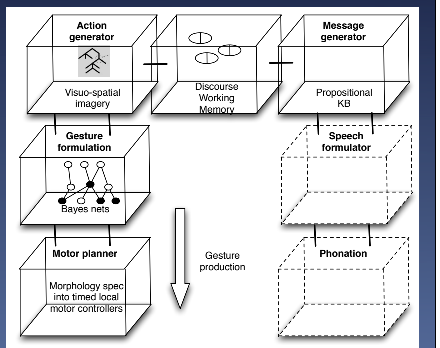
SFB 673
Alignment in Communication

Putting things together

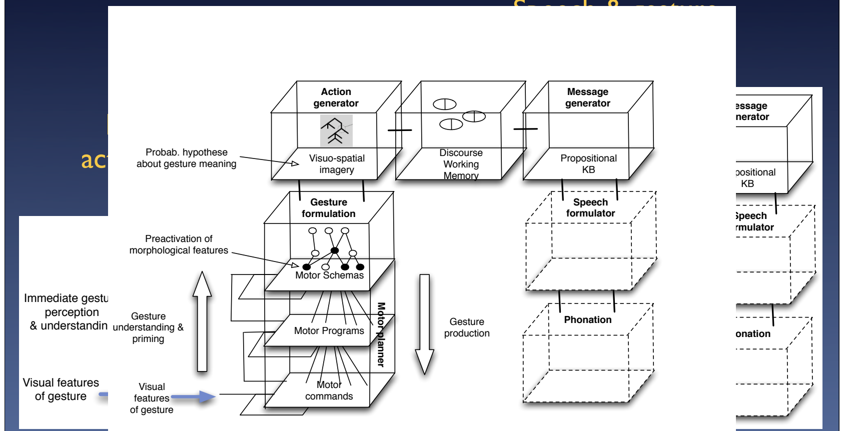
Speech & gesture production

Imitation and active perception





Putting things together



Putting it together

Example: Max perceives a gesture...

- immediate activation of motor representations
- preactivation of motor schemas
- increased probabilities of gesture features (morph., techniq.)
- probabilistic activation of meaning and corresponding multimodal conceptualizations

With respect to gesture this accounts for feedback and motor mimicry, attention and immediate understanding, inter-agent alignment, emulation, stimulus enhacement and engagement

Summary

HCI has been concerned with usable tools, starting to look into interactive and collaborative systems

Formal models and systems for framing collaboration as a joint activity are around

Social and relational behavior can be exploited to carefully foster collaboration

Embodied companions offer great promise for increasing engagement and for studying how the most elemental abilities of cooperation can be acquired via social learning

The final slide...

- Mensch-Maschine-Interaktion
  - Einführung, Grundannahmen, Historie
  - Kognitive Grundlagen: Modell, Wahrnehmung, Aufmerksamkeit, Gedächtnis, Handeln
  - Interaktionsstile und -technologien
  - User-centered Design: Prozess, Evaluationsmethoden
  - Natürliche Sprache und Sprachdialogsysteme
  - Multimodale Schnittstellen
  - Agent-basierte Schnittstellen
- Klausur: 11.8.2008, 12-14, H8
  - Anmelden per eKVV oder Email an *skopp@techfak*
  - Fragen zum Inhalt der Vorlesung (Folien)