Human-Robot Interaction

Module 4: Interaction

Lecture 2: Nonverbal Interaction

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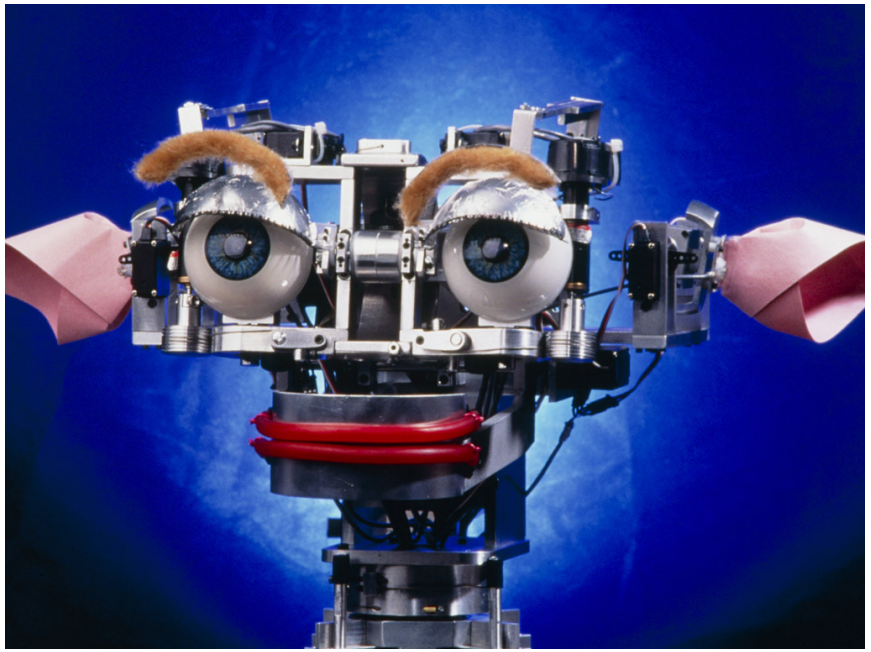
Topics

- Functions of nonverbal cues in interaction
- Types of nonverbal interaction
  - Gaze and eye movement
  - Gesture
  - Mimicry and imitation
  - Touch
  - Posture and movement
  - Interaction rhythm and timing
- Nonverbal interaction in robots
  - Robot perception of nonverbal cues
  - Generating nonverbal cues in robots

Functions of Nonverbal Cues in Interaction

- People use a variety of nonverbal cues when interacting
  - Facial expression
  - Hand gesture
  - Body posture
- From which they infer
  - Nuances of meaning
  - Emotion
  - Intention

Social Robots



Uses postural cues – pulling back and leaning forward –
to express affect and engage people in interaction

Kismet

Kismet was one of the first robots able to demonstrate social and emotional interactions with humans. It had a cartoonish face, spoke with a squeaky baby voice, and could always make people smile.

CREATOR
MIT

COUNTRY
United States

YEAR
1998

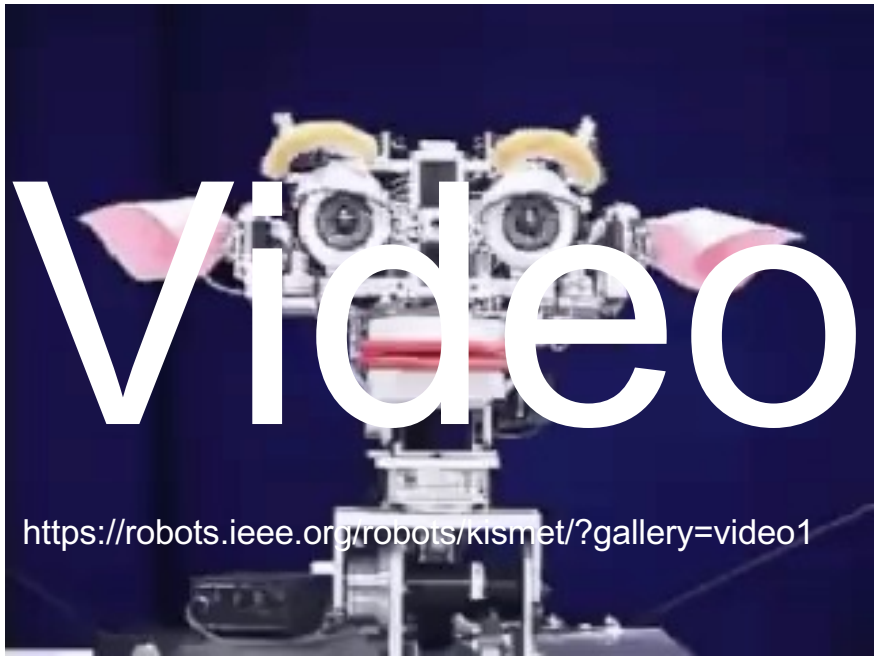
TYPE
Research, Humanoids

Source: https://robots.ieee.org/robots/kismet/

Social Robots

Humanoids

Research



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Social Robots

Uses gaze and reactive motion to express attention and affect

Keepon

Keepon is a social robot that interacts with people and dances when music is playing. It's used to engage with children in autism research. A toy version, My Keepon, is designed for general audiences.

CREATOR
BeatBots

COUNTRY
United States

YEAR
2003

TYPE
Consumer

Source: https://robots.ieee.org/robots/keepon/

Video

https://robots.ieee.org/robots/keepon/?gallery=video1

Source: https://robots.ieee.org/robots/keepon/

Functions of Nonverbal Cues in Interaction

- People use a variety of nonverbal cues when interacting
  - Facial expression
  - Hand gesture
  - Body posture

Robots need to do the same

- Which they use to signal
  - Mutual understanding
  - Shared goals
  - Agreement
  - Emotions
  - Attention

Nonverbal cues are believed to be unfiltered and more genuine (than spoken communication), "revealing people's true attitudes"

Remember this at your next interview

Functions of Nonverbal Cues in Interaction

- Robots will appear awkward if their gestures do not match
  - The rhythm
  - The meaning

  of speech
- Robots will appear awkward if they do not respond in an appropriate manner to a human's nonverbal cues
- Nonverbal cues are central to HRI

Functions of Nonverbal Cues in Interaction

- Eye gaze signal shared attention
- Eye contact (mutual gaze) is expected during interaction

May be culturally dependent:

Nonverbal signals may be appropriate or inappropriate, depending on the context, i.e., the social and cultural norms

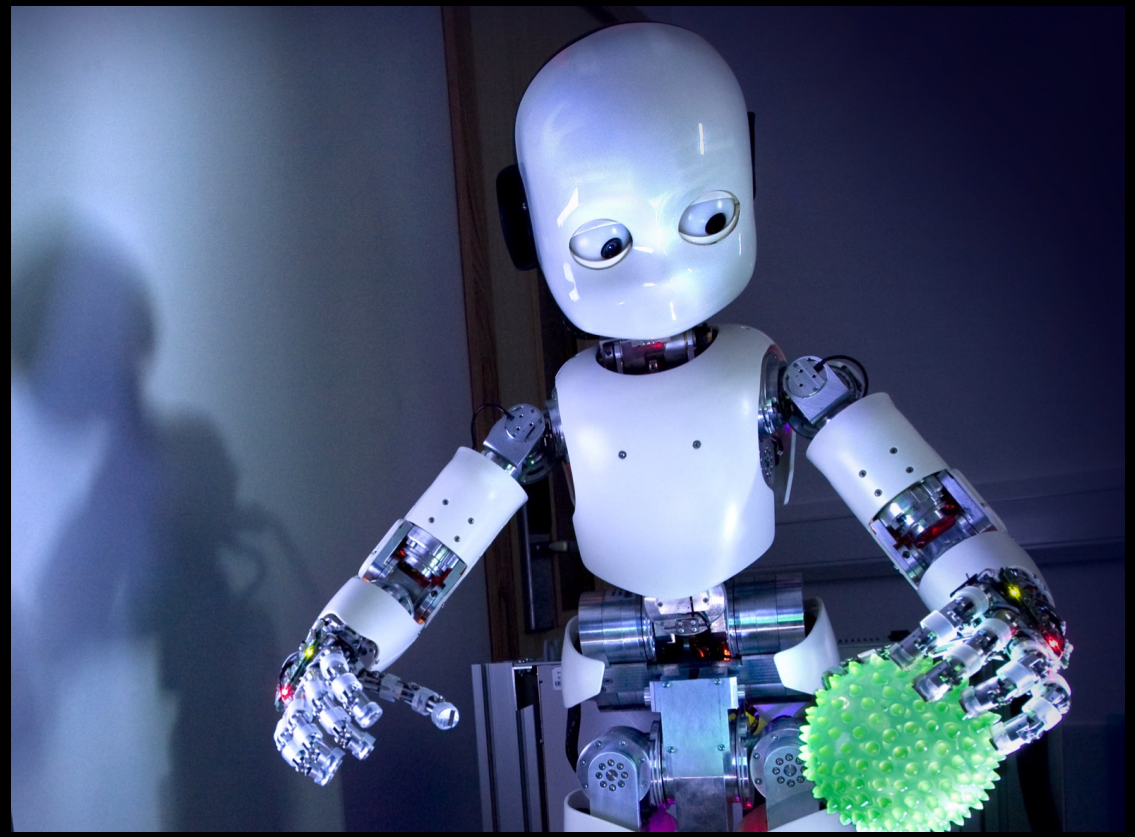
Shaking hands in the West
Bowing in Japan

Eye contact is expected in the West but may be considered disrespectful in other cultures

Gaze and Eye Movement

Gaze is a subtle and important cue for managing social interaction

- Gaze signals
  - Interest
  - Understanding
  - Attention
  - Ability to follow a conversation
  - Willingness to follow a conversation



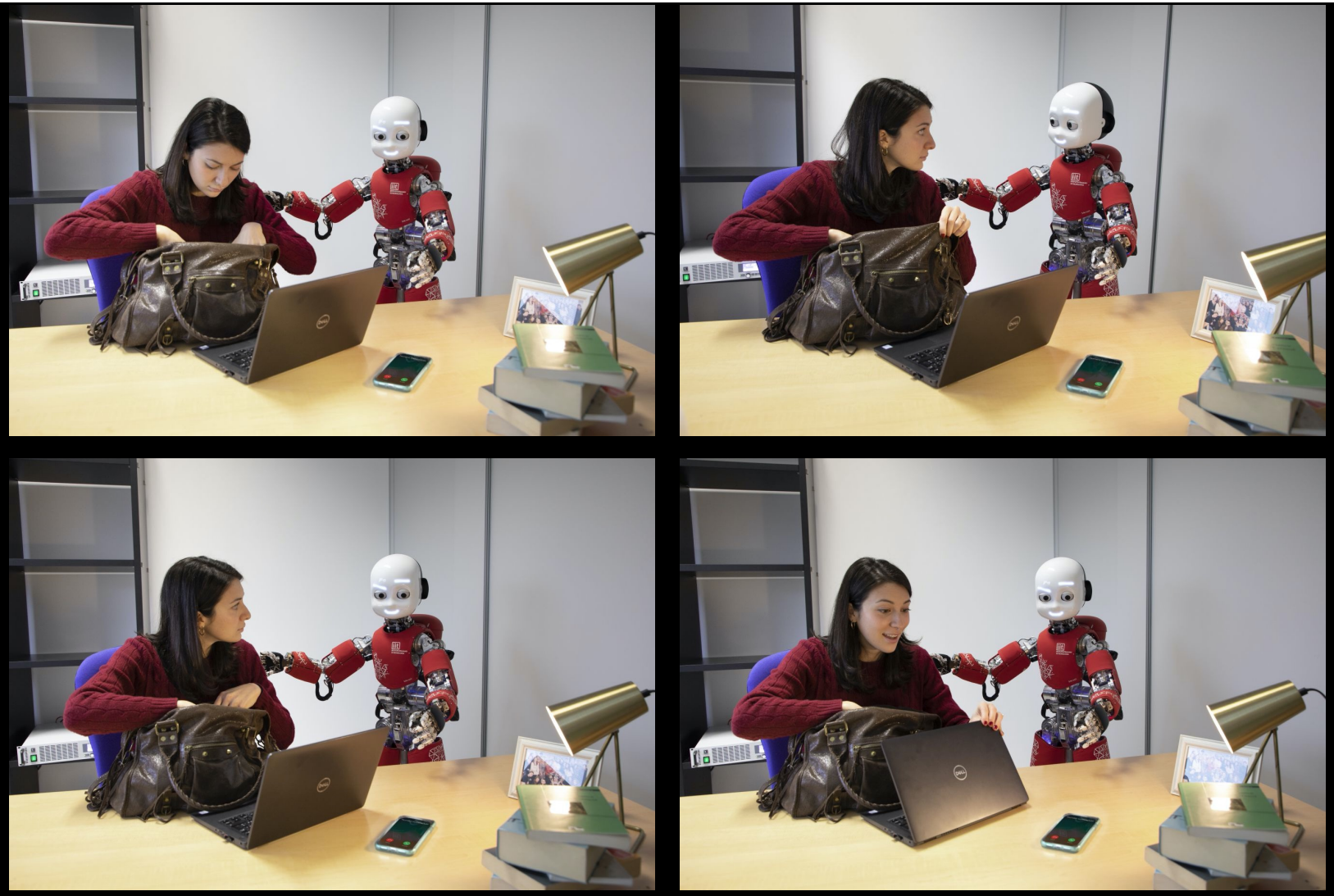
(Bartneck et al., 2020)

Is there anything odd about this picture?

Gaze and Eye Movement

Gaze is a subtle and important cue for managing social interaction

- Gaze solicits & keeps attention
- Gaze signals transitions in turn-taking
  - Action
  - Conversation



"This sequence of pictures depicts a situation in which the iCub humanoid robot (www.icub.org) is interacting with a human, reading her intention to get her phone from her bag, and alerting her to the fact that it is on the desk, hidden from her by the laptop.
Note that this sequence has been staged to illustrate the desired capabilities of a cognitive robot and has not yet been implemented."

Sandini, G., A. Sciutti, and D. Vernon, Cognitive Robotics. In M. Ang, O. Khatib, and B. Siciliano (Eds.), Encyclopedia of Robotics. Springer, 2021.
Images courtesy of Istituto Italiano di Tecnologia

Gaze and Eye Movement

Gaze is a subtle and important cue for managing social interaction

- Gaze is a mechanism for joint attention
  - Interaction partners attend to the same area or object at the same time
  - Timing and synchrony of gaze behavior is important

Gaze and Eye Movement

Gaze is a subtle and important cue for managing social interaction

- Pupil dilation sends strong signals
  - Controlled by the autonomic nervous system (cf. breathing, heartbeat)
  - Uncontrollable
  - Automatic dilation when people see someone physically attractive
  - Designers give robots large pupils to give the impression that the robot is attracted to the user

Gesture

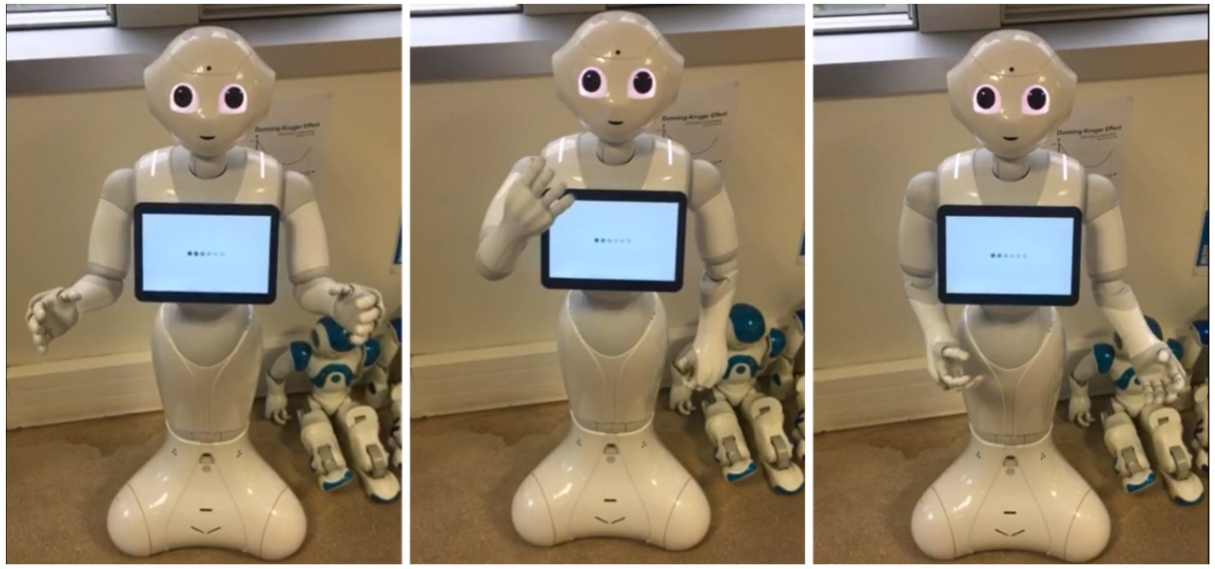
Gestures complement speech

- Deictic gestures
  - Pointing to specific things in the environment
- Iconic gestures
  - Spreading arms when speaking about something large in size
  - Making a heart shape with two hands
- Symbolic gestures
  - Waving hello or goodbye
- Beat gestures
  - Accentuate the rhythm of speech

Gesture

In HRI, the robot gestures have to be

- Natural
- Well-timed
- Smooth



(Bartneck et al., 2020)

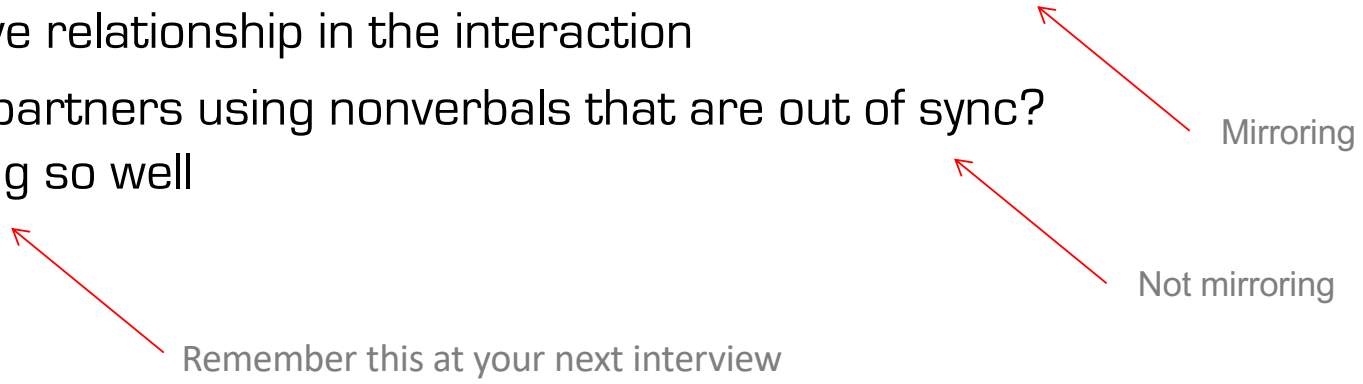
https://engage.ieee.org/AI-Alert-Sign-Up.html

Why does this animation look unnatural?

Mimicry and Imitation

Mimicry

- Unconscious replication of the behavior of another person
- Signals positive affect and liking for an interaction partner
- Two interaction partners use the same gestures or adopt the same posture?
  Probably a positive relationship in the interaction
- Two interaction partners using nonverbals that are out of sync?
  Probably not going so well



Mimicry and Imitation

Imitation

Conscious replication of the behavior of another person

Mimicry and Imitation

Imitation and mimicry can be used in HRI

- To improve interaction and
- Persuade people to follow the robot's suggestions

Touch

- Both deliberate and incidental touch can have beneficial effects
  - especially if the interaction partners are from the same social group
- Touch can have negative effects
  - especially if the interaction partners are from different social groups

Touch

Touch is an integral part of natural human-robot interactions

- Functional tasks, such as handover and manipulation
- Social tasks such as handshake (or fist-bump) when greeting

Posture and Movement

Posture can be used to interpret a person's emotional state

Slow movement
Dropping shoulders
Lethargic gestures

Upright bearing
Fast movements

Particularly important if the person's face is not visible

Posture and Movement

Posture can be used to signal a person's disposition:

- Attention
- Engagement
- Attraction

Defensive posture: holding arms in front of the body 

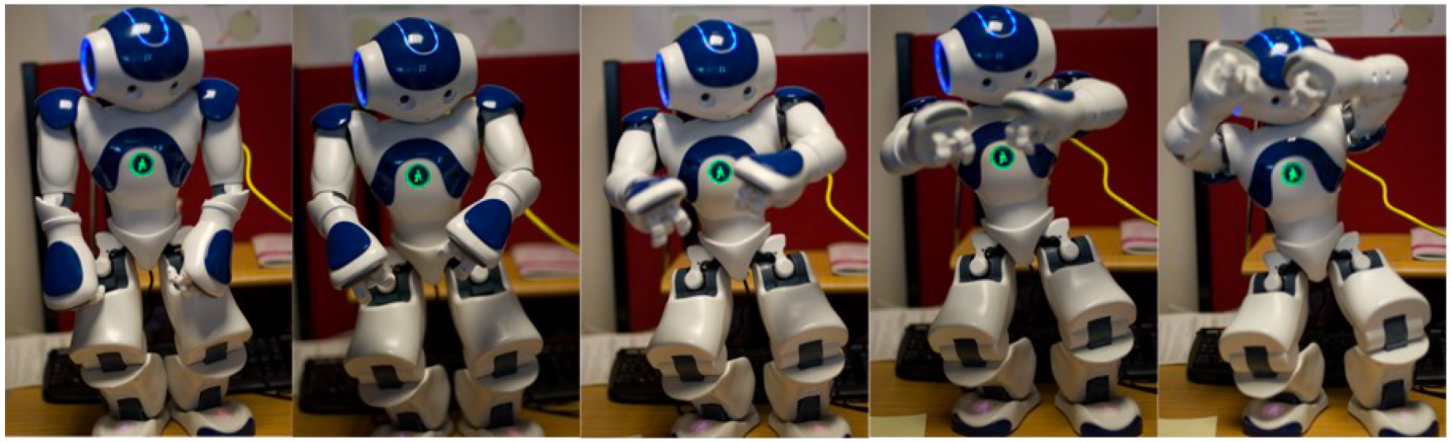
Positive posture: open arms; hands behind back 

Posture and Movement

Micromovements can convey the impression that a robot is lifelike

Often implemented as small, random perturbations of the robot's actuators

The amount and speed of movement can also signal the robot's (simulated) emotional state



(Bartneck et al., 2020)

Interaction Rhythm and Timing

Effective communication between two agents requires them to be "rhythmically entrained"

For example, when taking turns in the interaction: "turn-taking"

Entrainment: the "coupling of two independent oscillatory systems in such a way that their periods of oscillation become related"

(Cummins, 2009)
https://www.sciencedirect.com/topics/psychology/entrainment

Doing things together, such as speaking and acting, at the appropriate time, each interaction partner influenced by the pattern of behavior of the other interaction partner

Interaction Rhythm and Timing

The effects of rhythm are significant:

Being out of synchrony can impede effective interaction

Being out of synchrony can lead to a less positive impression of the interaction partner

Take-home message: establishing and maintaining a rhythm improves HRI

Robot Perception of Nonverbal Cues

Increasing use of machine learning to equip robots with the ability to

- Perceive nonverbal cues
- Infer the degree of engagement
  - Eye contact
  - Body posture

Robot Generation of Nonverbal Cues

Not a trivial task:

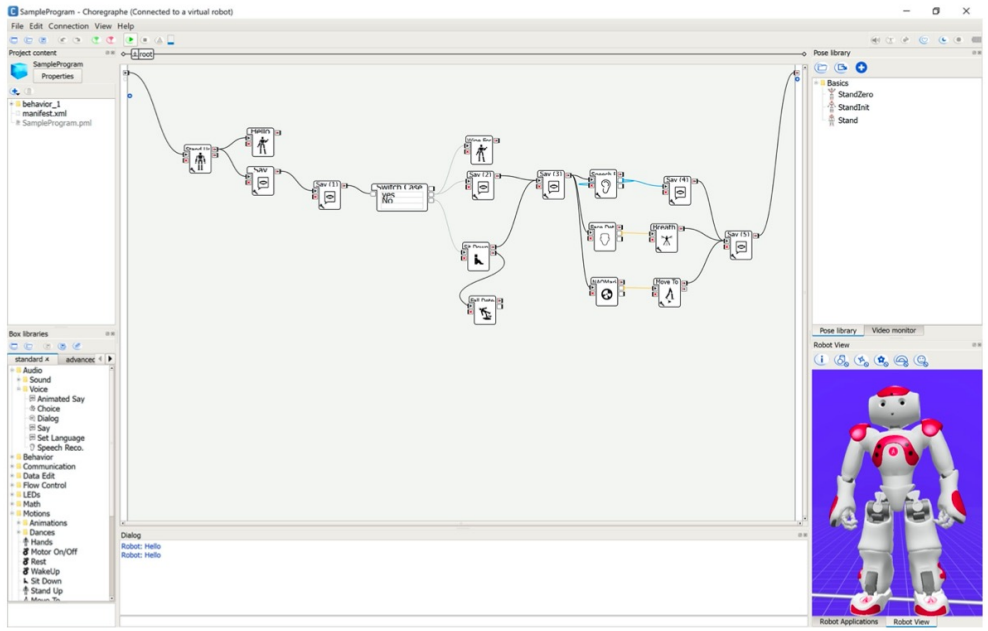
Need to be produced on demand, in real time, as dictated by the circumstances

- The cues are contingent on the interaction
- The cues need to be coordinated
  - with each other and
  - with other forms of communication, e.g. speech

Robot Generation of Nonverbal Cues

Some options include

- Interpolate between manually-determined key frame poses
- Graphical user interfaces, e.g. the Choreographe environment for Nao and Pepper robots
- Use motion-capture systems with humans to acquire natural movements and deploy these on robots



https://www.vicon.com/resources/case-studies/a-simple-motion-capture-system-delivering-powerful-results/

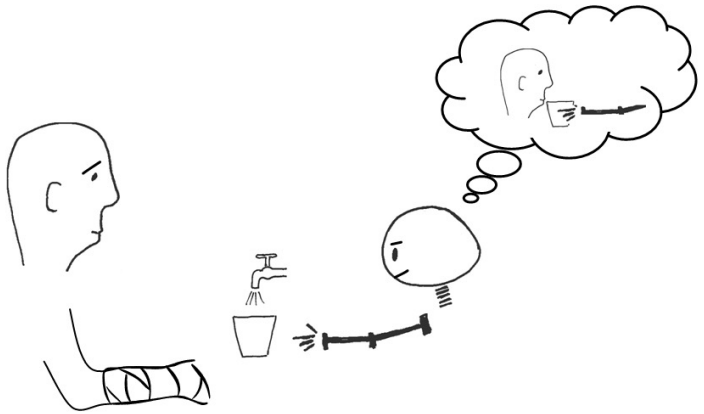
Robot Generation of Nonverbal Cues

Another option:

Cognitive mechanisms, e.g. theory of mind

Not a theory of how the mind works, but an ability to take a perspective (to read) the intentions, goals, desires of an interaction partner

Much research is necessary before this becomes viable



Reading

Bartneck, C., Belpaeme, T., Eyssel, F., Kanda, T., Keijsers, M., Sabanovic, S. (2020). Human-Robot Interaction - An Introduction, Cambridge University Press.

Chapter 6 – Nonverbal Interaction, pp. 81-97.