

Social Learning during Human-Robot Joint Action

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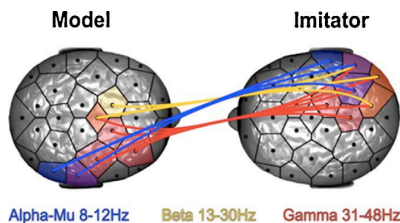
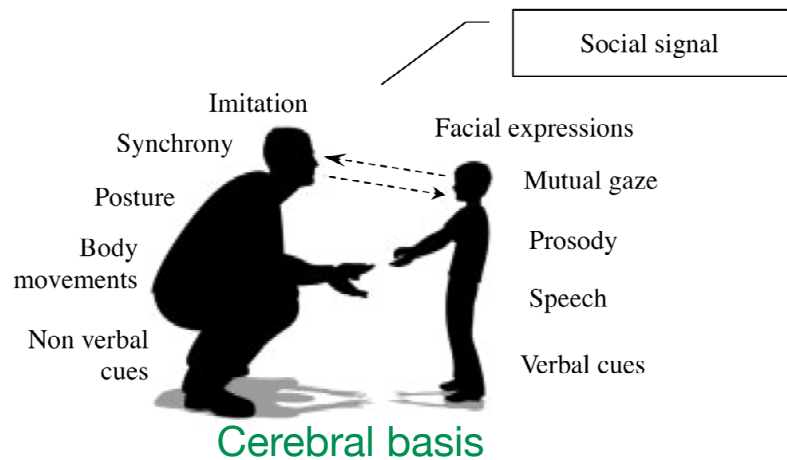
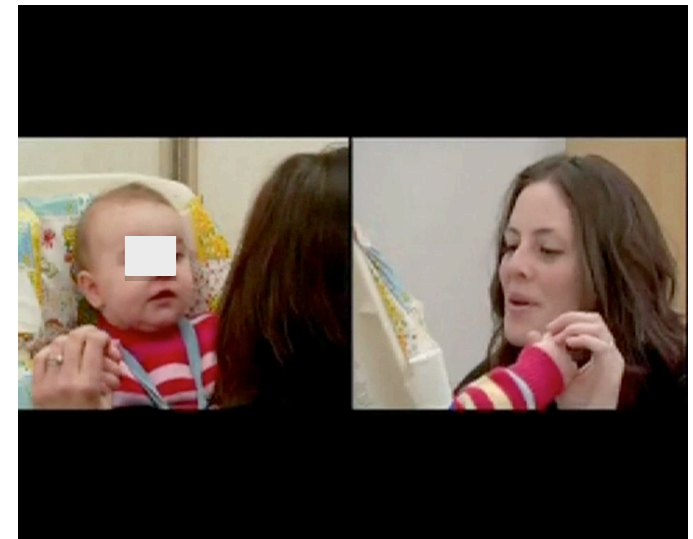
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Social signal processing

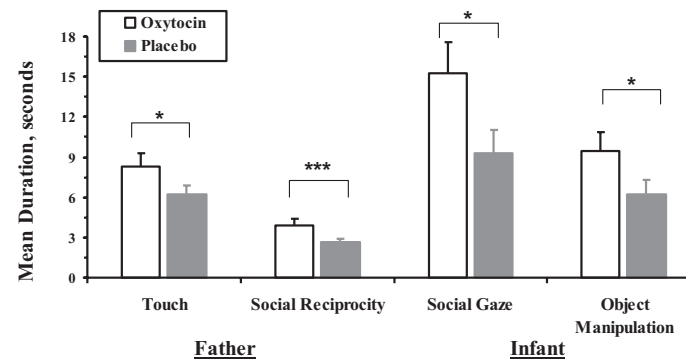
- ▶ Human communication dynamics (Delaherche et al. 2012a):
 - ▶ Computational models with explicit notion of social interaction
 - ▶ From signal processing to interpretation of behaviours
 - ▶ Inter-personal interaction: mutual and dynamic influence of partners
 - ▶ Key concepts in psycho-pathology and robotics

Still face experiments



Dumas et al., 2011

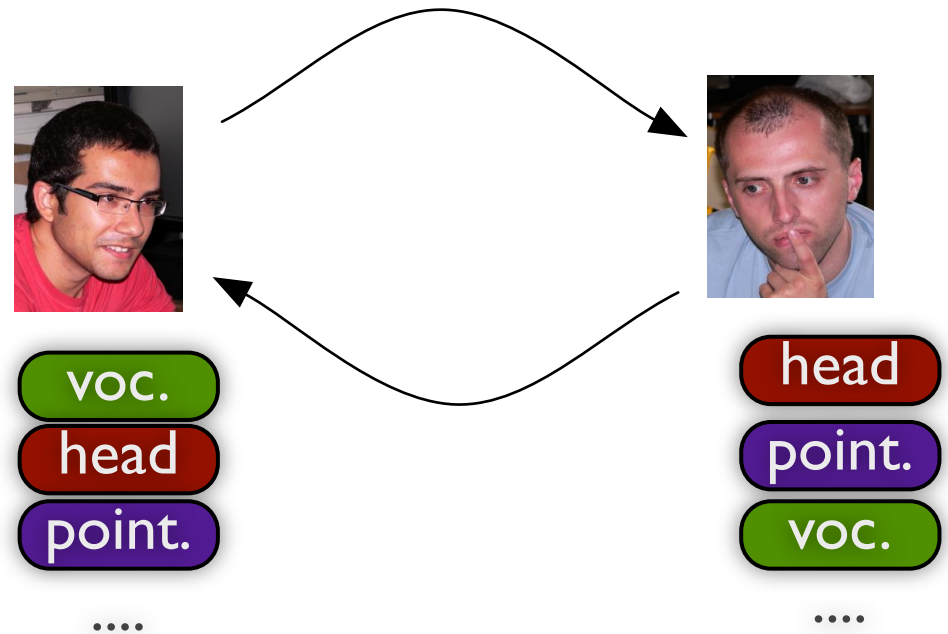
Physiology



Weisman et al., 2012

Interpersonal interaction is a highly dynamic process

- ▶ Behavioral dynamics: non-verbal signals (e.g. gesture)
- ▶ Individual dynamics: multimodal signals (e.g. gesture + speech)
- ▶ Interpersonal dynamics: social signals (e.g. gazing in response to pointing of the partner)
- ▶ The «Telegraphist model» of communication (Shannon) is usually considered in Human-Computer Interaction
 - ▶ Emit / Receive / Respond (Answer)

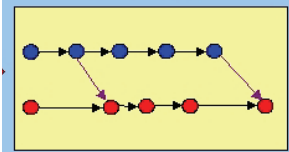


- ▶ **While Interpersonal Interaction in Humans involves «connected individuals»:**
 - ▶ **Interdependent individuals**
 - ▶ **Inherently relational (e.g. role)**
 - ▶ **Transactional (a person serves simultaneously as speaker and listener)**

Non-verbal behaviors in Human-Machine Interaction

Task Learning,
Planning, Decision

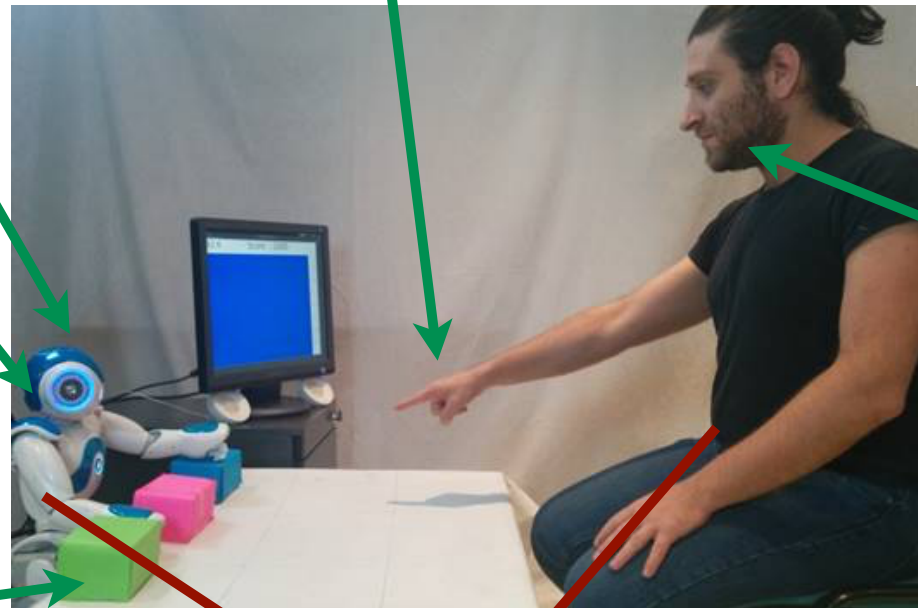
Human-Aware Task
Planner



Behavior synthesis

Object recognition

Action recognition



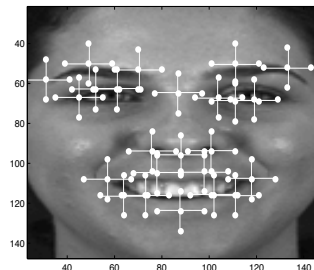
Social signal processing

Automatic Speech Recognition
and Natural Language Processing



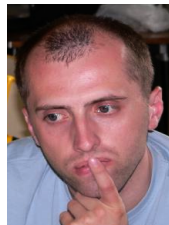
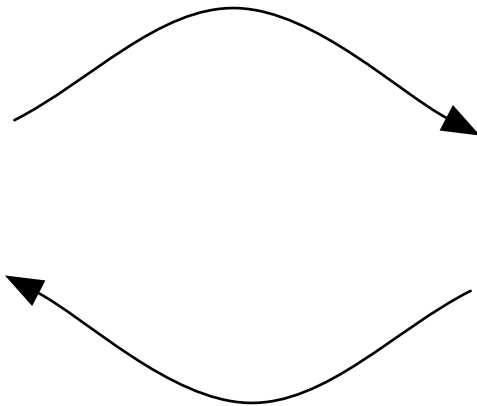
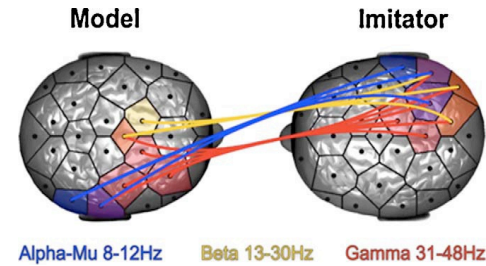
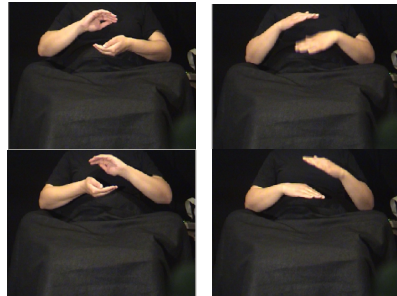
« Look at this box »

Affective computing



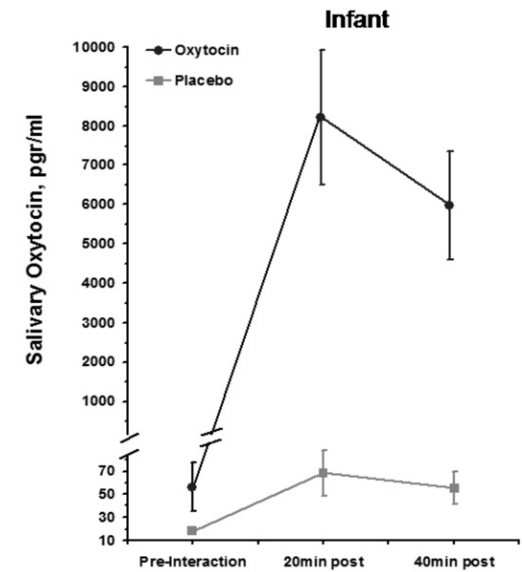
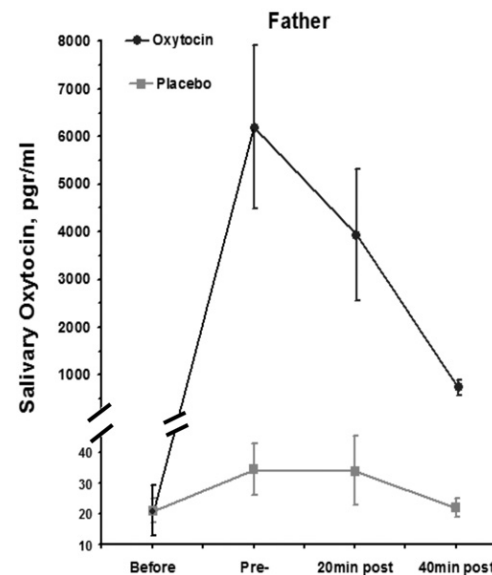
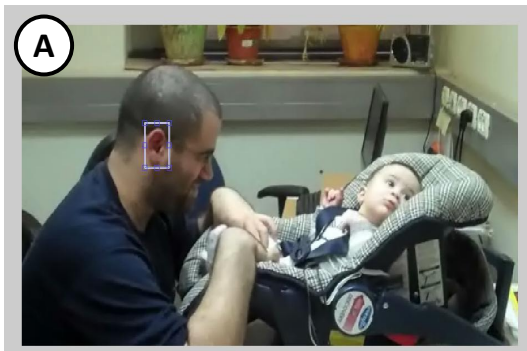
Modeling, Analysis and Synthesis of Machine-detectable traces of psychological and social phenomena (e.g., mimicry, engagement, conflict, interest...)

But these processes involve more than behaviors...



► While Interpersonal Interaction in Humans involves «**connected individuals**»:

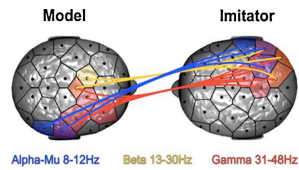
- « **Two body neuroscience** »
- « **Biological synchrony** »



Timing issues

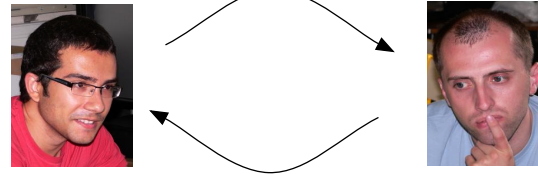


Still face experiments



Neural level

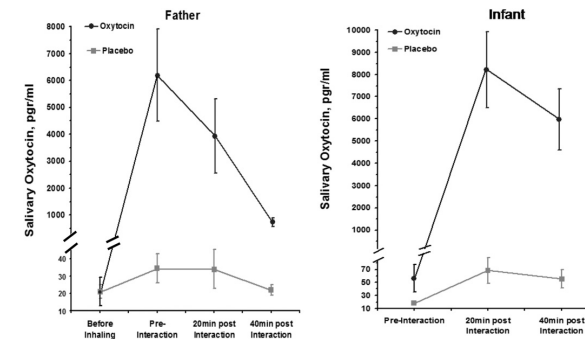
milliseconds



Behavioral level

seconds

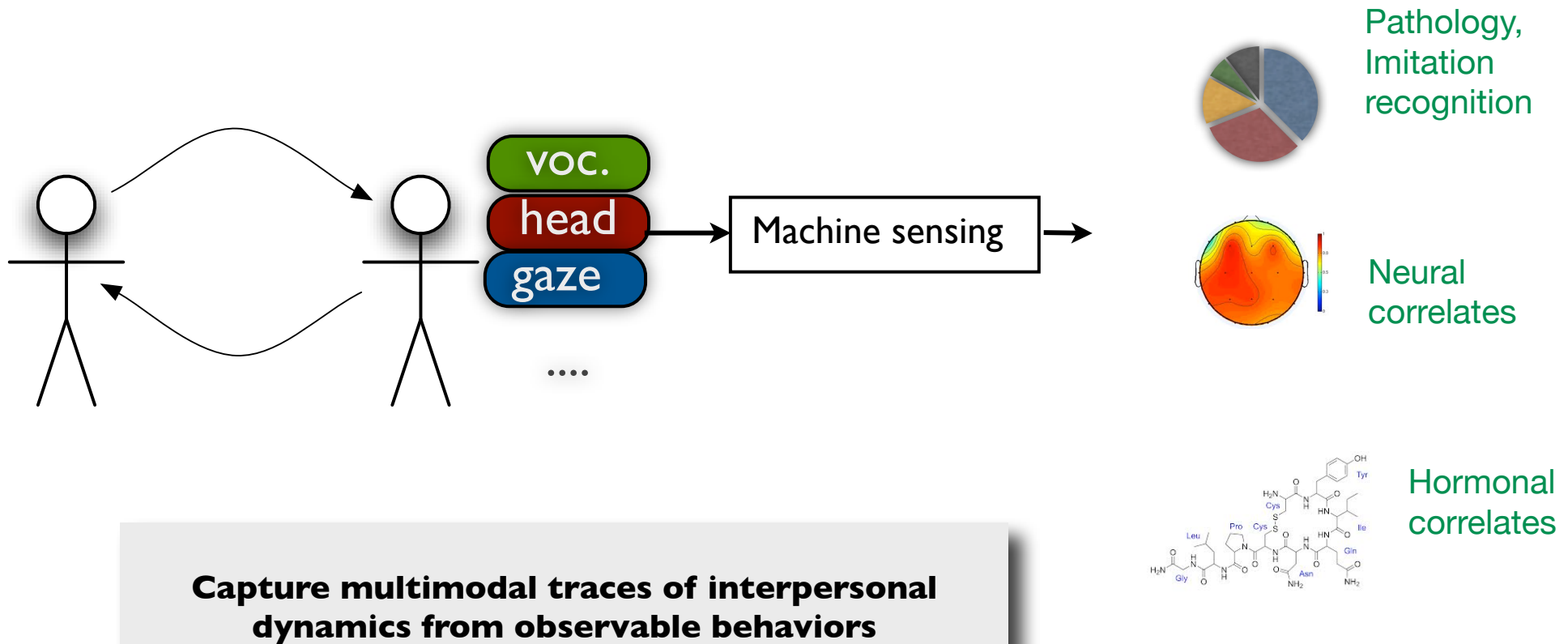
Time-scales



Hormonal level

minutes

Computational modeling of interpersonal interactions

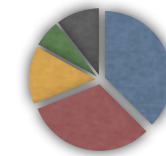


Computational modeling of interpersonal interactions

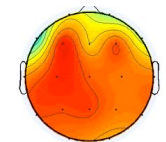
«An observer monitoring an action performed by someone else is never far from also being the agent of that actions» (Jeannerod)



Machine sensing



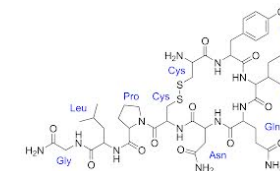
Pathology,
Imitation
recognition



Neural
correlates

**Detectable traces of interdependence of partners
by Machines that Perceive and Act!**

► **Cross-coupling reveals a social signature
(pathology)**



Hormonal
correlates

Interpersonal synchrony

Definitions:

- ▶ « The degree to which the behaviors in an interaction are non-random, patterned, or synchronized in both timing and form» (Bernieri et al., 1988)
- ▶ Social resonance, mirroring, mimicking, matching, congruence, imitation, convergence, the chameleon effect... or interactional synchrony

Interpersonal synchrony

Definitions:

- ▶ Interpersonal synchrony in social interaction between interactive partners is the dynamic and reciprocal adaptation of their verbal and nonverbal behaviors (Delaherche et al. 2012)
- ▶ Three main types of assessment methods for studying synchrony emerged:
 - ▶ (1) global interaction scales with dyadic items;
 - ▶ (2) specific synchrony scales;
 - ▶ (3) micro- coded time-series analyses.
- ▶ It appears that synchrony should be regarded as a social signal per se as it has been shown to be valid in both normal and pathological populations.

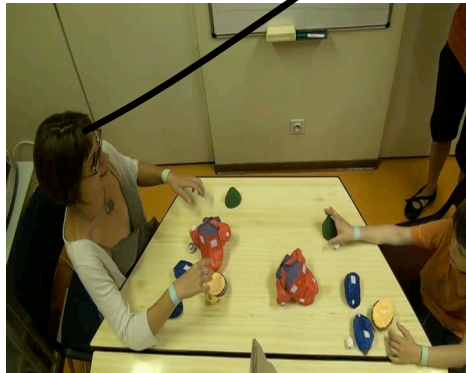
Leclère C et al. (2014) Why Synchrony Matters during Mother-Child Interactions: A Systematic Review. PLoS ONE 9(12): e113571. doi: 10.1371/journal.pone.0113571

E. Delaherche et al. : Evaluation of inter-personal synchrony: multidisciplinary approaches. *IEEE Trans. on Affective Computing* (2012)

Extraction of social signatures during Human-Robot Joint Action

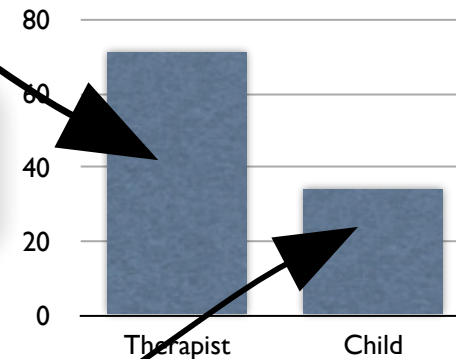
▶ Case of Human-Human Interaction

- ▶ Mutual influence of partners
- ▶ Paradigm-shift **Looking at partner A to analyze partner B!**



Machine sensing of interpersonal interactions

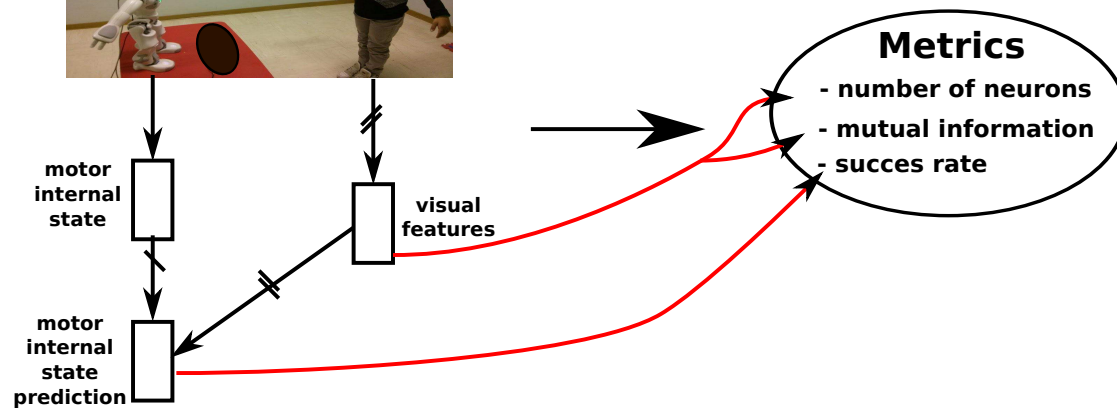
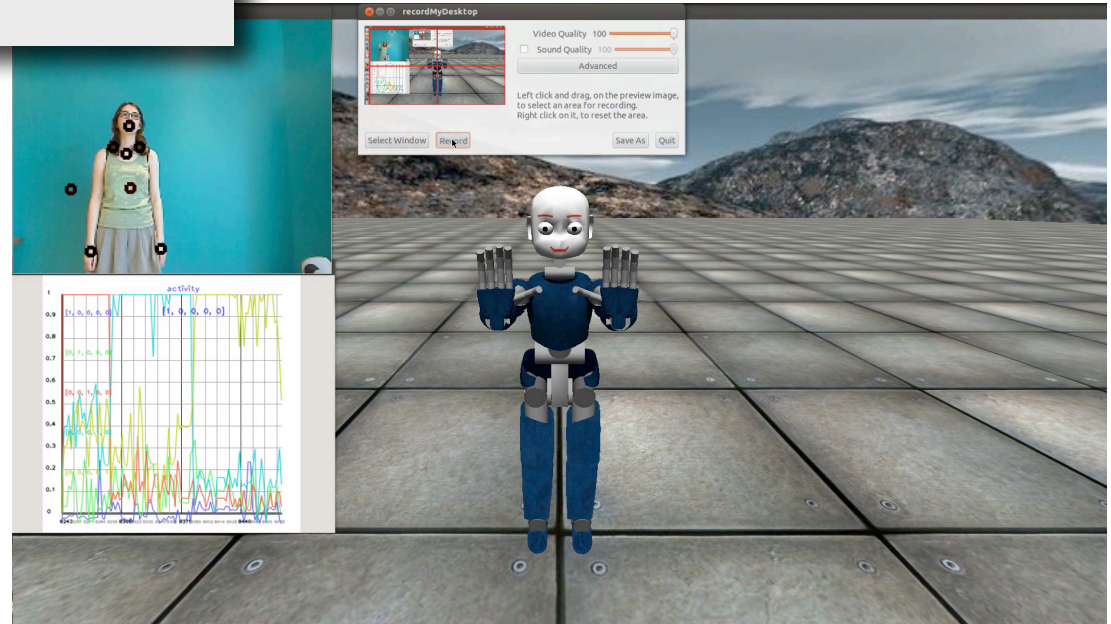
Machine-detectable traces of interdependence of partners



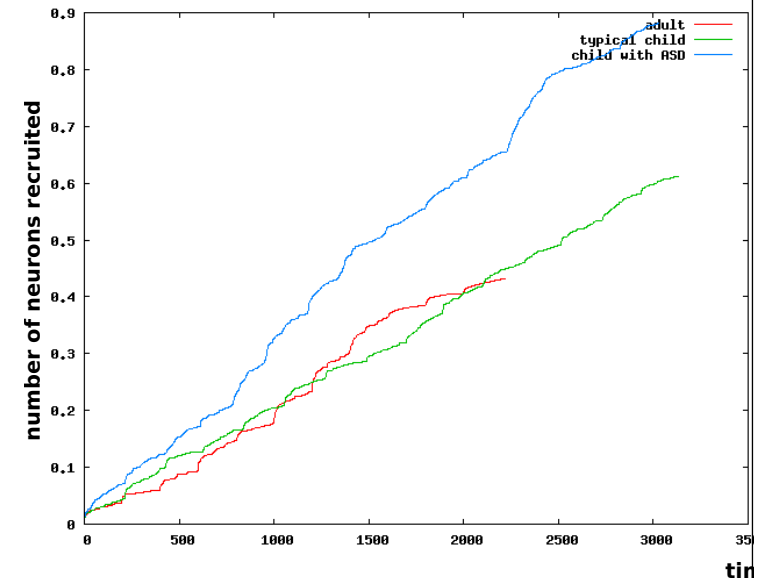
Prediction of the developmental age from non-verbal behaviors

Detectable traces of interdependence of partners by Machines that Perceive and Act!

► **Cross-coupling reveals a social signature (pathology)**



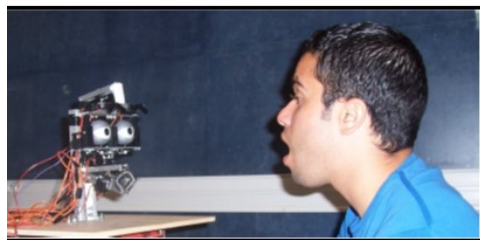
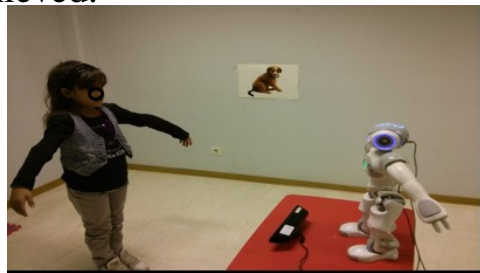
Learning: Sensory Motor architecture



Extraction of social signatures during Human-Robot Joint Action

► Generalize to other tasks and conditions:

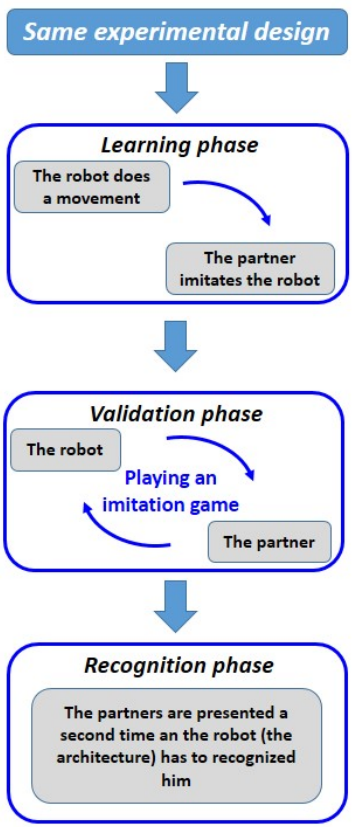
- « Early imitation serves a social identity function » (Meltzoff, 1992 1994)
- Learning dynamics of imitation to recognize identity



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Experiment 1
Nao learns through a motor imitation task (5 arms positions) with:

- 11 adults
- 15 typical developing children
- 15 children with ASD

Basic experiment

Experiment 2
Robot head learns through a motor facial imitation task (5 facial expressions) with 25 adults

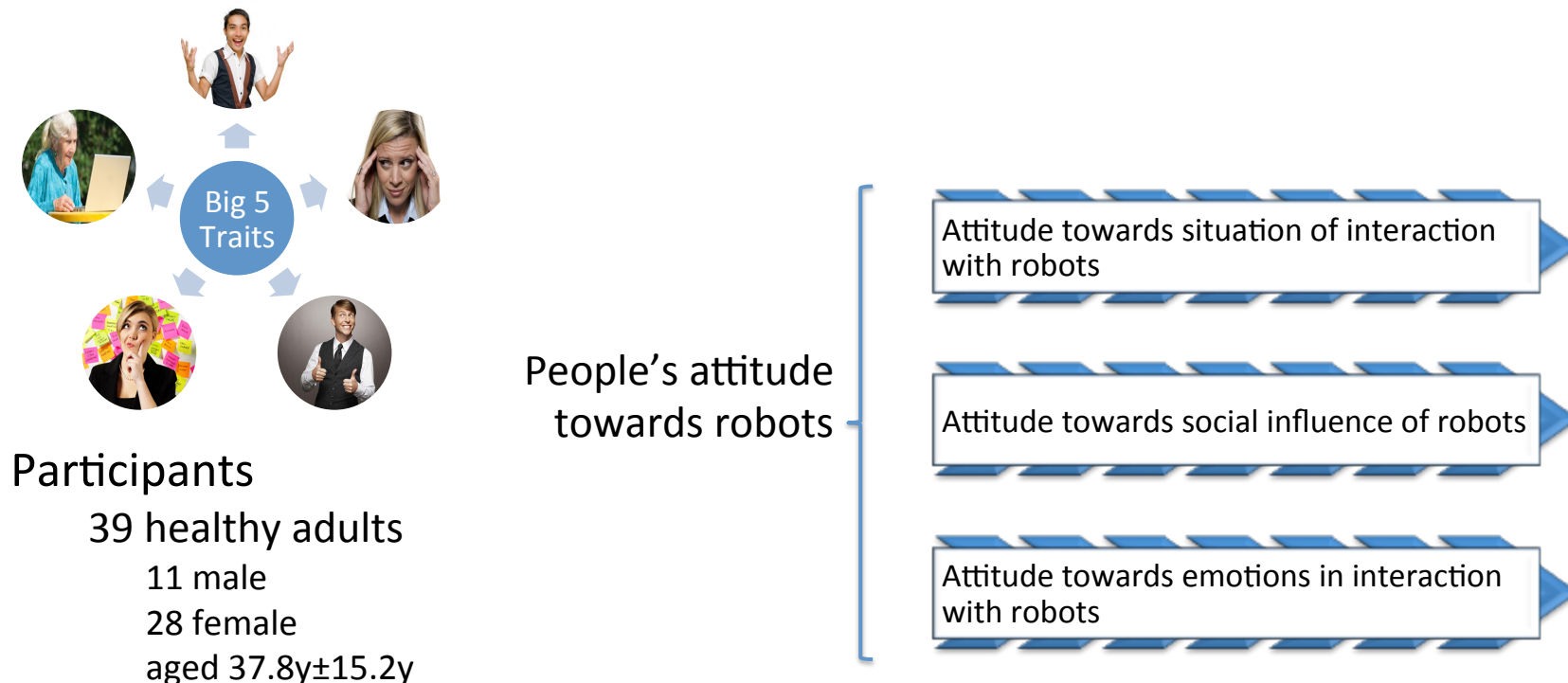
To control for other robot and other task

Experiment 3
Nao learns through a motor imitation task (5 arms positions) with 12 different avatars

To control for visual features independent of motor task

Extraction of social signatures during Human-Robot Joint Action

- ▶ Extracting social traits and a priori on robotics (Rahbar et al. 2015)
 - ▶ Predicting extraversion from non-verbal features during a face-to-face human-robot interaction
 - ▶ Interpersonal (Human-Human) Interactions are not necessarily



Extraction of social signatures during Human-Robot Joint Action

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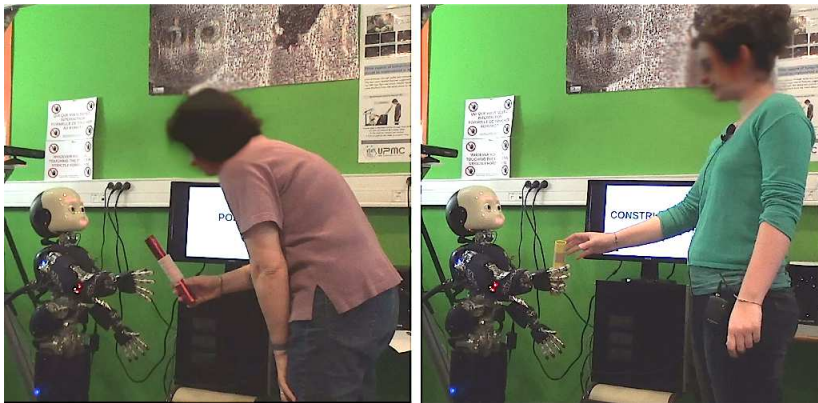


Fig. 2. iCub interacting with two participants.

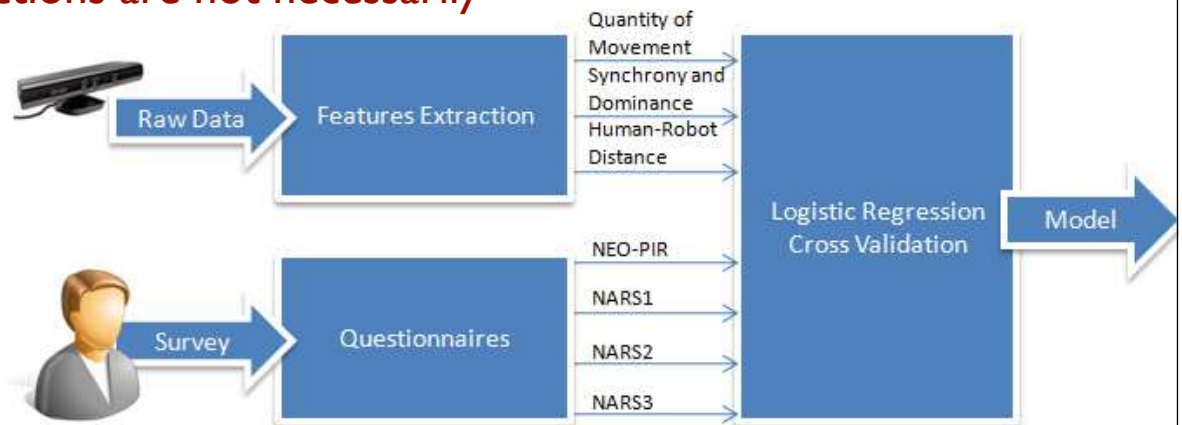


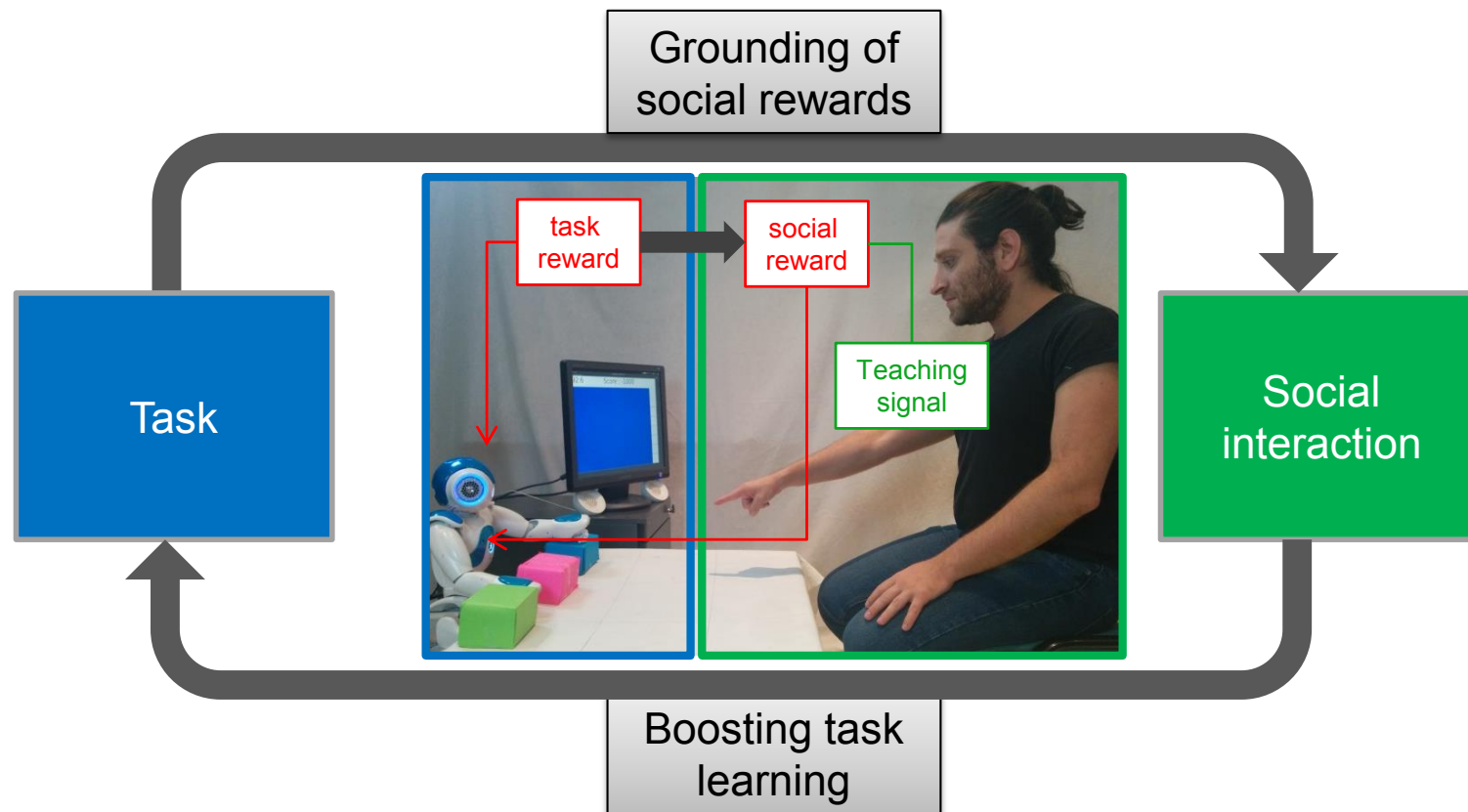
Fig. 1. Overview of the proposed system.

Features	Precision	Recall	F-score
std-d, h-QoM	33%	27%	46%
std-d, h-QoM, h-dom	59%	62%	61%
std-d, h-QoM, h-sync	60%	64%	63%
std-d, h-QoM, h-sync, h-dom	64%	69%	66%

Table 1. Average Percentage of Precision, Recall and F-score

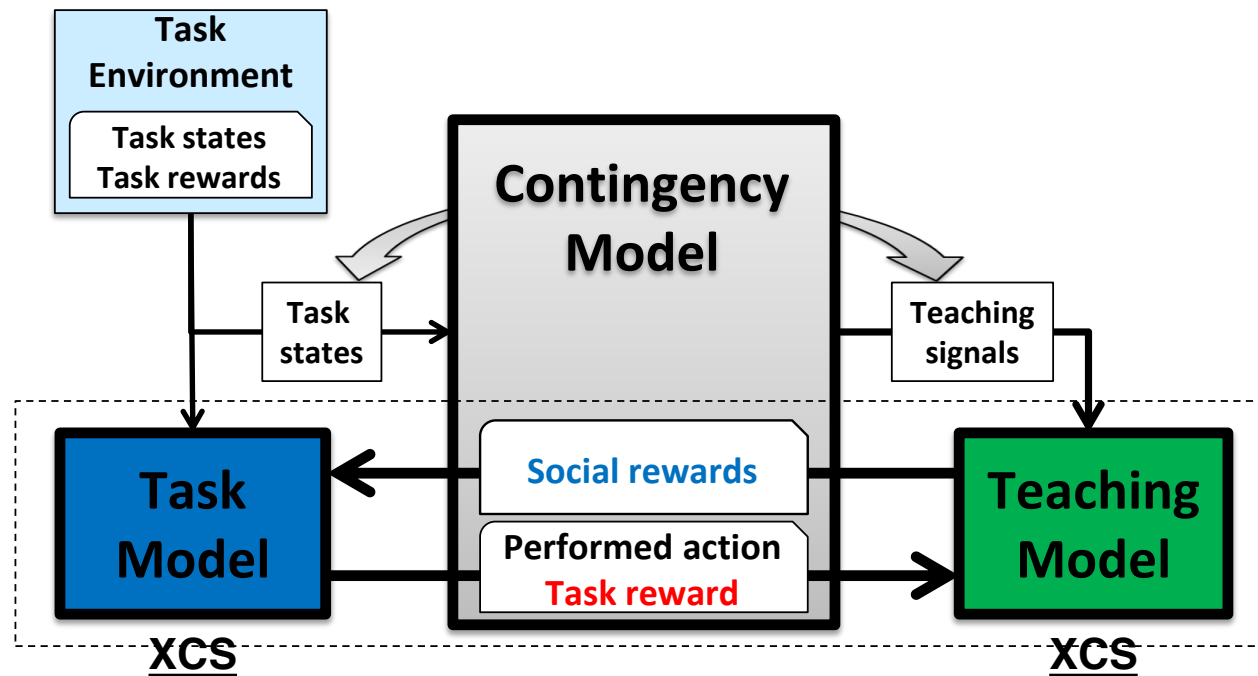
Interpersonal interaction for robot learning

- ▶ Learning new skills (Najar et al. 2015)
 - ▶ Boosting traditional task-learning by interpersonal interactions



Interpersonal interaction for robot learning

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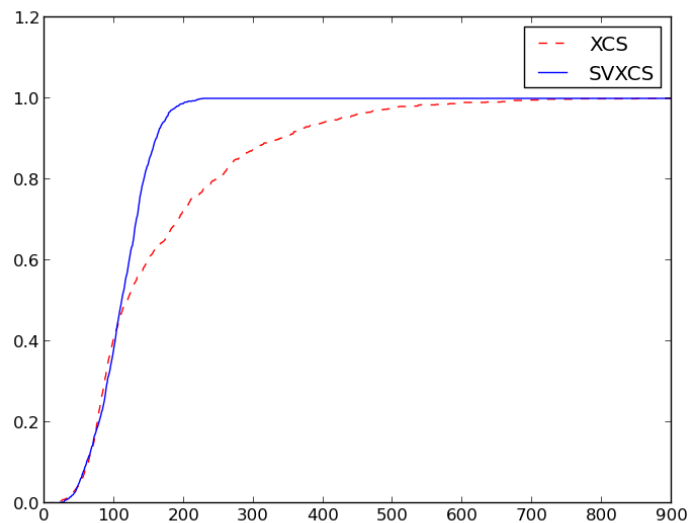
The Task Model learns the task using:

- **task rewards** in multi-step.
- **social rewards** in single-step.

The Social Model learns to predict **action values** using **task rewards** in multi-step.

Interpersonal interaction for robot learning

- ▶ Learning new skills (Najar et al. 2015)
 - ▶ Boosting traditional task-learning by interpersonal interactions



Probability to converge before n steps
(performance over 1000 runs)

The poster features a blue header with the title "Social-Task Learning for HRI". Below the title, the names of the authors are listed: Anis NAJAR, Olivier SIGAUD, and Mohamed CHETOUANI, followed by their affiliation: ISIR UMR 7222 - UPMC / CNRS. On the right side, there is a 3D rendering of a humanoid robot. At the bottom, there are logos for UPMC Sorbonne Universités, ISIR (Institut des Systèmes Intelligents et de Robotique), CNRS (Centre National de la Recherche Scientifique), and the ICSR 2015 International Conference on Social Robotics. The logo for "PROJET ROMEO2" is also present.

Interpersonal interaction for robot learning

- ▶ Exploiting dynamics of social and task learning

Training a robot with evaluative feedback and unlabeled guidance signals

Anis Najar¹, Olivier Sigaud¹ and Mohamed Chetouani¹



March 4, 2016

Conclusions

- ▶ Modeling and exploiting interpersonal interaction dynamics for individual characterization
- ▶ What are the good representation(s) of social signals?
- ▶ Nature of signals: discrete, events, dynamics, multimodal...
- ▶ Learning Interpersonal Human-Robot Interaction during focused tasks
- ▶ Scenarios and applications: lack of synchrony, pathology, Human-agent interaction

Thank you for your attention



Questions?

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