Using sensorimotor communication to enhance on-line social interactions: data and modeling

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GOAL LEADERS

SEVENTH FRAMEWORK PROGRAMME

HFSP

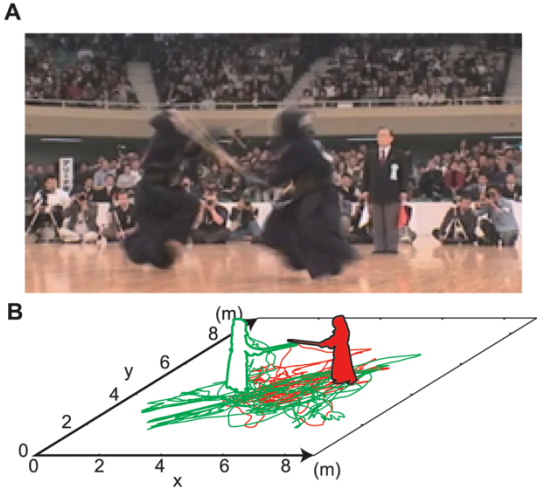
HUMAN FRONTIER SCIENCE PROGRAM

FUNDING FRONTIER RESEARCH INTO COMPLEX BIOLOGICAL SYSTEMS

We continuously exchange bodily (social) signals for coordination

Contact Dance

Penalty kicks (2006)



Deceiving signals in martial arts (Yamamoto et al. 2013)

Sensorimotor coupling

Mutual prediction

From Marc Jeannerod's hompage

Action simulation: off-line re-enactment of the same motor programs (and internal models) implied in online action control and prediction

Prediction (and understanding) in social contexts is hard…

…but we can help each other solve this problem!

Sensorimotor communication - signaling

“The process of altering one's own behavior to facilitate its recognition by other persons”

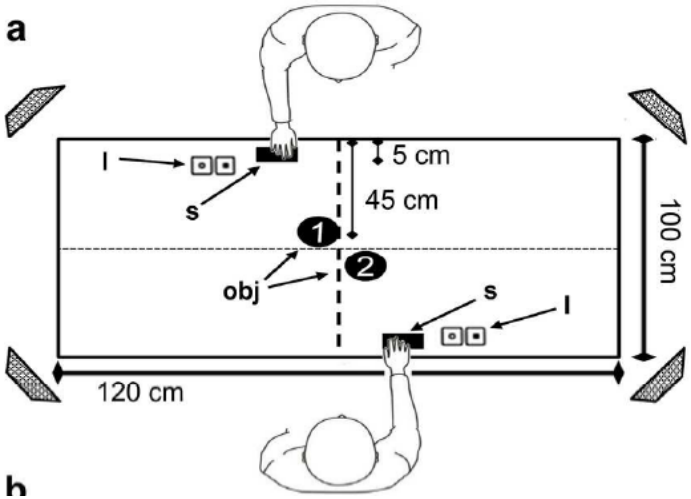
Beyond automatic forms of signaling: we can intentionally / strategically deliver bodily signals as coordination signals to a co-actor (e.g., to reduce her uncertainty) – ultimately, to enhance joint goals. (But also to feint.)

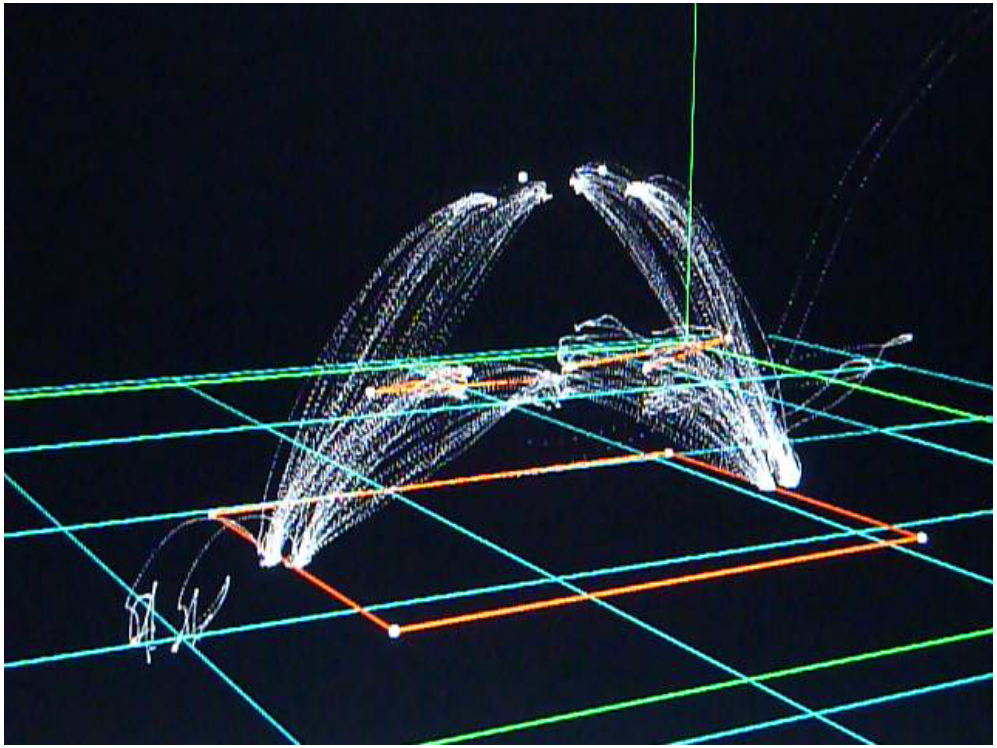
OUTLINE:

- “Why” and “when” using sensorimotor communication?
- “How” can sensorimotor communication be formalized?
- Which task / contexts promote it?
- Which are the relations between sensorimotor and other (more sophisticated) forms of communication?

Sensorimotor communication in joint actions: one example

A simple joint action: reaching a "bottle" simultaneously

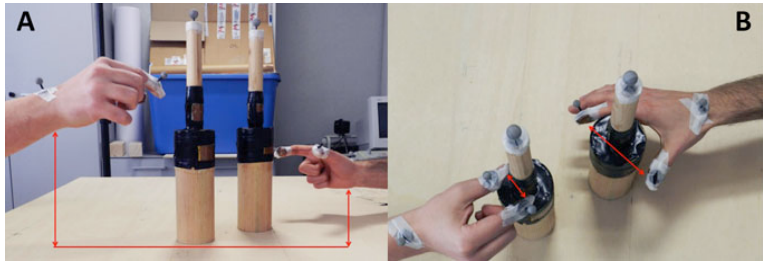




Sacheli, Tidoni, Pavone, Aglioti, Candidi 2013, Exp Brain Res

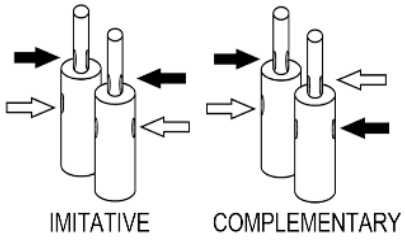
Mutual adjustments (Sebanz et al., 2006); alignment and synchronization of behavior (Bargh & Chartrand, 1999; Pickering & Garrod, 2013); many others

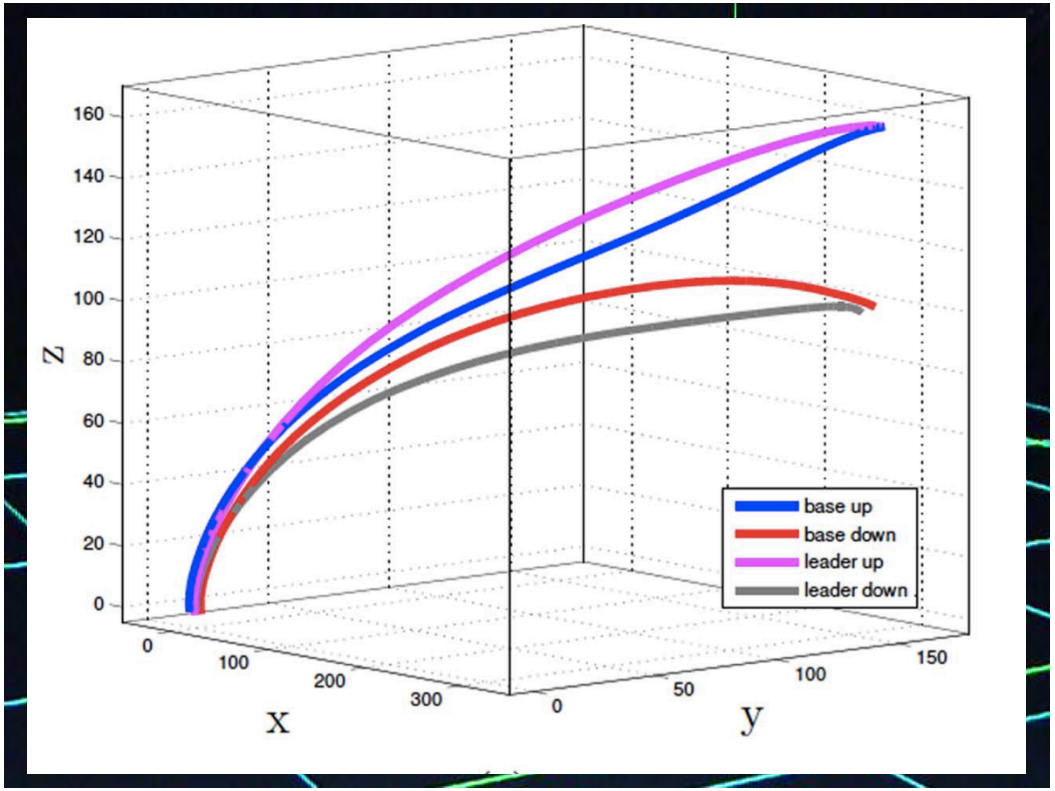
Same joint action, with *asymmetric information*: "leader" and "follower"



Leader: knows where to reach

Follower: knows only if the action is imitative or complementary





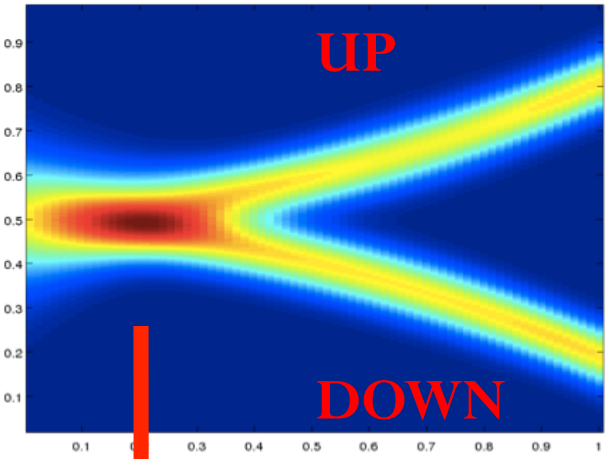
Sacheli, Tidoni, Pavone, Aglioti, Candidi 2013, Exp Brain Res

Signaling strategies! Leaders signal their intentions by carving their movements kinematics

(Note that this is not pantomime or conventional gesture)

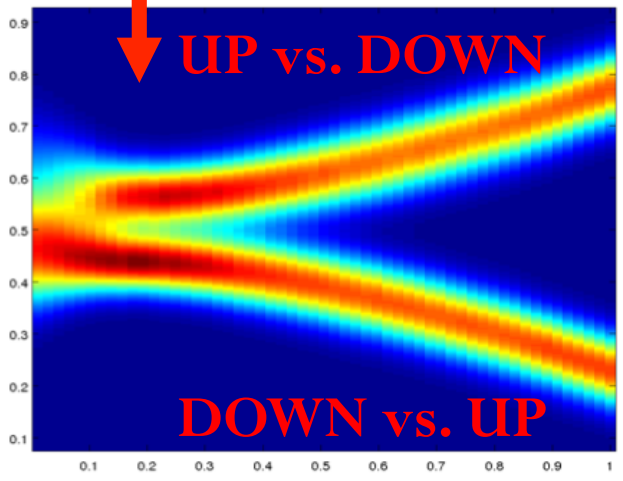
Modeling signaling as *dissimilation*

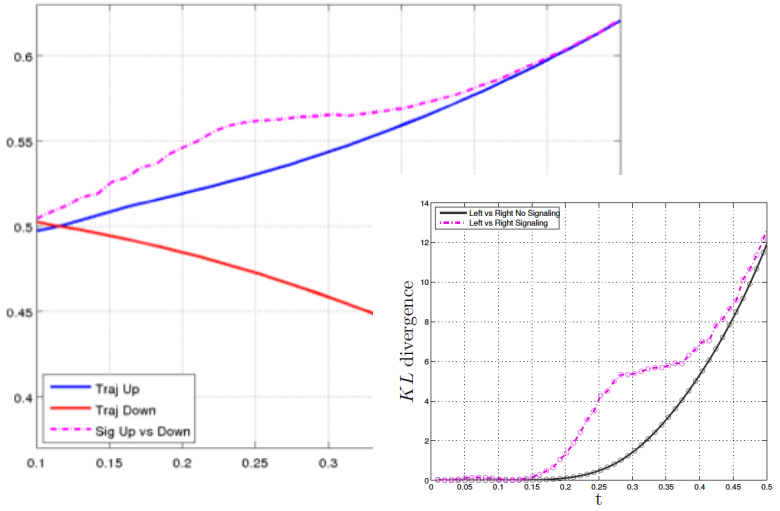
Pezzulo, Donnaumma, Dindo, 2013, PLoS ONE



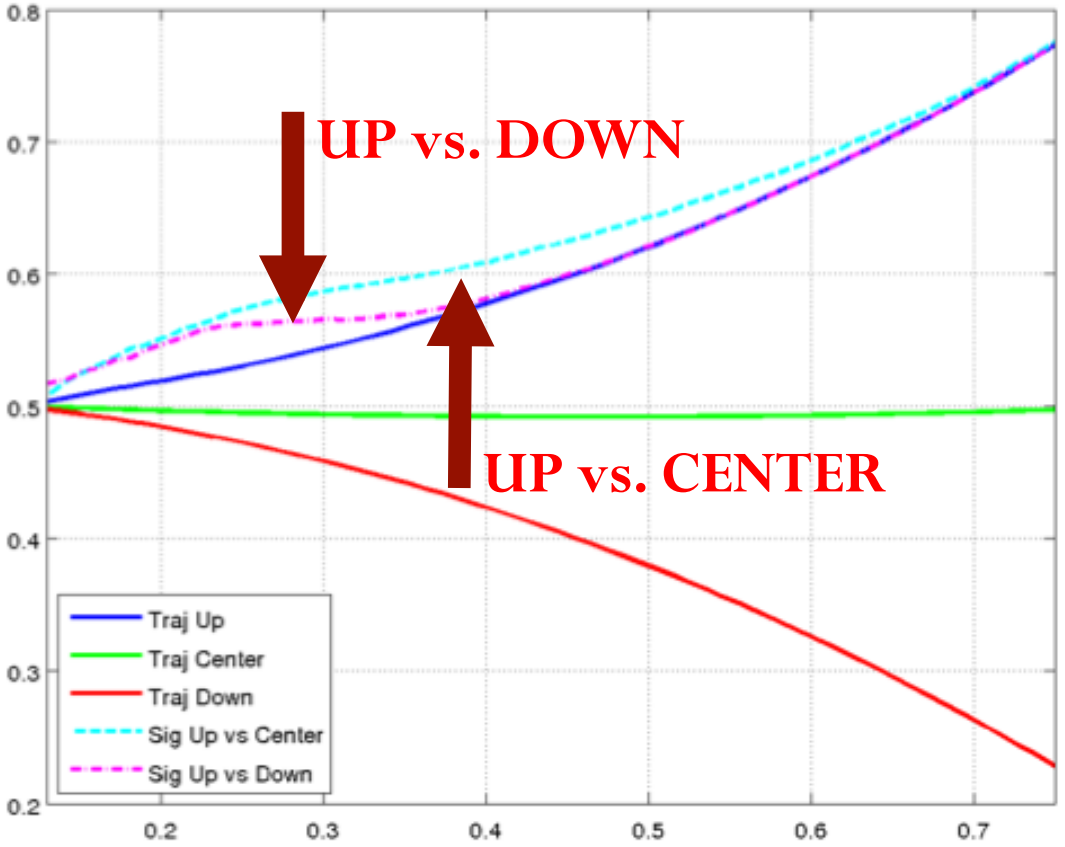
"Default" trajectories for the two actions

When signaling: *dissimilation* effect





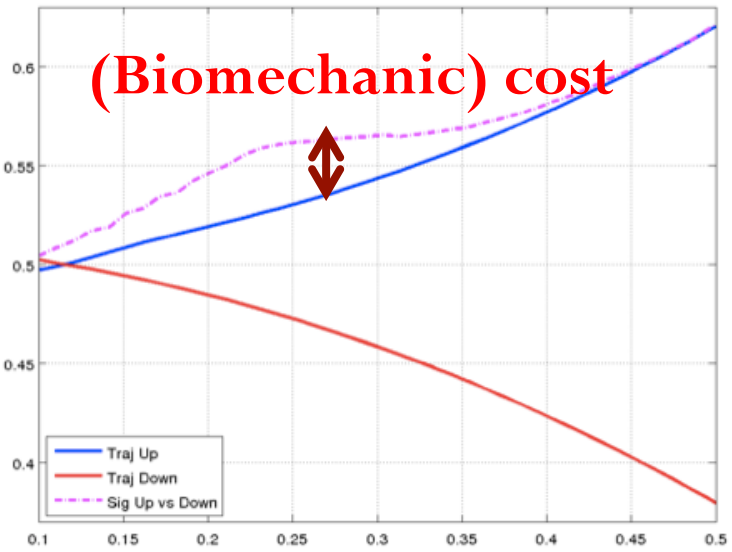
Signaling with three possible actions



Signaling can differ depending on which are the alternative actions – can be a *specific* message

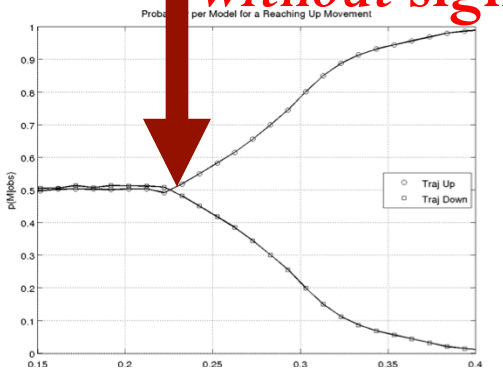
How much to signal? Cost-benefit analysis

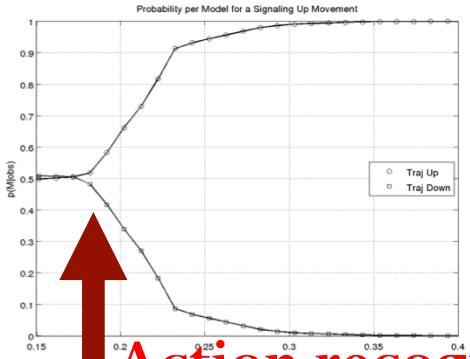
COST for Leader



BENEFIT for Follower / dyad

Action recognition *without* signaling





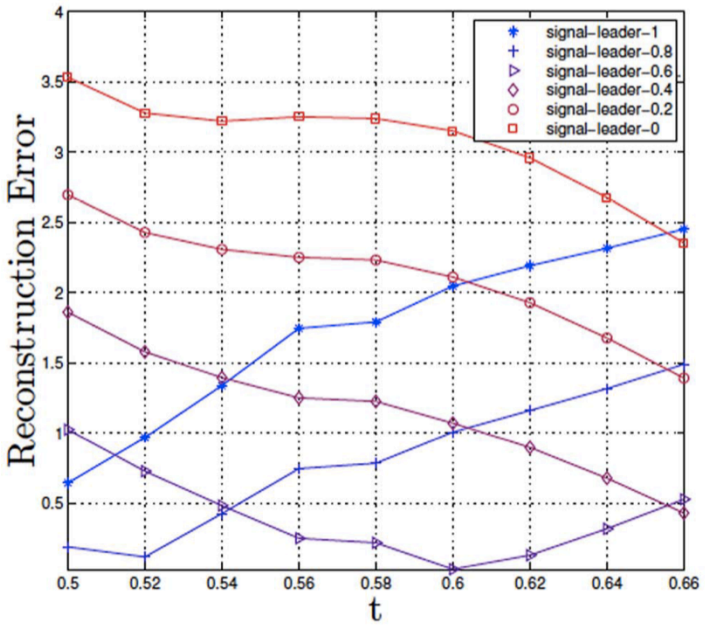
Action recognition *with* signaling

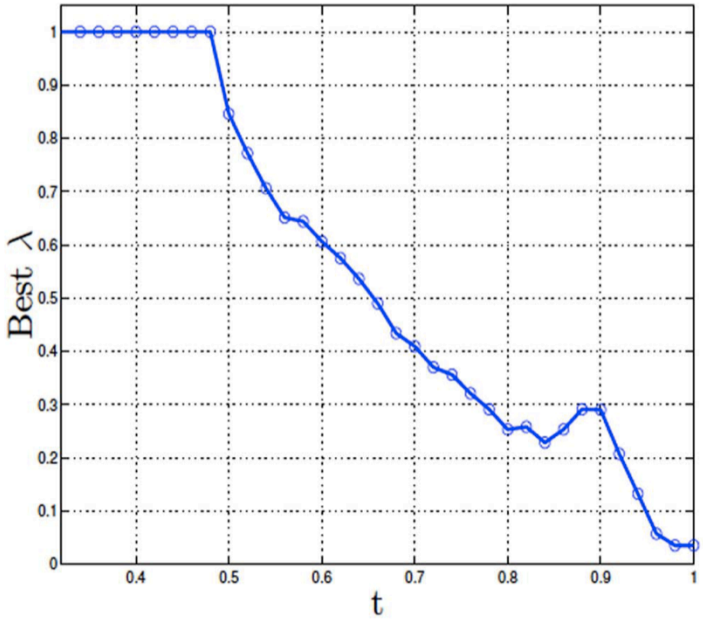
The result of the cost-benefit computation (i.e., the amount of signaling) is called λ (lambda) coefficient.

How much to signal?

Best lambda coefficient over time

- Data analysis: We reconstructed Leaders' λ (i.e., amount of signaling) over time in *Sacheli et al. 2013 (Exp Brain Res)*





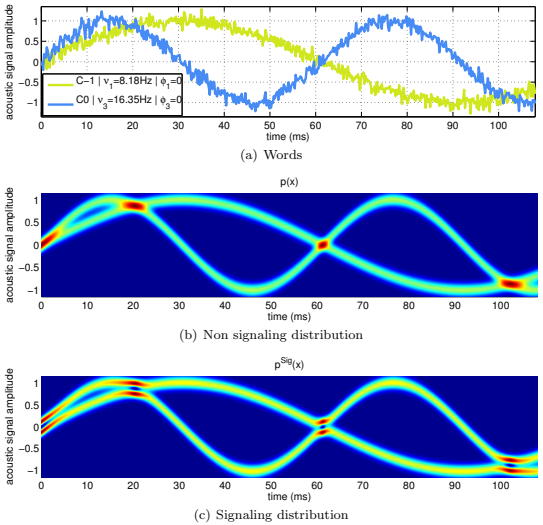
Amount of signaling varies within trials

To sum up

- We use bodily signals *strategically* to enhance interaction success
- **Signaling: pragmatic + communicative intention**
- **Joint action optimization**: pay a cost to help solve interaction problems
  - Signaling has a **cost** (e.g., biomechanic cost); seems unreasonable from an individualistic perspective. But can be advantageous if considered part of a **joint action optimization** framework
  - Make your action discriminable / predictable; your mind "readable"

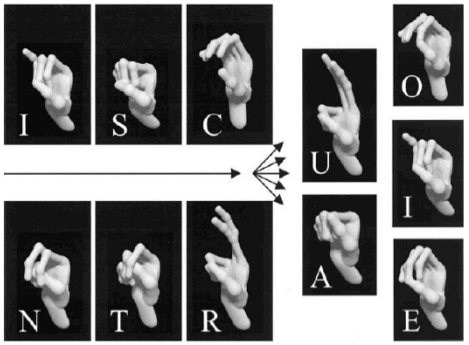
Signaling in other domains…

Picture from Asada Laboratory



Child-directed speech (*motherese*, Kuhl et al., 1997); over-articulation of speech in noisy pubs (*Lombard Effect*). Child-directed action (*motionese*).

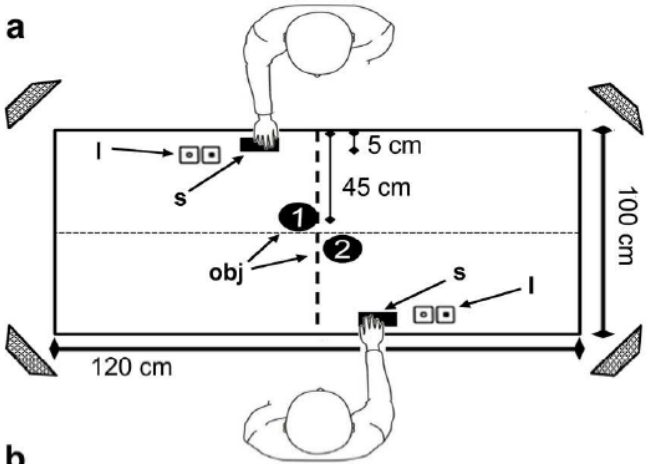
Orchestras (D'Ausilio et al 2012)

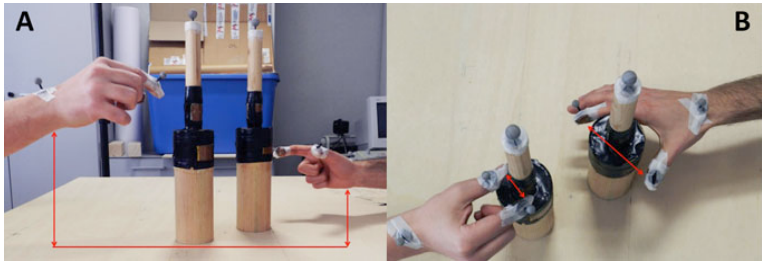


Fluent fingerspelling (Jerde et al., 2003)

Sensorimotor communication in repeated interactions

Studying repeated interactions

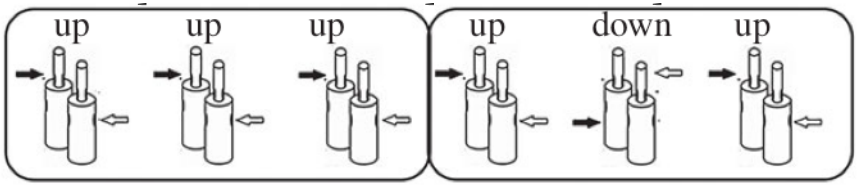




Candidi, Curioni, Donnarumma, Sacheli, Pezzulo 2015, J Roy Soc Interface

8 blocks (552 trials)

Leader executes triplets of movements, with "rules", for example:



While the Follower cannot predict the first and second trials, he can predict the third once he learns the "rules" (implicit learning)

Trial-by-trial, model-based analysis

Null hypothesis

M1: uniform distribution

History

M2: Grasping Asynchrony (GA) at the previous trial t-1

M3: average of the GA over all the exp. trials

M4: GA of k previous trials

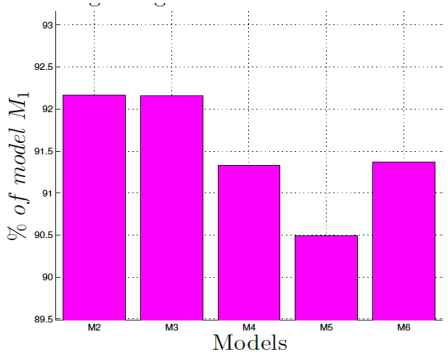
Structure

M5: GA third trials of each triplet

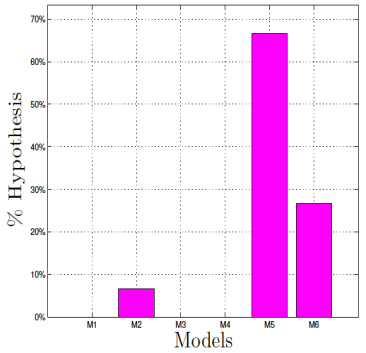
On-line info

M6: current co-actor's kinematics

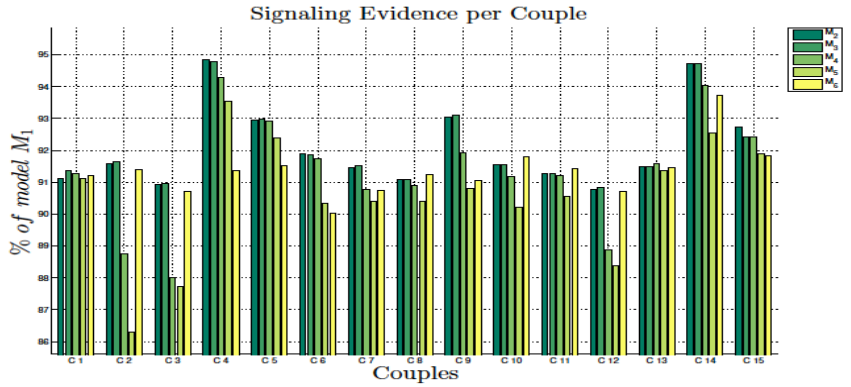
Results: Leader's signaling



BIC score



% winning models



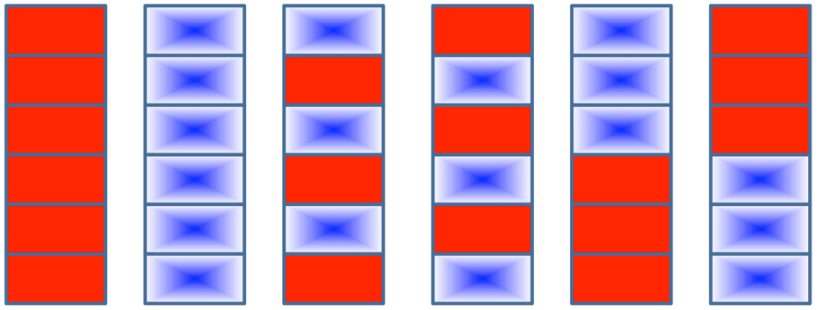
Results for each dyad

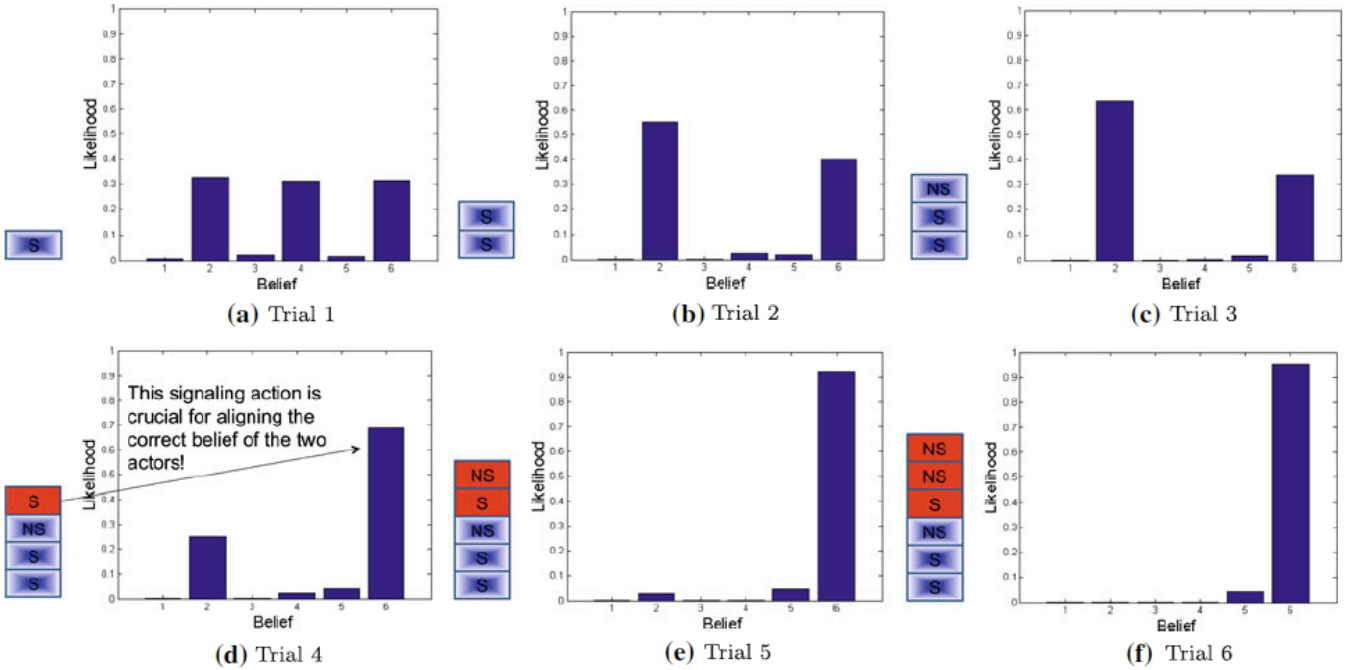
To sum up

- Signaling and imitation behaviors change during repetitive interactions – the hallmark of a flexible process
- Leaders strategically use past interactions to shape their signaling strategies
- (Followers rely on on-line information more than on past interactions)
- (Good signaling strategies - especially M5 - good predictors of dyad performance)

Sensorimotor communication and the alignment and sharing of plans

Signaling can be used strategically to influence your plans (not only your current action)

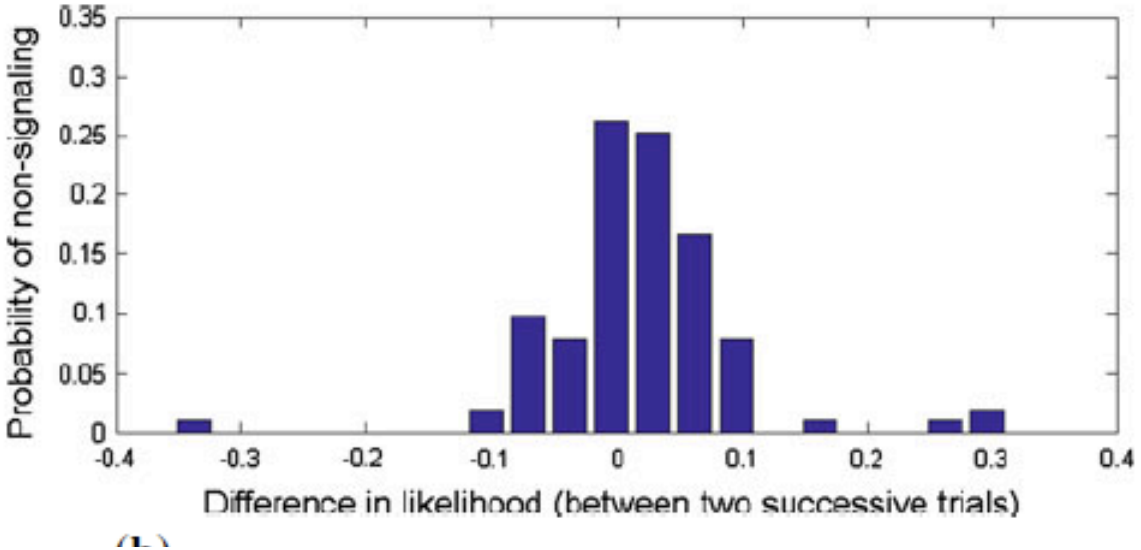




Pezzulo and Dindo, 2011, Exp Brain Res

Humans consider / monitor another's uncertainty when deciding (not) to signal

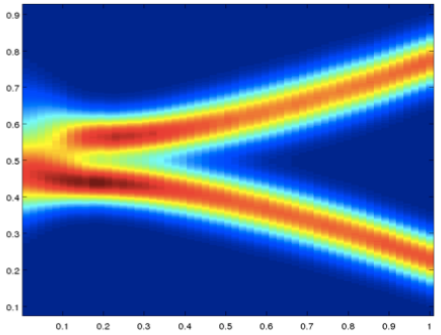
Signaling only when there is information gain



Pezzulo and Dindo, 2011, Exp Brain Res

Interim summary

- Signaling in **joint action optimization**. Helps solving interaction problems



- Signaling in 1) single interactions, 2) repeated interactions, 3) repeated interactions with multi-step plans

- In single interactions, dissimilation. In multi-step plans, signaling helps aligning our strategies ("which tower are we building")
  - Common ground (Clark 1996); shared representations (Sebanz et al 2006)