Seemingly Automatic Adjustments in Human-Robot Joint Action

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Aim

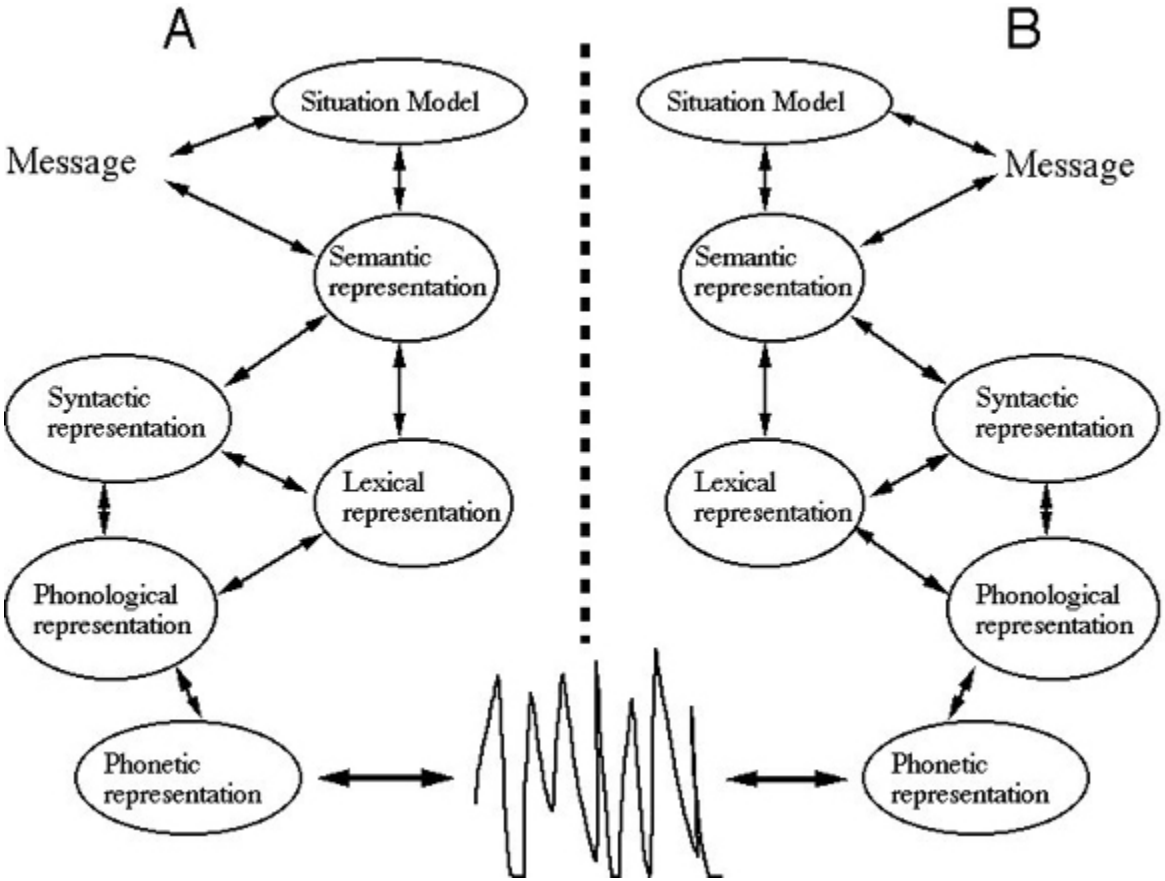
- investigate one aspect of the nature of (verbal) coordination: degree of automaticity

- two proposals:
  - interactive alignment model (Pickering & Garrod 2004)
    - based on automatic priming
    - partner modeling only as an exception
  - collaboration model (Clark 1996)
    - coordination is based on partner models

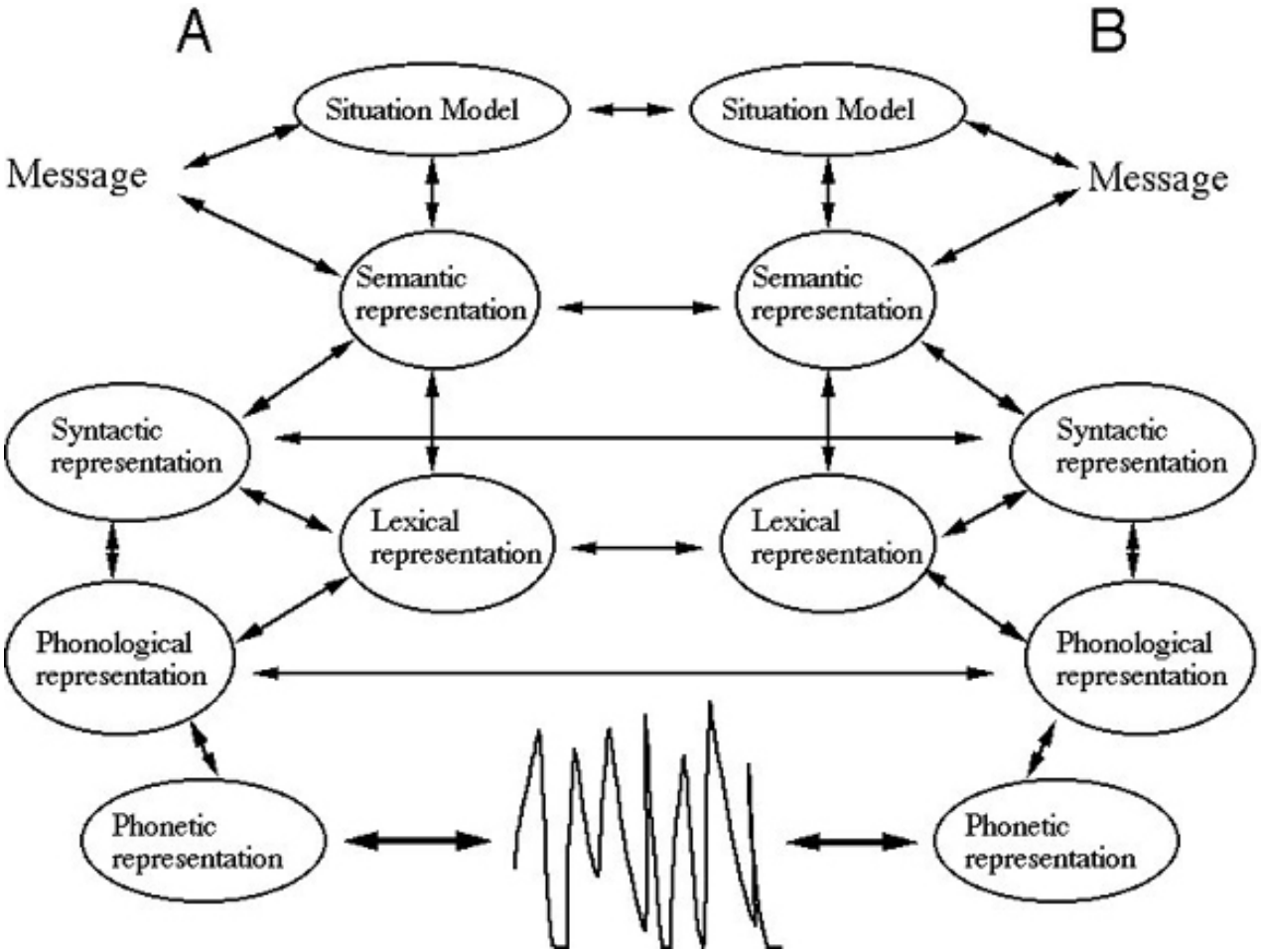
The Interactional Alignment Model

- Pickering & Garrod (2004)
  - the same processes for production and comprehension
  - alignment at lower levels leads to alignment at higher levels
  - relies on mindless, automatic priming
  - renders cognitive partner models superfluous

Traditional Psycholinguistic Processing Models



The Interactive Alignment Model



Problems with Automatic Alignment

- alignment is dependent on the partner
  - more alignment with non-native speakers (Pearson et al. 2006a)
  - more alignment with old, basic computer software than new, expensive software (Pearson et al. 2006b)
- alignment has strategic functions (Mills 2007, Mills & Healey 2008)
- alignment presupposes choice (Bateman 2006)
  - ➢ methodological problems

Interactions with Aibo

- Two conditions:
  - 13 native speakers of English each
  - task: get Aibo to move to certain objects
  - robot behavior according to script
  - condition 2: verbal output
    - Aibo greets participant
    - Aibo uses relative clauses
    - Aibo names objects directly
    - Aibo uses an extrinsic reference system

Condition 2: Robot Utterances

- *yes hello, how do you do?*
- *do you want me to go to the object that is in front?*
- *I did not understand*.
- *do you mean the object that is south south east of the box?*
- *do you want me to go to the glass?*
- *a turn of 360 degrees is not useful*.
- ...

Condition 1: non-verbal behavior

- 84.6% of the participants direct Aibo as if with a verbal remote control:

  A004: okay robot - short left please? (breathing) - short left. (5) go on, - you are doing fine, (10) now stop, (breathing) -- stop, (breathing) - robot please stop. –

  A005: um turn left, (breathing) (6) um turn left, (breathing) (6) stop, (1) oops stop. (laughter) forward,

- there are no relative clauses
- there are no uses of an extrinsic reference system

Alignment of Instruction Strategy

In Condition 2:

- 84.6% of the speakers consistently use object-based instructions
- path-based instructions are only used for ‘fine-tuning’:

  A043: I want the middle, - uh, - plastic box. with the red lid. yeah, the one at the left hand side. (2) yep, and straight ahead. – good, okay, stop.

Alignment of Reference System

- 46.2% of the speakers take up the robot's extrinsic reference system, e.g.:

A046: the red and white container in the middle.

Robot: I did not understand.

A046: go to the objects south south east from the container.

A032: I want you to go to the<L> (2) uh blue bowl, that is furthest from you.

Robot: alright. (11) should I head towards the blue object?

A032: the one that is, - north-east.

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note: extrinsic reference not in the previous turn!

Lexical Alignment

- 69.2% of the speakers take up the robot`s lexical choice of *object*, e.g.:

A044: hello Aibo. – I want you to go, straight ahead, - past the first cup on your left, - and then, make, a right angled turn to your left. – to the f+ second cup. that you come to.

Robot: do you want me to go to the object that is in front?

A044: keep going towards the object that is in front.

Constructional Alignment

- 61.5% of the participants align wit the robot's relative clauses:

Robot: do you want me to go to the object that is in front?

A031: - no, to the object that is to your right

(...)

A031: now move to the glass in front of you

Robot: I did not understand

A031: -- move to the object that`s in front of you.

Interim Conclusion:

- alignment (in the sense of behavior matching) can be found on various levels
  - however, it is unclear whether it is due to priming
- in addition, many other differences can be found

Further Differences

- there are numerous other significant differences
  - fewer instances of zoomorphisation
  - fewer comments about the robot
  - fewer vocatives
  - differences in intonation contours
  - fewer interjections
  - fewer imperatives
  - less formal language
  - complexity of constructions increases, e.g.:

    A032: the correct object will be the first

Interim Conclusion:

- alignment (in the sense of behavior matching) can be found on various levels
  - however, it is unclear whether it is due to priming

- in addition, many other differences can be found
  - suggesting that based on the robot's utterances, speakers' understandings of the robot change – and thus that the alignment observable is not based on priming, but on partner modeling

Approaching Partner Models

method: dialog beginnings

Robot: yeah, hello, how do you do?
A008: (2) go straight.
Robot: what can I do for you?
A008: go straight. (7)
Robot: do you want me to go to the object that is in front?
A008: (1) no, go straight.

- this participant ignores the social aspects of the robot's utterance

Approaching Partner Models

method: dialog beginnings

Aibo: Yes, hello, how do you do?

A042: (1) I I'm good, and you, (laughter)

Aibo: (1) which object should I head towards?

A042: towards the cup on the furthest, that's furthest left.

- this participant responds socially to the social aspects of the robot's utterance

Partner Model Influences Behavior

- significant correlations between dialog beginning and:
  - number of turns r= 0.50*
  - number of falling intonation contours r= 0.54*
  - number of feedback signals r= 0.52*
  - number of declarative sentences r= 0.35
  - number of structuring signals, e.g. *okay* r= 0.39*

- does the partner model influence also the alignment?

Partner Model Influences Alignment

Robot as non-social communication partner

Aibo: Yes, hello, how do you do?

A032: (3) so I (...) go straight

Aibo: What can I do for you?

A032: (1) go straight about a meter and a half

…

Aibo: Do you want me to go to the object that is in front?

A032: (1) no I want you to go to the object that is behind the first one

- Alignment used to secure understanding

Partner Model Influences Alignment

Robot as social communication partner

Aibo: Yes, hello, how do you do?
A042: (1) I I'm good, and you, (laughter)
Aibo: (1) which object should I head towards?
A042: towards the cup on the furthest, that's furthest left.

- Alignment with the greeting
- otherwise: shared basis

Aibo: Yes, hello, how do you do?

A046: (1) I'm fine, thank you, -- please go to the object, (2) to your left, - in the back.

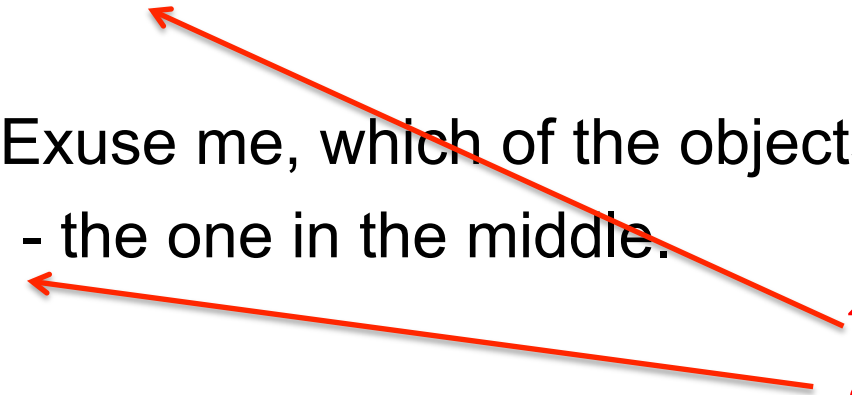
Aibo: (5) Do you want me to go to the object that is in front

A046: - no. to the object in the back.

…

Aibo: Exuse me, which of the objects did you name?

A046: - the one in the middle.



taken to be common ground

Partner Model Influences Alignment

- Robot as social/unsocial communication partner influences alignment with different aspects of the robot's utterances:

	glass	I mean	towards	I want	degrees	RelCl
r	-.43	-.23	-.26	-.12	-.15	-.41

- it is thus the cooperative speakers who don't align

Alignment: Summary

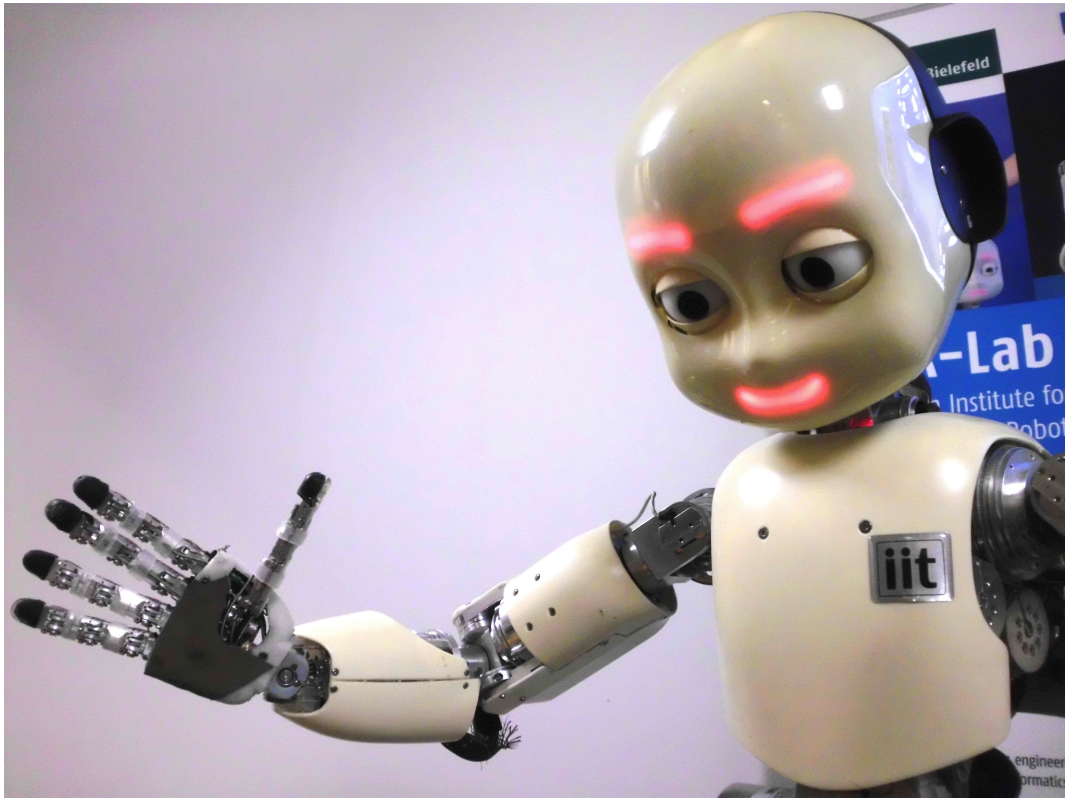
- there are no indicators that alignment is due to automatic priming
- instead, kind and frequency of alignment depend on the respective partner model (social actor or not)
- alignment is used strategically to establish a shared basis
  a) to secure understanding
  b) as common ground
- in line with results showing that alignment with features of the communication partner is highly selective (e.g. Kraljic & Brennan 2008)

Conclusions

- people coordinate their behaviors with a robot based on what they consider the affordances of the partner to be
  - ➢ interpersonal differences

- based on perceived communicative tasks, they choose their behaviors
  - possibly subconsciously
  - possibly routinized
  - however, not as automatic response to the partner's utterance

Thank you!



Further Evidence

- suggestion is in line with recent findings (Manson et al. 2013) on the relationship between alignment and cooperation; they find
  - lexical alignment and alignment of laughter to correlate significantly with liking, yet not with cooperativeness
  - alignment of prosodic properties does not lead to liking, and only alignment of speech rate is correlated with cooperation