Artificial Language Understanding in Robots

CHIST-Era Projects Seminar 2016

Bern, SNSF

28-29 April 2016

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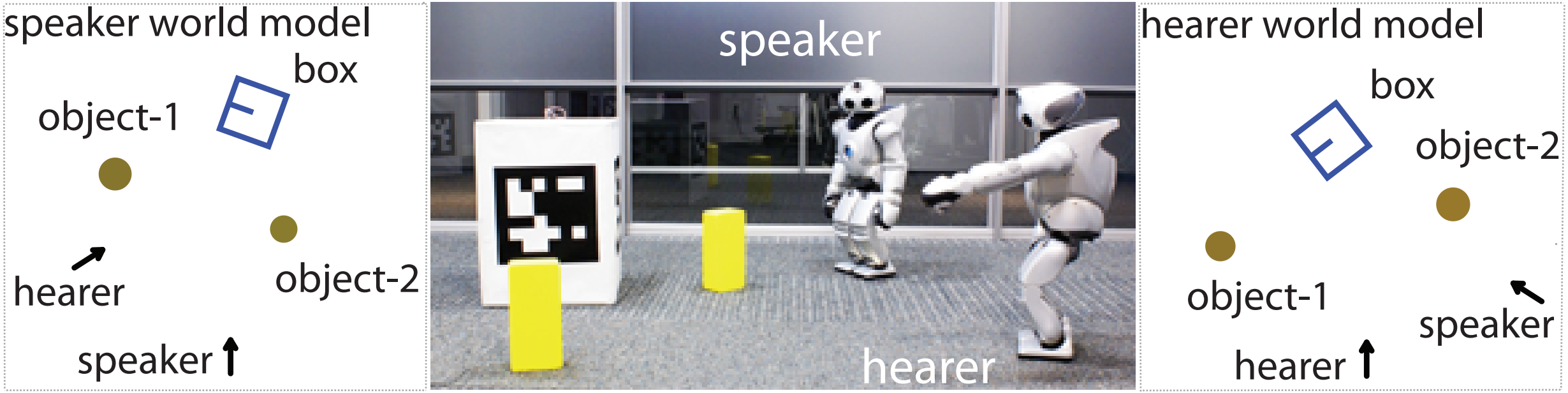
chist-era



Synthesize the major transitions in the emergence of languages using agent-based computational models

Spranger, M. Incremental Grounded Language Learning in Robot-Robot Interactions. IEEE ICDL-EPIROB 2015

Proposed stages

1. From action to gesture
2. From sounds to words
3. From single words to protolanguage
4. From words to grammar

The objective of ATLANTIS is to develop multi-modal, grounded, artificial learning machines (i.e. models) for the first three stages

Specific objectives

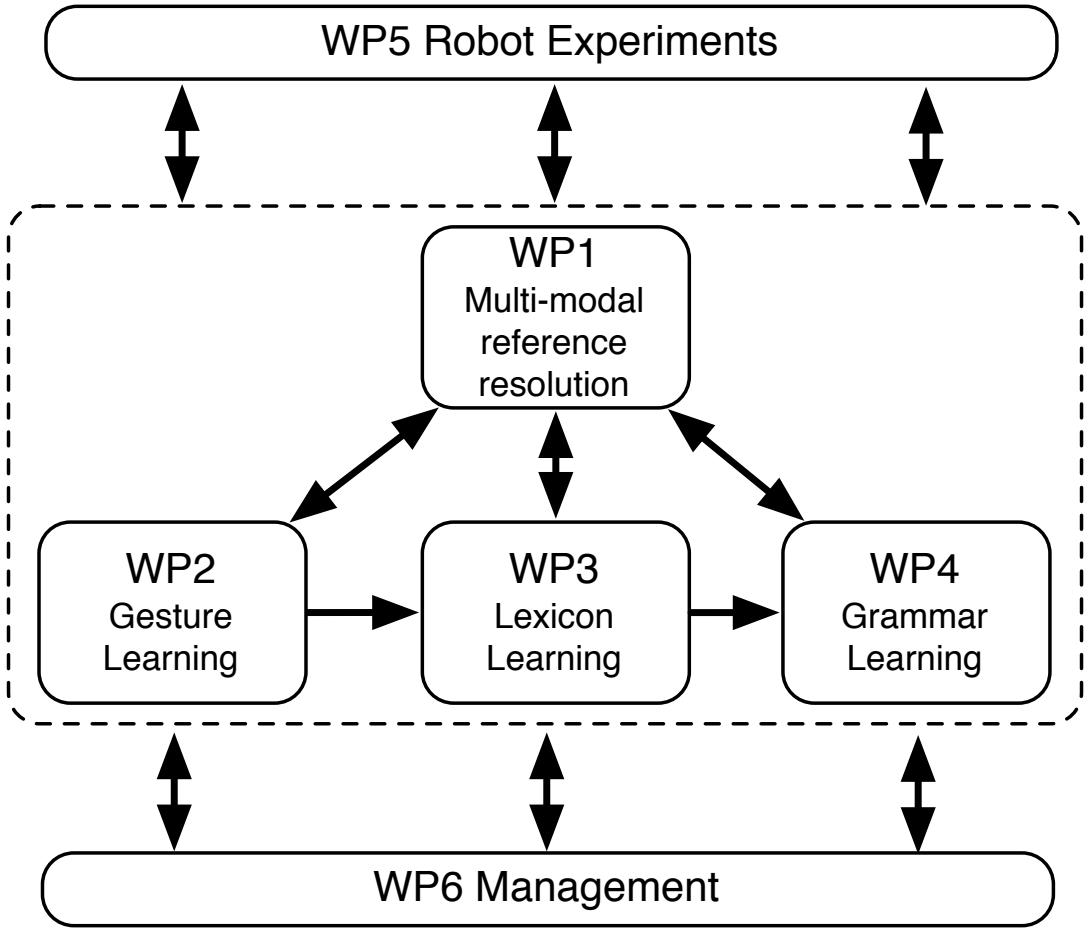
1. Develop a computational model for **multi-modal reference resolution** integrating eye gaze, gesture, speech, words and grammar
2. Develop a computational framework for the **early emergence of gestures** in processes of ontogenetic ritualization and cultural learning
3. Research and develop learning operators and models governing the **vocabulary spurt**
4. Develop a model of **early construction grammar learning** for holo-phrase and item-based constructions
5. Demonstrate integrated systems that can **transition between different phases**
6. Create a **new research community** around grounded language learning in artificial tutor-learner agent communities through open data, open source software, benchmarks and challenges, and course materials

Two task scenarios

Empirical studies complemented with detailed robotic studies

1. Object reference
2. Navigation

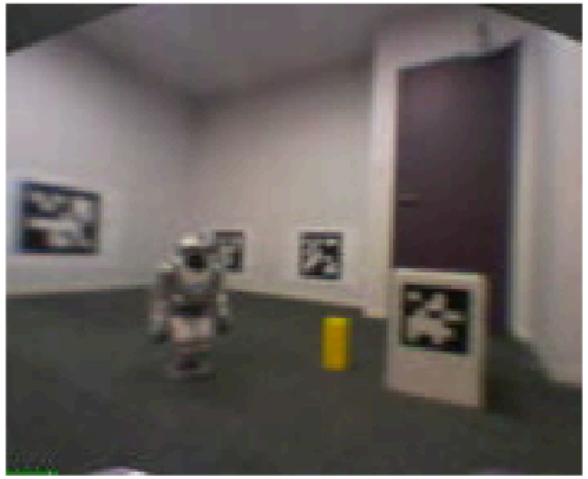
Common thread for all work packages

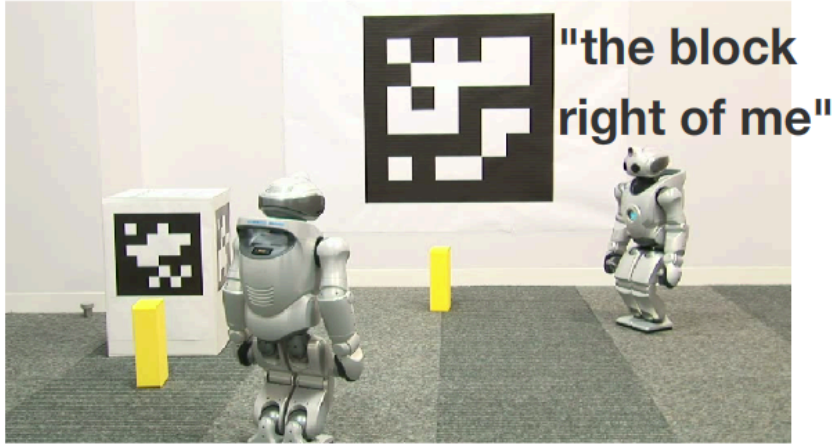


Experimental setup = language games

- Routinized turn-taking
- Population of agents
- Speaker has a goal
- Listener decodes utterance
- Success if listener carries out the goal, otherwise failure

Learning more complex phrases: "The block right of me"





video

1. Object reference

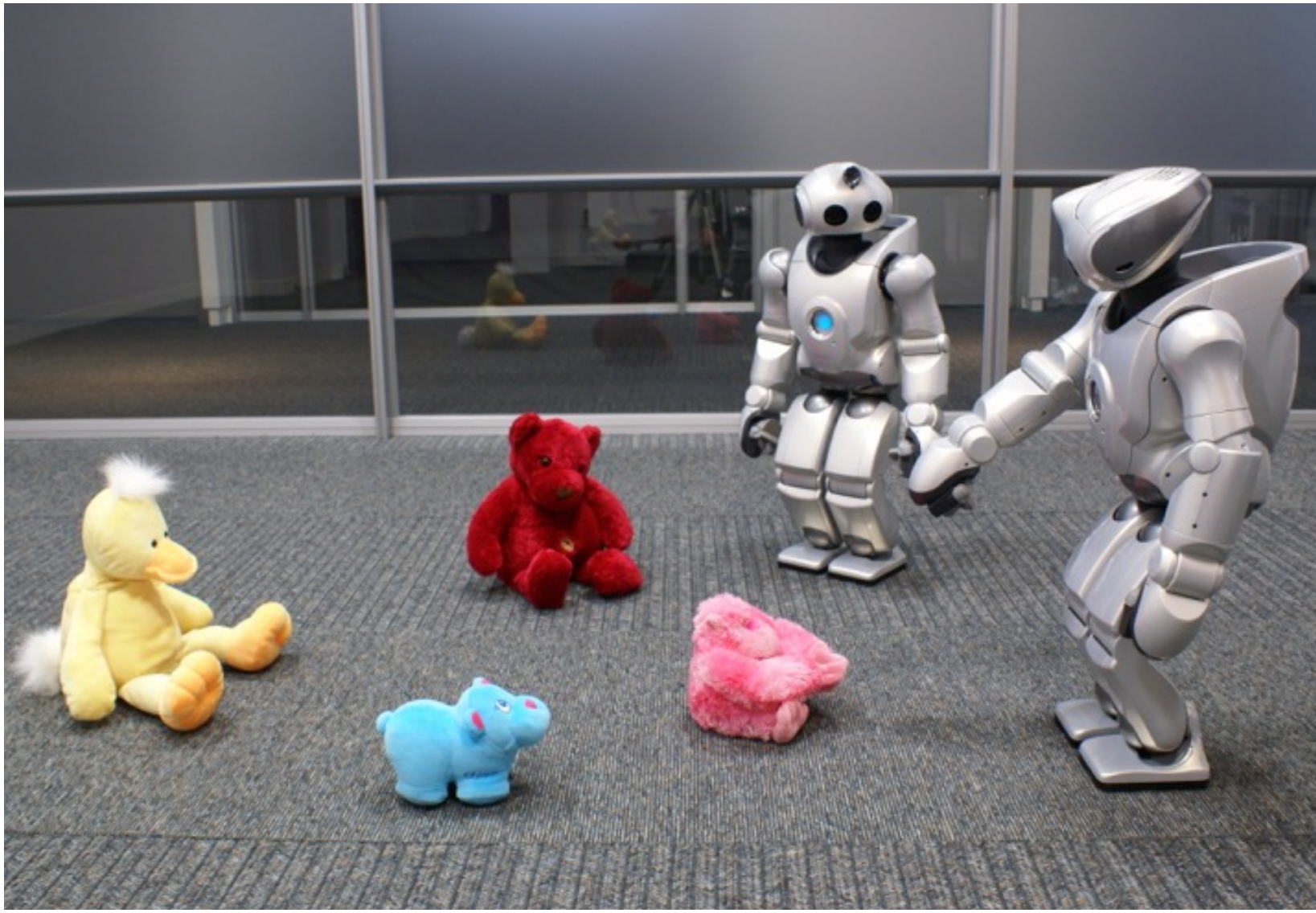
- Goal = draw attention to objects and/or their properties and spatial relations.
- Test environment: set of objects with variations in number, spatial position, color and type
- Robots have to use gesture, vocalizations, words and grammar as well as other cues such as eye gaze

- Empirical data: Multi-modal Task Description Corpus (OFAI)

Current situation

600 scenes
of different objects

1200 scenes
of spatial games

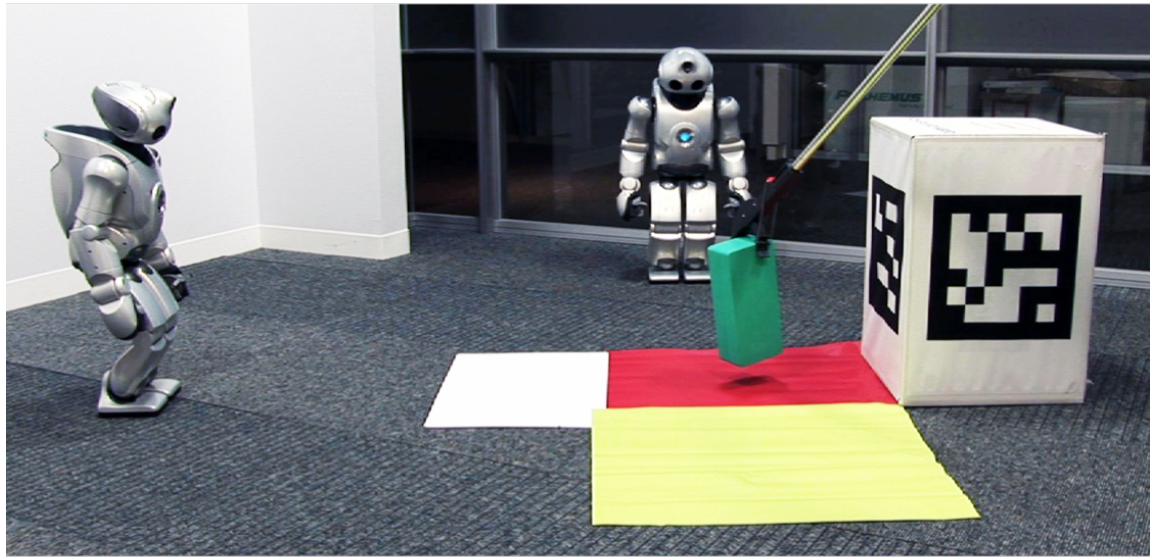


2. Navigation

- Goal = describe a particular path of movement
- Test environment: moving objects and robots + colorful regions on the ground and landmark objects
- Scenario lends itself for multi-modal interaction

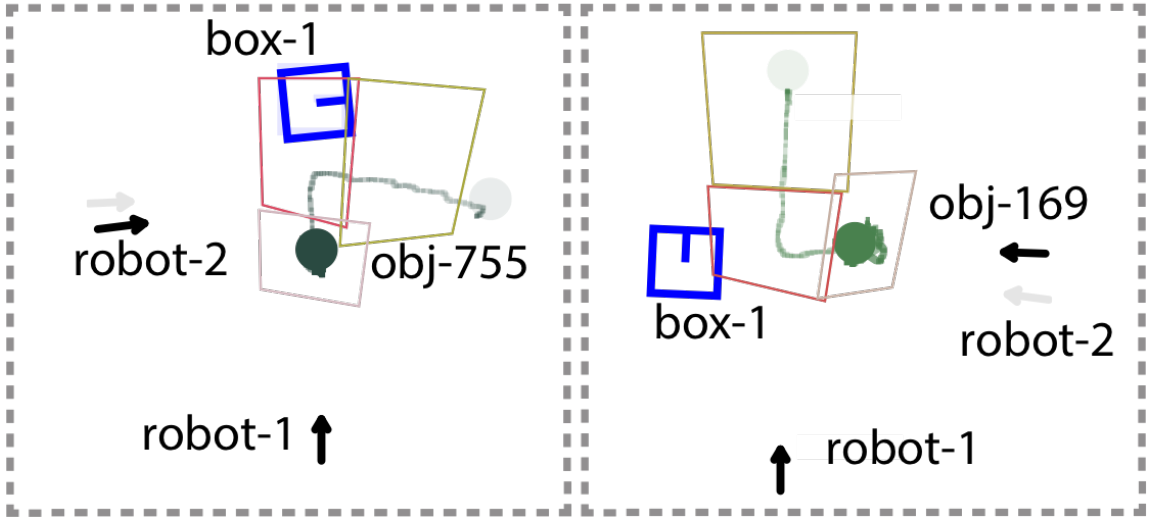
- Backed by preparation and analysis of a multi-modal empirical corpus

Current situation



600 scenes
of objects moving through regions

A system for extraction of dynamic spatial relation data



Michael Spranger, Jakob Suchan, Mehul Bhatt (2016) In IJCAI'16: Proceedings of the 25th international joint conference on Artificial intelligence, Palo Alto, 2016. AAAI Press.

Methodology

1. Choose/design experimental setup
2. Build a target model based on empirical data (interaction between two adult speakers)
3. Build a learner model that learns aspects of the target model
4. Study the impact of different strategies (tutoring and learning)
5. Integrate different models for understanding and emergence of gesture, lexicon and grammar

Empirical corpora as a blueprint for robotic experiments

- How do speakers refer to objects, navigation paths etc. in a particular task setting?
- What is the interplay of gesture, eye gaze, and language in a particular task description by the tutor?
- How large is the inter/intra-speaker variation when referring to objects?
- How often are linguistic expressions such as nouns (as object references) or verbs (as action references) omitted?

Consortium

Vrije Universiteit Brussel

Artificial Intelligence Lab
(Ann Nowé, Katrien Beuls)

upf.

Evolutionary Biology Lab
(Luc Steels)

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ENS
ÉCOLE NORMALE SUPÉRIEURE

LATTICE-CNRS
(Thierry Poibeau)

OFAI

Austrian Research Institute
for Artificial Intelligence
(Brigitte Krenn)

SONY

Sony Computer Science Laboratory, Paris
(Michael Spranger)

Artificial Intelligence Lab
Vrije Universiteit Brussel

Vrije Universiteit Brussel

- Prof. Ann Nowé, Dr. Katrien Beuls
- Project coordinator
- Leader of WP3 (Lexicon learning) and WP6 (Management)
- Experience: machine learning, language games

- Main role:
  Grounded word learning in high-dimensional spaces (sound -> word)

Austrian Research Institute for Artificial Intelligence

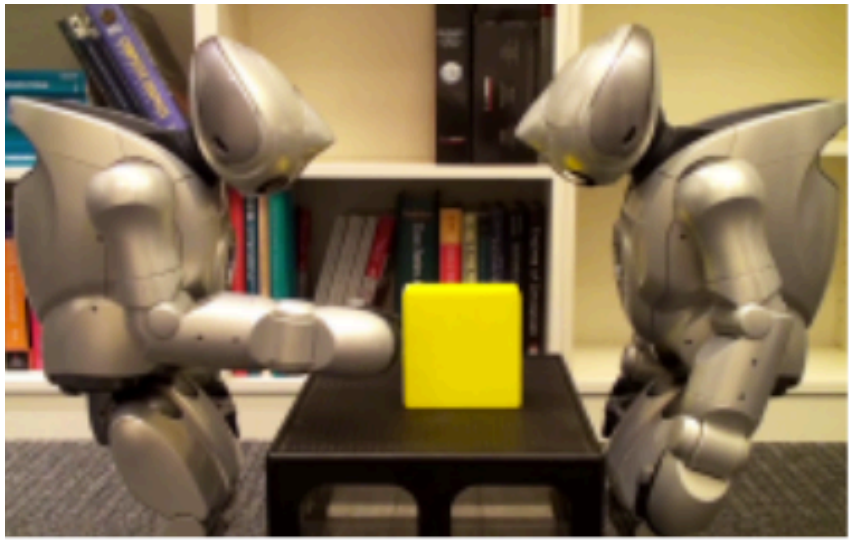
- Dr. Brigitte Krenn, Stephanie Gross
- Leader of WP 1: Multi-modal reference resolution
- Experience: multi-modal corpus design and analysis

- Main role:
  Extract the relevant tutor and learning strategies, modeling components, and model parameters for the computational models.

Evolutionary Biology Lab
Universitat Pompeu Fabra

- Prof. Luc Steels
- Leader of WP 2: Gesture learning
- Experience: ontogenetic ritualization models

- Main role:
  Gesture recognition, planning
  Tools for tracking and quantifying evolutionary change



LATTICE-CNRS

- Dr. Thierry Poibeau, Dr. Isabelle Tellier
- Leader of WP 4: Early grammar learning
- Experience: State-of-the-art language technologies

- Main role:
  Include NLP techniques into language game experiments to build the bridge from words to multi-word expressions

Sony Computer Science Laboratory

SONY

- Dr. Michael Spranger
- Leader of WP 5: Robot experiments
  (simulated, recorded robot data, real world)
- Experience: robotic communication scenarios

- Main role:
  Validation and testing of project results , community building

Upcoming Atlantis events in 2016

- Workshop on Cognitive Aspects of Computational Language Learning at ACL, 11 August 2016, Berlin.
- Summer School on Creativity and Evolution with scientific atelier on ‘Multi-modal grounded language learning’, 5-9 September 2016, Lake Como, Italy.
  - Registration now open: http://caes.lakecomoschool.org/
- Workshop on Language Learning at IEEE ICDL-EPIROB, 19 September 2016, Paris.

Recent Publications

Luc Steels (in press). Agent-based Models for the Emergence and Evolution of Grammar. *Phil Trans. Royal Society B.*

Michael Spranger and Katrien Beuls (subm.) Referential Uncertainty and Word Learning in High-dimensional, Continuous Meaning Spaces.

Stephanie Gross and Brigitte Krenn. (2016). The OFAI Multi-Modal Task Description Corpus. *Proceedings of 10th Language Resources and Evaluation Conference*. Portorož (Slovenia), 23-28 May 2016.

Luc Steels and Katrien Beuls. (2016). How to Explain the Origins of Complexity in Language: A Case Study for Agreement Systems. *Complexity in Language*. Cambridge University Press.

Michael Spranger. (2015). Incremental Grounded Language Learning in Robot-Robot Interactions - Examples from Spatial Language. In *2015 Joint IEEE International Conferences on Development and Learning and Epigenetic Robotics (ICDL-Epirob),* pages 196-201, IEEE.

Michael Spranger and Luc Steels. (2015). Co-Acquisition of Syntax and Semantics - An Investigation in Spatial Language. In *IJCAI'15: Proceedings of the 24st international joint conference on Artificial intelligence*, pages 1909-1905, Palo Alto, 2015. AAAI Press.

Four ongoing student projects

- Project 1: "Investigating the role of prosodic prominence in multi-modal situated open world reference resolution"
- Project 2: "A corpus-based investigation of multimodal presentation of spatial information and its impact on the design of spatial language games”
- Project 3: “Online, multi-modal lexicon learning - the impact of representation, interaction scripts and learning operators on developmental trajectories”
- Project 4: “Weakly supervised, grounded grammar learning for parsing and generation”

Community building

- Kick start an active research community around open-source technologies, benchmarks, open access data produced in the project
- Encourage project external researchers to replicate, extend and challenge results achieved in the project
- Promote reproducibility of research results, ensure impact of the project beyond project lifetime

open data, open source software,
benchmarks and challenges, course materials

Artificial Language Understanding in Robots

http://www.atlantis-project.eu/

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Artificial Intelligence Lab, Vrije Universiteit Brussel

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