Modeling the concurrent development of speech perception and production in a Bayesian framework
Marie-Lou Barnaud, Julien Diard, Pierre Bessière, Jean-Luc Schwartz

To cite this version:
Marie-Lou Barnaud, Julien Diard, Pierre Bessière, Jean-Luc Schwartz. Modeling the concurrent development of speech perception and production in a Bayesian framework: COSMO, a Bayesian computational model of speech communication: Assessing the role of sensory vs. motor knowledge in speech perception. 5th International Conference on Development and Learning and on Epigenetic Robotics (ICDL-Epirob), Aug 2015, Providence, United States. hal-01202418

HAL Id: hal-01202418
https://hal.archives-ouvertes.fr/hal-01202418
Submitted on 23 Sep 2015

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L’archive ouverte pluridisciplinaire HAL, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d’enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.
Context and Bayesian model

Issues
Question of interest: Why perceptuo-motor units?
Hypothesis: The auditory and the motor systems would be complementary.

COSMO: from a model of communication...

COSMO: ...to a model of communicating agent (the internalization hypothesis)

Model learning and simulation of perception processes

Model learning

Sensory learning

Learning agent

Master

Motor learning

Motor system

Sensory system

Simulation of perception processes

Comparison of three perception processes:
- Sensory system $P(O_S | S)$
- Motor system $P(O_M | S)$
- Perceptuo-motor system $P(O_{SM} | S)$

In 1D simulations:
- 2 objects $O_S$ and $O_M$
- Spaces $S$ and $M$ in one dimension
- $P(M | O_S), P(S | M)$ and $P(O_{SM} | S)$ gaussians

Discussion

Learning pace: Comparison of the entropy of the sensory and motor learning

The entropy of the sensory model converges quickly to a level close to the entropy of the stimuli produced by the master (in less than 200 learning steps), while the entropy of the motor model converges more slowly (in more than 20,000 learning steps).

Evaluation of perception: Comparison of recognition rates of the three perception processes in noisy conditions

The sensory system provides good recognition scores without noise, with a quick degradation of performance when noise is added. The motor system is better than the sensory model in noise, though still being poorer without noise. The perceptuo-motor system performs better than both isolated systems in all conditions.

Conclusion

We have compared and illustrated in detail the behavior and the performance of the learned sensory and motor models. We have shown that the sensory model directly exploits the associations between objects and stimuli to learn the sensory classifier in a quick and efficient way. In contrast, the motor model needs to build both motor repertoires and an internal model of the sensory-motor mapping. In order to do so the Learning Agent explores its motor space. As a result, the motor model is less efficient for the processing of stimuli typical of the learning set ("nominal conditions") but more robust to degradations and adverse conditions. The motor model has some generalization capacities thanks to its exploration phase, when the sensory model, in some sense, overlearned. This is what we summarize as the "sensory narrow-band vs. motor wide-band" property.

Perspectives

- We have already extended COSMO to more complex configurations in multi-dimensional spaces involving synthetic plosive-vowel sequences.
- We are currently exploring further the learning algorithm and its ability to produce "idiosyncrasies" which are variations in learned motor and sensory strategies in the learning agent.