The Institute for Cognitive Studies at the Ecole Normale Supérieure in Paris is proposing research internships to students with an engineering/maths/computer science background in the 'synthetic learner' project.

The general aim of this project is to understand how babies spontaneously learn their first language by applying a 'reverse engineering' approach, i.e., by constructing an artificial language learner that mimics the learning stages of the infant.

The internship will focus on one specific subproblem, for instance: how do infants extract words from speech, how do they construct phoneme categories, how do they figure out the meaning of words? (see detailed list below). To address this problem, the student will apply weakly supervised or unsupervised, bio-inspired machine learning algorithms, to large corpora of child-adult verbal interactions in several languages and compare the results with behavioral and/or neural recording data. In particular, the student will work with tools selected from:

- signal processing (speech, video, brain imaging features)
- deep neural networks (optimized on GPUs)
- sparse dictionary methods
- hierarchical non-parametric Bayesian models
- other tools from Natural Language Processing (Finite State Transducers, MaxEnt models, parsers, etc)

The student will work in a multidisciplinary team composed of researchers with various backgrounds (neuroscience, psycholinguistics, machine learning, etc) located at the Ecole Normale Supérieure in the quartier latin in Paris, and will have access to high performance computing resources (CPU/GPU cluster), large language databases, and cutting edge expertise in the cognitive (neuro)science of language as well as machine learning algorithms for speech and language applications. Some of the projects will involve a collaboration with other teams in France (INRIA) or abroad (J. Hopkins, MIT, Facebook AI, etc).

The student will ideally combine:

- a strong background in statistical modeling or linear algebra,
- knowledge of scientific computer programming (Matlab, python, etc).
- a strong interest in cognition and/or language,
- enthusiasm for interdisciplinary and team-based research,

Candidates should send a CV, paragraph of motivation, contact information of one referee to syntheticlearner@gmail.com. Women are encouraged to apply.

Further information about the project can be found at: http://www.syntheticlearner.net
Examples of possible internships

- **Deep language learning from scratch**
  Deep Neural Networks (DNNs) have recently broken ground on state-of-the-art in several areas (image recognition, speech recognition, etc.)\(^{[1,2]}\). However, these algorithms depend on large human-annotated datasets. Yet, infants spontaneously achieve similar performance without direct supervision; the internship explores various ideas to ‘de-supervise’ deep learning using side information, loss functions or architectures inspired by research in human infants\(^{[3]}\).

- **Can babies actively select the data on which they learn?**
  Infants are not passive listeners, but actively select the data that they are learning on. The internship will use tools from artificial curiosity/active learning\(^{[4,5]}\) to model possible mechanisms for data selection/filtering in the face of noisy\(^{[6]}\) or multilingual input\(^{[7]}\).

- **Time invariance in speech perception**
  Speech perception is invariant with respect to large variations in speech rate\(^{[8,9]}\). How is this achieved? The internship will explore time normalization using various computational architectures for speech recognition (convolutional coding, networks of oscillators, etc.) and compare the results to human data\(^{[10]}\).

- **The role of prosody in language bootstrapping.**
  Speech prosody is the 'melody' and 'rhythm' of language, and infants are very sensitive to it. We think that it provides bootstrapping into linguistic structures at many levels (lexical, grammatical)\(^{[11]}\). The internship will explore this using a variety of speech technology techniques (signal processing, spoken term discovery, word segmentation, etc.)\(^{12}\).

- **Rules and meaning**
  The human language faculty is unique in its ability to combine a finite number of categories to express infinitely varied meanings\(^{[13]}\). The internship addresses how the basic constituents of language (categories and rules) could be learned during infancy focusing on two ideas: extracting proto-categories and rules from the sensory inputs using clustering or sparse coding techniques\(^{[14]}\), and using mutual constraints linking the different levels of linguistic structures\(^{[15]}\).

- **Birth of the ‘protolexicon’**
  At four months of age, infants recognize a few very common words (their names, mommy, daddy, etc)\(^{[16]}\), even though they are unable to produce them. There are several hypotheses regarding how infants may construct such a protolexicon of frequent speech fragments\(^{[17]}\), but they have never been compared. Here, we will implement these hypotheses using pattern matching algorithms\(^{[18]}\) and apply them to home recordings of speech directed to infants.

- **Big baby home data collection**
  Big baby data is essential to uncover the mysteries of early language acquisition\(^{[19]}\). Here, we develop dense data recording in baby’s homes using arrays of audio/3D video sensors\(^{[20]}\), as well as toy-based evaluation of preverbal infant language acquisition, and we analyze the data in relation to computational models with unsupervised algorithms.

- **Cracking the neural code for speech**
  How does the brain encode speech sounds? Progress in neuroimaging (ECoG, intracerebral electrical recording, etc) have resulted in a flow of data, both in human and animals\(^{[21,22]}\). The internship will apply neural decoding methods and apply to neural data and data generated from deep neural architectures\(^{[2]}\) to explore hypotheses about the neural code for speech.

Visit us and discuss about other possible internships!


