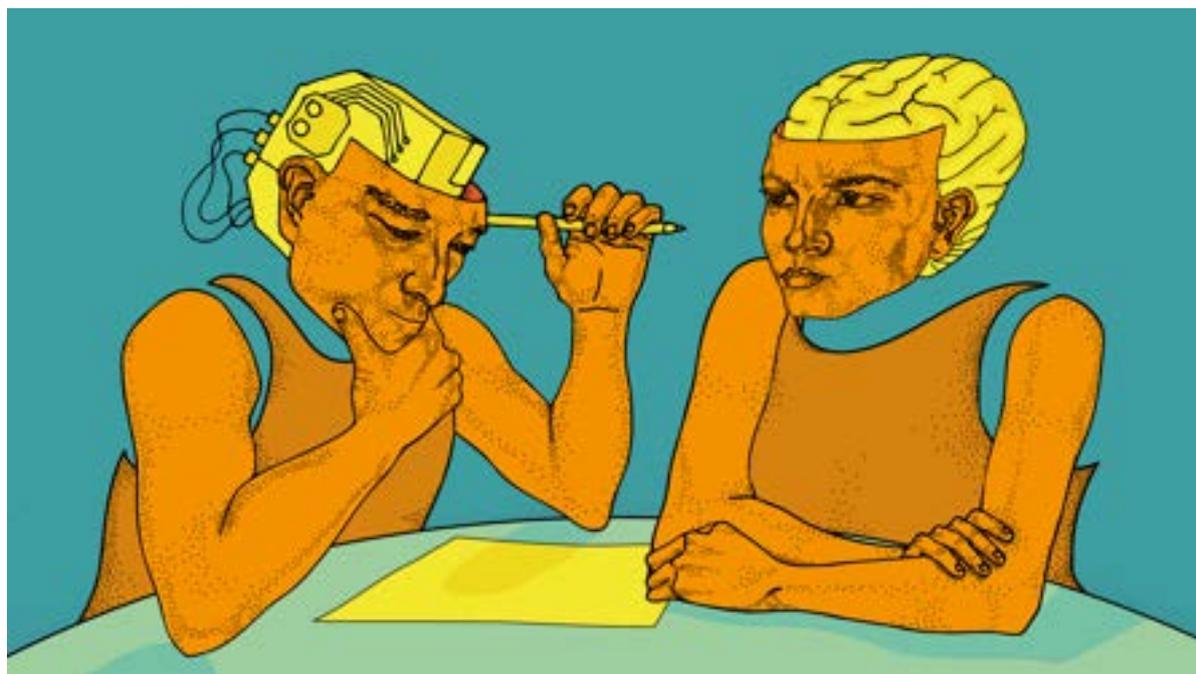


# Cognitive AI @DEC: A Synthesis<sup>1</sup> Across Five Strategic Axes



Artificial intelligence has become a central object of inquiry across the cognitive sciences, raising scientific, societal, and philosophical questions of unprecedented scope. To structure this rapidly evolving landscape, the DEC Cognitive AI initiative distinguishes five complementary research axes. The first concerns *understanding and building AI systems*, an area in which cognitive science and neuroscience have historically played an influential role by inspiring key advances in machine learning and computational architectures. The second axis focuses on *using AI to understand cognition and the brain*: models originating in AI—whether deep neural networks, language models, or multi-agent systems—now provide powerful tools for probing perception, learning, reasoning, and neural dynamics.

A third axis examines *how humans interact with AI systems*, a theme of growing importance as artificial agents participate in decision making, communication, and daily life. Establishing safe, interpretable, and cognitively compatible human–AI interactions requires both conceptual and empirical investigation. The fourth axis addresses the *role of AI in society, education, and health*, recognising that the deployment of AI technologies will be pervasive and that their impact must be assessed, anticipated, and translated responsibly into real-world applications. Finally, a fifth axis encompasses the *philosophical and ethical questions* raised by AI, from the foundations of cognition and meaning to issues of safety, agency, governance, and normative responsibility.

All five axes are richly represented within the DEC. Together, they highlight the breadth of the department’s engagement with AI and its unique capacity to connect computational advances with cognitive theory, empirical research, and societal issues.

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<sup>1</sup> **Disclaimer** Artificial intelligence research at the Département d’Études Cognitives spans a broad spectrum, from building new AI systems to using them as tools for understanding cognition, studying human–AI interaction, examining societal impacts, and addressing philosophical questions. The following condensed synthesis provides an (not fully exhaustive) overview of some of the ongoing activities across the five axes of the Cognitive & AI initiative.

## Presentation of the DEC

The *Département d'études cognitives* (DEC) at *Ecole normale supérieure* (ENS) brings together several leading research laboratories: the Jean Nicod Institute (IJN), the Cognitive Science and Psycholinguistics Laboratory (LSCP), the Perceptual Systems Laboratory (LSP), the Cognitive and Computational Neuroscience Laboratory (LNC<sup>2</sup>), and the Interventional Neuropsychology Group (NPI). Together, these units cover the study of the mind and brain — from perception, language, reasoning, and development to neural mechanisms, computational models, and the philosophical foundations of cognition.

### Jean Nicod Institute (IJN)



The IJN is a multidisciplinary research center at the intersection of philosophy, cognitive science, psychology, linguistics and social sciences. It focuses on the nature of human cognition—reasoning, language, perception, and social interaction—through both conceptual analysis and empirical approaches.

### Cognitive Science and Psycholinguistics Laboratory (LSCP)



The LSCP studies how humans acquire and process language, from early infancy to adulthood. Its work combines experimental psychology, computational modeling, and linguistics to uncover the mechanisms underlying speech perception, grammar learning, and language use.

### Perceptual Systems Laboratory (LSP)



The LSP investigates how the brain constructs visual, auditory, and multisensory representations from incoming sensory signals. It explores the computational principles and neural mechanisms that support perception, recognition, and adaptive behavior.

### Cognitive and Computational Neuroscience Laboratory (LNC<sup>2</sup>)



The LNC<sup>2</sup> examines the neural and computational bases of decision-making, learning, memory, and cognitive control. Using neuroimaging, electrophysiology, and computational modeling, it seeks to understand how brain circuits give rise to intelligent behavior.

### Interventional Neuropsychology Group (NPI)



The NPI studies cognition through the lens of brain lesions, neuromodulation, and clinical intervention. By linking behavioral deficits and neural disruption, it aims to design evidence-based approaches to rehabilitation and cognitive enhancement.



## Five axes of the Cognitive AI

### 1. Understanding and Building AI Systems

Cognitive science and neuroscience have historically been major sources of innovation in artificial intelligence—from expert systems to reinforcement learning and modern deep neural architectures. Following and extending this strong historical thread, the DEC provides several examples of how our research can be used both to understand (explain) and to build (improve) AI systems.

Several groups in the DEC actively develop AI architectures, simulations, and computational tools. In LNC2, the **Network Dynamics and Computations team** (S. Ostojic) trains recurrent neural networks on cognitive tasks to study how learning shapes network structure and dynamics, contributing to mechanistic interpretability. The **Cognitive Variability team** (V. Wyart) builds artificial neural networks trained under controlled constraints to uncover which learning conditions yield human-like inference strategies, and collaborates with Meta AI to compare brain and transformer representations.

The **Neural Representations of Learning and Behavior team** (A. Cayco Gajic) develops neural-network models for motor learning and interpretable ML tools to track representational changes, while the **Human Reinforcement Learning team** (S. Palminteri) develops training and tuning techniques to improve meta-cognitive performance in large language models, as well as tools to evaluate LLMs' performance (LogProber and PhyloLM). Also at the LNC2, the **Neural Dynamics and Adaptive Behavior** (Gutkin, Koechlin) develop multi-agent simulations to better understand and predict financial markets as well as theories of embodied allostatic reinforcement learning “animats”.

At the LSCP, AI development is also central to the **Language Acquisition Across Cultures group** (Cristia, Tsuji), which produces tools such as the Voice Type Classifier, the

ChildProject infrastructure, and ML-based systems for automated gaze analysis. The **Language Processing & AI team** (Lakretz) designs or modifies LLMs to generate testable predictions about syntactic and phonological processing.

In the LSP, the **Vision team** (Neri, Mamassian) builds new machine-learning architectures with improved biological plausibility, while the **Audition team** (Pressnitzer, Lorenzi) applies deep learning to auditory-scene analysis and real-time denoising for hearing prostheses.

The **NPI team** (Dibot, Jacquemot) contributes through multimodal clinical AI models and generative systems for social cognition.

At the IJN, the **Concept, Logic and Reasoning group** (Mascarenhas) develops meta-learning frameworks, contextual embedding analyses, and transformer-based cognitive maps with a strong theoretical orientation. Also at the IJN, the **Language Thought and Behavior Team** (Mari, Bourgeois-Gironde, Nicolas) builds hybrid AI systems that encode fine semantic distinctions in the realm of subjectivity, epistemic stances and commitments, with a variety of applications, and most notably emergency detection, hope detection, intention identification, in the broad domain of crisis management and disinformation analysis.

### 2. Understanding Culture, Cognition and the Brain Using AI Systems

From automatic classification of naturalistic data, such as speech, to the analysis of neural activity, and from modelling learning to decision making, AI provides powerful tools to understand human cognition. It is therefore unsurprising that a large part of the DEC uses AI to model, interpret, or probe cognitive and neural processes, sometimes resulting in the original development of innovative analytical (and conceptual) tools.

In the LNC2, train neural networks serve as mechanistic hypotheses about cortical computation. **Network Dynamics and Computations team** uses RNNs to study

population gating, timing, and structure–function relationships, while the **Cognitive Variability team** uses both computational cognitive models and ANNs to explain human inference under uncertainty and identify shared principles between brains and deep networks. The **Neural Representations of Learning and Behavior team** analyses representational dynamics during learning in both biological and artificial systems. The **Subjectivity, Brain and Viscera team** (Tallon-Baudry) builds representational spaces of perception and cognition using generative models and applies semantic and graph-based methods to clarify theoretical constructs such as arousal. They also use machine-learning techniques to improve diagnosis in disorders of consciousness. The **Human Reinforcement Learning team** tests decision-making and learning in LLMs to compare human and machine processes, enriching both cognitive theory and machine-behaviour analysis.

Perception research at LSP also relies on AI: The **Vision team** evaluates when deep networks reproduce aspects of human visual processing, and the **Audition team** uses classifiers and interpretable ML to characterise soundscapes and perceptual strategies.

At the LSCP the **Consciousness and Cognitive team** (Sackur) uses language-model semantic spaces to model streams of thought and GPT for large-scale annotation. In developmental and historical research, the **Language Acquisition Across Cultures group** uses LLMs to extract and analyse large-scale behavioural patterns. The **Language Processing & AI team** develops neural architectures that preserve biologically and cognitively plausibility, which may thus inform about neural mechanisms of human language processing.

In the IJN, the **Evolution and Social Cognition team** (Mercier, Baumard) uses models trained on historical text to study cultural evolution.

In clinical neuroscience, the **NPI team** employs AI to infer cognitive, psychiatric, and biological markers from multimodal data.

### 3. Understanding How Humans and AI Systems Interact

Another crucial challenge for the future will be to establish safe and efficient interactions between human agents and AI systems. For this to succeed, we need to understand the specificities—and the risks—of human–machine interaction at the cognitive level.

The **Human Reinforcement learning team** investigates human–LLM interaction in reasoning, strategic decision-making, and moral judgment, analysing how humans align with or misinterpret machine behaviour.

The **Language Acquisition Across Cultures group** evaluates user interaction with automated diarisation and gaze-coding systems and conducts participatory design studies on young people's interactions with conversational agents.

In clinical settings, the **NPI group** develops interactive AI systems that patients engage with during assessments or training tasks, integrating AI into human cognitive workflows in real-world contexts.

### 4. Role of AI in Society, Education, and Health

AI deployment is expected to become massive and pervasive across many human activities—work-related, commercial, and personal. The potential of these technologies requires both an analysis of their projected social impact and an effective transfer from laboratory research to real-world applications. At the DEC the AI's societal impact is explored through several lenses.

At IJN, the **Evolution and Social Cognitive group** studies how generative AI affects misinformation and leads institutional work at the AI and Society Institute. They are also investigating ways to integrate AI tools into education.

In health, the **NPI group** advances AI-based diagnostics, rehabilitation tools, and multimodal biomarkers for neurological and psychiatric conditions. The LSP **Audition team** develops

speech-enhancement systems for hearing aids and explores vocal biomarkers of sleep deprivation, while the LSCP **Language Acquisition Across Cultures group** studies biases and limitations in real-world AI tools used in developmental research.

## 5. Philosophical and Ethical Questions Related to AI

AI is a very hot topic in philosophy. Since its beginnings, it has provided an inexhaustible source of inspiration for philosophical debates concerning the very foundations of cognitive and mental phenomena, and more recently it has also prompted questions about our ethical positions—whether regarding the safety of AI systems or their status as agents. Several DEC teams engage directly with the foundational and ethical issues raised by AI.

At the IJN, the **Concept, Logic and Reasoning group** explores theoretical limitations of contemporary models and conceptual questions about systematicity, semantic competence, and Bayesian vs connectionist reasoning. Relatedly, the **Language Thought and Behavior Team** explores theoretical issues related to intentionality and referentiality in LLMs.

The **ECN Team at IJN** (Sacha Bourgeois-Gironde) develops a distinct axis at the intersection of AI, law, and cognition, focused on the capacity of artificial systems to act as *legal representatives* of non-human entities, in particular ecological systems. Rather than treating AI as a tool for litigation or prediction, it explores its potential role as a juridical and epistemic mediator capable of expressing ecological interests that exceed human cognitive scales. The research contributes to the philosophical foundations of artificial agency and the emerging field of AI-assisted rights of nature.

The **PRISME Team at IJN** (Giardino) studies (i) how AI tools will affect (or not) the practice of science, in particular of mathematics (Valeria Giardino); (ii) the relationship between creativity and imagination through the prism of AI (Margherita Arcangeli). Several activities

have been conducted (an interdisciplinary conference, three internships, research visits and participation in seminars) within the PSL Global Seed Fund project *CreAltion* (PI: Margherita Arcangeli, 2024/2025).

The **Human Reinforcement Learning team** develops a theoretical framework for evaluating machine consciousness and investigates how cognitive biases shape human judgments about AI.

The **Language Acquisition Across Cultures group** investigates ethical concerns about privacy, fairness, and responsible deployment of AI tools in sensitive contexts such as child development research. At LSP, the **Vision group** critically examines the use of AI in peer

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## Conclusions

AI research at the DEC is both broad and deeply interconnected. The department not only builds and analyses AI systems but also uses them as scientific tools, studies their interaction with humans, examines their societal impact, and contributes to the conceptual foundations that guide responsible AI development. This multidimensional engagement positions the DEC as a major interdisciplinary hub for cognitive and artificial intelligence research.



# DEC

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## About the coordinators

**Alda Mari** is a Research Director at the CNRS at the Institut Jean Nicod (CNRS/EHESS/ENS-PSL) and a specialist in formal semantics. With a dual background in classical studies (Greek, Latin, Sanskrit) and computational linguistics, she has devoted nearly fifteen years to investigating the distinction between subjective and objective truth, with particular attention to the cross-linguistic expression of bias and belief in contexts of uncertainty. Her work led to the creation of the flagship Phronesis program, which in 2024 contributes to the development of the international HumanitiesPlus research laboratory (CNRS/University of Chicago). Starting in 2017, she expanded her theoretical research on mental states and their linguistic expression into the field of hybrid artificial intelligence. In particular, she developed an innovative methodology to detect and prioritize urgent information shared on social media during ecological crises. This approach was implemented in the INTACT software (Detecting Intentions, Predicting Actions), developed in partnership with the Institut de recherche en informatique de Toulouse, for which she received the CNRS Innovation Medal in 2025. Based on a linguistic modeling framework that fully accounts for acts of enunciation, INTACT shows strong potential for adaptation to other types of crises, especially informational crises, which Alda Mari is currently studying. *She is also currently working .... (ultima frase sul blurb attuale)*

**Stefano Palminteri** is a behavioural and computational scientist whose research focuses on understanding how humans and machines learn to make decisions. He is Research Director at INSERM and Professor at the École Normale Supérieure (ENS), where he leads the Human Reinforcement Learning (HRL) team at the Laboratoire de Neurosciences Cognitives et Computationnelles (LNC2), ENS-PSL, Paris. Palminteri's research has provided foundational insights into how value is learned in biased and context-dependent ways, and how feedback shapes choice behaviour. He has extended his work to the study of the cognitive and decision-making abilities of large language models, as well as to broader epistemological questions in cognitive science and artificial intelligence. He holds a PhD in Cognitive Neuroscience from Université Pierre et Marie Curie and has held postdoctoral positions at leading institutions, including University College London and the University of Trento. He has received several awards, including the Théodule Ribot Prize and the Alexander von Humboldt Foundation's Bessel Prize. He is an ERC awardee, a member of the ELLIS Society and the Cercle FSER, and co-author of *Decision-Making: A Very Short Introduction*.

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